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2018-19

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 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 to 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

(An ISO 9001:2008 Certified Organization)

ICAR-DIRECTORATE OF RAPESEED-MUSTARD RESEARCH
Sewar, Bharatpur-321 303 (Rajasthan), India

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(Indian Council of Agricultural Research)
Sewar, Bharatpur-321 303 (Rajasthan), India

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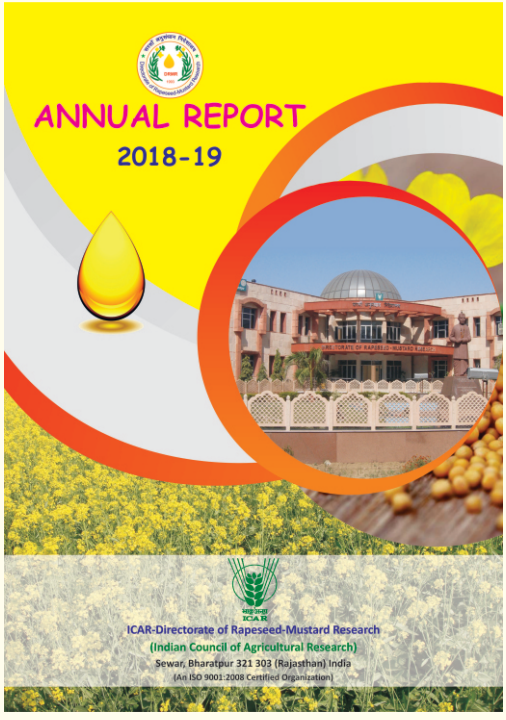

This report includes unprocessed or semi-processed data that would form the basis of scientific papers and products in due course. The material contained herein may not be used without the permission of Director, ICAR-Directorate of Rapeseed-Mustard Research except for quoting it for scientific reference.

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VISION
Brassica science for oil and nutritional security
MISSION
Harnessing science and resources for sustainable increase in productivity of rapeseed-mustard
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.

Preface

It is the matter of great honor and pride for me to present the annual report 2018-19 of ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur. The research accomplishment and technical competence of the Directorate can be judged by the facts that in two and a half decades period, rapeseed-mustard productivity has increased upto 1410 kg/ha from 847 kg/ha during the last 25 years. At present the rapeseed-mustard is grown in about 6 million hectare with more than 8 million tonnes production. Its contribution to total oilseed area and production in country are 24.4% and 26.8% respectively. The oil recovery from mustard seed ranges between 38-44% depending upon the variety and crushing processes. The country is producing about 7-8 millian tonnes edible oil from primary sources out of which the largest share is of rapeseed-mustard and contributes more than 33% of vegetable oil production.

In this year's report, salient outputs were highlighted. Most significant results during 2018-19 includes identification of genotypes DRMRCI-92 and DRMR 4005 for high temperature (thermo) tolerant at seedling stage under controlled conditions and DRMR 5206 for white rust resistance. A yellow seeded double low white rust resistant germplasm DRMR 1-5 (IC 625996/INGR 19020) was registered by PGRC, New Delhi.

A total 335.85 q TL seeds of rapeseed-mustard varieties and hybrid and breeder seed of DRMRIJ31 (2.66 q), NRCDR02 (1.40q), NRCHB101 (6.54 q), and NRCYS 05-02(0.30q) was produced during 2017-18 and supplied during Rabi 2018-19 to indenters as per DAC & FW guidelines. An income of Rs. 64,29,929 was generated from various resources.

Rapeseed-Mustard seed hub project was initiated at eight seed hub centres i.e. KVK, Kamrup, Kahikuchi (AAU, Jorhat), Assam; RRS, Bawal (CCSHAU, Hisar); ZARS, Morena (RVSKVV, Gwalior); KVK, Kota (AU, Kota); ARS, Srigangangar (SKRAU); RLBCAU, Jhansi; KVK, Mirzapur (BHU) and DKVK, Ramkrishna mission, Saragachi, Murshidabad (WB). A target of 3850 qt certified seed production was allotted to eight seed hub centers for rabi 2018-19.

A total of 353 frontline demonstrations (FLDs) with five improved varieties Giriraj, NRCHB 101, RH 725, PM 30 and DRMR 1165-40 were organized in different villages of Bharatpur district of Rajasthan. Several trainings/ awareness/exposure programme of 1 to 5 days each for farmers, extension workers were organised for effective dissemination of technology.

For upliftment of the socio-economic status of the farmers, specially tribal area, 69787 tribal farmers and farm women from East Singhbhum, West Singhbhum, Gumla and Ranchi district of Jharkhand were benefitted through FLDs, Meetings, exposure visits, kisan mela, field days, etc. under STC programme.

During the period 25 research papers, 21 popular articles, 11 technical folders and 14 book chapters were published by the scientists.

The overall growth and development of the directorate was possible wi th the able guidance, encouragement and continuous support received from Dr. T. Mohapatra, Director General, ICAR and Secretary, DARE, Dr Anand Kumar Singh, Deputy Director General (Crop Science) and Dr.P.K Chakrvarty, Ex-ADGs (O&P), ICAR, which I acknowledge with sincere gratitude and reverence.

I am thankful to the members of Publication Committee, Drs. Vinod Kumar, Hariom Kumar Sharma, M.L. Dotaniya, M. D. Meena and Sujith Kumar for their praiseworthy efforts for making this report crisp comprehensive and informative. All the scientific, technical, administrative, account supporting staff of the directorate who have contributed in bringing out this report are worthy of appreciations.

19.7.19

(P. K. Rai)
Director (Acting)

List of Acronyms

AAU	Assam Agricultural University
ADG	Assistant Director General
AICRM	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 Centre
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
FIRBS	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 Joint Staff Council
IPR	Intellectual Properly 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 PI-TP
MBC	Microbial Biomass Carbon
MEY	Mustard Equivalent Yield
MOU	Memorandum of Understanding

MPUAT	Maharana Pratap University of Agriculture and Technology
MPKV	Mahatma Phule Krishi Vidyapeeth
MS	Murashige 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 Resources
NC	National Check
NCD	North Carolina Design
NDN	National Disease Nursery
NGO	Non-Governmental Organization
NIFM	National Institute of Financial Management
NPTC	Network Project on Transgenic in Crops
NRCPB	National Research Centre of Plant Biotechnology
NSSO	National Sample Survey Office
PAU	Punjab Agricultural University
PCR	Poly cyclic Chain Reaction/Polymerase 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
RLB CAU	Rani Laxmi Bai Central Agricultural University
R&M	Rapeseed & Mustard
RRS	Regional Research Station
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
RWC	Relative Water Content
SAC	Space Applications Centre
SAU	State Agricultural University
SCSP	Scheduled Caste Sub Plan
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 Micro-satellites
TSP	Tribal Sub Plan
UAS	University of Agricultural Sciences
VPKAS	Vivekanand Parvatiya Krishi Anusandhan Sansthan
WHO	World Health Organization
WP	Wettable Powder/Whole Package
WSC	Wide Spaced Crop
WUE	Water Use Efficiency
ZC	Zonal Check

Executive Summary

- Strain DRMRCI-92 and DRMR 4005 were identified as high temperature (thermo) tolerant at seedling stage. Strain DRMR 5206 was identified as white rust resistant.
- A yellow seeded double low white rust resistant germplasm DRMR 1-5 (IC 625996/INGR 19020) was registered by PGRC, New Delhi
- The thirteenth harvest of mustard crop indicated that green manuring with sesbania significantly (p=0.05) increased mustard seed yield by 21.3% over control. Whereas, application of balance fertilizer (N: P2O5:K2O:80: 17.4: 33.3 kg/ha) increased the seed yield by 26.7% over control.
- Among the cropping systems, the system productivity was higher in maize-mustard system (6098 kg/ha) followed by green gram-mustard (5301 kg/ha), cluster bean-mustard (3914 kg/ha), pearl millet-mustard (3889 kg/ha), sesame-mustard (3649 kg/ha) and the lowest in fallow-mustard system (3031 kg/ha).
- Based on artificial stem inoculation and sick plot screening, nine Indian mustard germplasm viz., DRMR 11, DRMR 2249, DRMR 2356, DRMR 364, DRMR 506, DRMR 1309, DRMR 496 DRMR 1396 and DRMR-1099-SR-1 showed tolerant reaction (lesion size <3.0 cm and disease incidence<10%).
- A total 335.85 q TL seeds of rapeseed-mustard varieties and hybrid and breeder seed of DRMRIJ31 (2.66 q), NRCDR02 (1.40q), NRCHB101 (6.54 q), and NRCYS 05-02(0.30q) was produced during 2017-18 and supplied during Rabi 2018-19 to indenters as per DAC & FW guidelines.
- Rapeseed-Mustard seed hub project was initiated at eight seed hub centres i.e. KVK, Kamrup, Kahikuchi (AAU, Jorhat), Assam; RRS, Bawal (CCSHAU, Hisar); ZARS, Morena (RVSKVV, Gwalior); KVK, Kota (AU, Kota); ARS, Srigangangar (SKRAU); RLBCAU, Jhansi; KVK, Mirzapur (BHU) and DKVK, Ramkrishna mission, Saragachi, Murshidabad (WB). A target of 3850 qt certified seed production was allotted to eight seed hub centers for rabi 2018-19.
- A total of 353 frontline demonstrations (FLDs) with five improved varieties Giriraj, NRCHB 101, RH 725, PM 30 and DRMR 1165-40 were laid out in different villages of Bharatpur district of Rajasthan which showed yield improvement of 9.8, 7.38, 10.1, 7.6 and 13.7 % respectively over prevailing varieties.
- ICAR-DRMR organized 15 trainings/ awareness/exposure programme of 1 to 5 days each for farmers, extension workers for effective dissemination of technology.
- In Mera Gaon-Mera Gaurav (MGMG) programme, farmers were provided scientific advisories through 325 FLDs on mustard, 7 Sarson field days and a number of kisan gosthies, off-campus training and literatures.
- Under Tribal Sub Plan, 69787 tribal farmers and farm women from East Singhbhum, West Singhbhum, Gumla and Ranchi district of Jharkhand were benefitted through FLDs, Meetings, exposure visits, kisan mela, field days, etc
- A total 25 research papers, 23 popular articles, 13 technical folders and 14 book chapters were published during the period.
- Rs. 64,29,929 income was generated from various resources.

1 ICAR-DRMR: *An Overview*



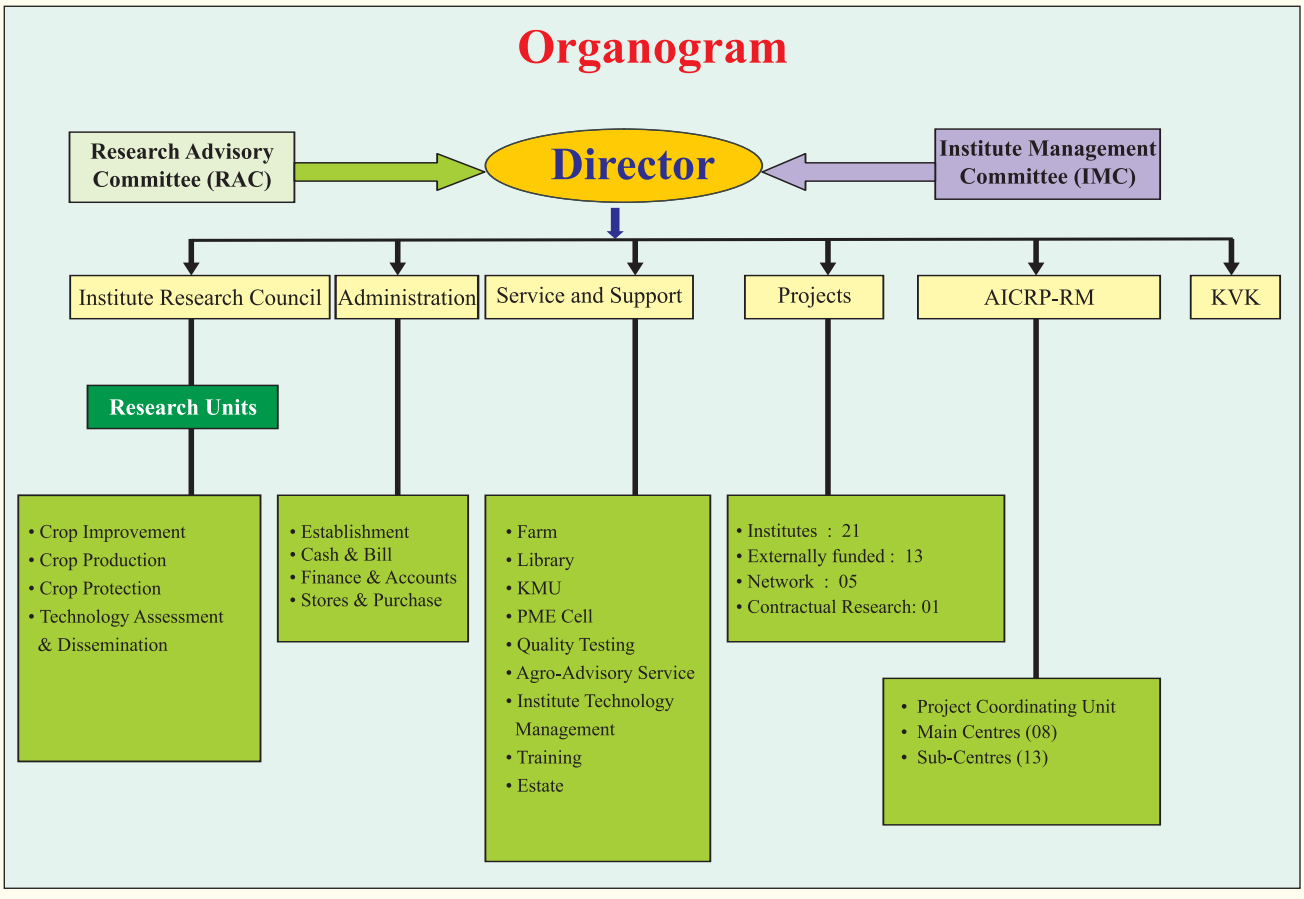
Indian Council of Agricultural Research established All India Coordinated Research Project on Oilseeds (AICRPO) in April, 1967 for the improvement of oilseeds in the country. Setting up separate Project Coordinating Unit in the V plan (1974-79) further strengthened the research program on oilseeds, especially 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 8 main and 13 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 km 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 located 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.

Functions

- The national repository of rapeseed-mustard genetic resources and information.
- Basic, strategic and applied research to 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 inter-disciplinary 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 extended technical expertise and consultancies.

Organogram



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, Pr. Scientist (Genetics and Plant Breeding).

Co-Investigators: P.K. Rai, Pr. Scientist (Plant Pathology), R.S. Jat, Pr. Scientist (Agronomy), H.S. Meena Sr. Scientist (Genetics and Plant Breeding)

Contribution and performance of entries in AICRP-RM trials

5 promising entries viz; DRMRCI 96 (IVT, early sown), DRMRCI 107 (IVT, timely sown, irrigated), DRMRCI 95 (IVT, timely sown, rainfed), DRMRCI 114 (IVT, timely sown, rainfed), DRMRCI 111 (IVT, late sown) were contributed for multi-location testing in AICRP-RM trials during 2018-19. DRMR 1153-12 recorded 12.2, 28.9, 33.6 and 29.0 percent higher seed yield over checks, Kranti, Pusa bold, JD- 6 and Pusa Mustard 25, respectively in 09 environments across the Zone V. On the mean basis of all locations, DRMR 1153-12, gave 10.5, 20.0, 31.3 and 29.3 percent higher seed yield over Kranti, Pusa bold, JD- 6 and Pusa Mustard 25, respectively in 26 environments across the Zone V. However, due to insufficient valid locations in AVT –II entry was repeated for further testing in AVT-II. DRMRCI-98 recorded near about 10% yield superiority over best check (PM 25) in IVT early sown coordinated breeding trials in Lin Zone-III. However, due to longer maturity duration entry could not promoted.

Based on lower seedling mortality (<20%) and higher seedling dry matter (>40 mg/10 seedling), under controlled conditions, DRMRCI-92 has been identified as thermo tolerant at seedling stage. Genotypes DRMRCI 85, DRMRCI 91 and DRMR 15-9 were found promising for aphid tolerance.

Performance of entries in station trials

Entry DRMRCI 107 (2780 kg/ha) recoded maximum yield in comparison to checks (Best check DRMRIJ 31 yielded 2462 kg/ha) under irrigated timely sown trial. In station trial, under rainfed conditions, entry DRMRCI 95 (1969 kg/ha) and DRMRCI 114 (2076 kg/ha) out yielded the best check RGN 48 (1707 kg/ha). In early trial, entry DRMRCI 96 recorded more yield i.e. 2514 Kg/ha in comparison to best check NPJ 112 (2441 kg/ha).

Generation of breeding material

Crosses attempted between (RH 749 x NRCHB 101) x PDZ 1, (RH 749 x NRCHB 101) x Heera, (RH 749 x NRCDR 02) x PDZ 1, (RH 749 x DRMR 150-35) x Heera, (RH 749 x DRMR 150-35) x RLC 3, (RH 749 x DRMRIJ 31) x RLC 3, (RH 749 x DRMRIJ 31) x Heera, (RH 725 x DRMR 150-35) x DRMR 1165-40, (RH 725 x DRMR 150-35) x DRMR 1153-12, (RH 725 x DRMRIJ 31) x DRMR 1153-12, (RH 555 x NRCHB 101) x DRMR 1165-40, (RH 555 x NRCDR 02) x DRMR 1153-12, (RH 555 x DRMRIJ 31) x DRMR 1165-40, (RH 555 x DRMRIJ 31) x DRMR 1153-12, (RH 406 x NRCDR 02) x DRMR 1153-12, (RH 406 x NRCDR 02) x RLC 3, (RH 406 x NRCDR 02) x PDZ 1, (RH 406 x DRMR 150-35) x RLC 3, (RH 406 x DRMRIJ 31) x Heera

Selections from F2 populations

From variable F2 populations, 40 individual plants having more than 8.0 g test weight and 100 SPS having >7.0 g test weight were advanced. The highest test weight was recorded in DRMR 1813-29 (10.2 g), followed by DRMR 1819-101 (9.9 g), DRMR 1813-11 (9.5 g), DRMR 1813-27 (9.2 g), DRMR 1813-34 (9.2 g), DRMR 1813-20 (9.1 g), DRMR 1813-31 (9.0 g), DRMR 1813-3 (9.0 g), DRMR 1813-12 (8.97 g) and DRMR 1813-27 (8.9 g). About 100 SPS having >42% oil content were selected from F2 populations. 14 individual plants recorded more than 43% oil content derived from BPR 1818 F2 population. Total 600

SPS in F2, 210 in F3, 260 SPS in F4 and 190 SPS in F5 selected for generation advancement.

Observation nursery

136 advanced progenies grown during 2017-18 in observation nursery along with checks (NRCHB 101, DRMRIJ 31, RH 749 and NRCDR 2). On the basis of *per se* performance, following progenies selected (Table 1).

Table 1: Performance of selected lines under irrigated condition

Progeny (ies)	Seed yield (kg/ha)	Oil content (%)	Test weight (g)
DRMR 1566-27-16	2756	41.2	4.2
DRMR 1784-47-7	2423	42.4	5.3
DRMR 1758-8-49	2364	42.4	4.8
DRMR 1758-34-64	2340	43.2	5.5
DRMR 1758-11-52	2293	41.9	5.5
DRMR 1741-18-28	2281	41.1	5.1
DRMR 1566-9-19	2199	41.6	5.3
DRMR 1741-17-27	2199	40.7	6.3
DRMR 1758-8-50	2163	41.4	3.7
DRMR 1616-61-44	2092	41.7	5.4
Best check (RH-749)	1856	40.7	6.0

Total 46 progenies exhibited >42% oil content, out of these seven progenies (DRMR 1758-34-64, DRMR 1758 -13-53, DRMR 1741-91-39, DRMR 1758-14-55, DRMR 1761- 72-134, DRMR 1761-65-129) recorded more than 43% oil content.

Rainfed

Observation Nursery

Same set of observation nursery (136) was grown under rainfed conditions. On the basis of plot yield, following progenies were selected in comparison to best check (Table 2).

Table 2: Performance of selected lines under rainfed condition

Progeny (ies)	Seed yield (kg/ha)	Oil content (%)	Test weight (g)
DRMR 1758-7-49	2092	40.4	5.9
DRMR 1724-72-5	2057	40.1	6.4
DRMR 1761-52-124	1998	41.7	5.4
DRMR 1758-2-46	1974	41.4	5.6
DRMR 1686-34-11	1962	40.5	5.4
DRMR 1686-39-12	1927	41.5	6.4
DRMR 1688-54-14	1938	41.7	5.9
DRMR 1758-12-56	1880	41.2	3.8
DRMR 1758-26-61	1867	42.4	5.1
DRMR 150-35	1708	40.1	5.2

15 progenies recorded >42% oil content and progenies DRMR 1765-34-72 and DRMR 1761 - 58-127 have >43 % oil content.

Selection from segregating generations

Under rainfed conditions, [5 F2 populations, F3 200 SPS (6 crosses), F4 126 SPS (10 crosses), observation nursery (136 bulk from 19 crosses)], were grown for selection. Individual plant (390 SPS in F2, 450 SPS in F3, 270 SPS in F4 36 bulks in observation nursery) as well as promising lines selected.

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

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

Co-investigators: H.S. Meena, Sr. Scientist (Genetics and Plant Breeding), Anubhuti Sharma, Sr. Scientist (Plant Biochemistry)

Contribution of entry in AICRP-RM

One promising entry (DRMRIS- 2017-6)

developed through inter-specific hybridization (*B. juncea*, cv. NRCDR-2 x *B. carinata*, NRCKR 304) contributed in AICRP-RM 2018-19 for multi-location testing in early sown conditions.

Evaluation of advance lines/genotypes developed through inter-specific hybridization

Evaluation of brown seeded type *B. rapa* genotypes/lines

Two advance lines (DRMR-YS-17-01 and DRMR- YS-17-02), developed through inter-specific cross between *B. tournefortii* and *B. rapa* cv. NRCYS 05-02, were advanced to F_7 generation selected for brown seeded with tetra-locular pods and another with brown seeded with bi-locular pods types, respectively. On morphological comparison with parent (NRCYS 05-02) leaf colour of both the selected lines were light green compared to NRCYS 05-02 with medium green. Some of the salient characteristics of these lines such as tetra and bi-locular pods plant types of F_6 progenies revealed on agro-physiological data analysis that photosynthetic rate of DRMR- YS-17-01 (tetra-locular pods type) and DRMR- YS-17-02 (bi-locular pods type) was 17.56 and 14.97, respectively even though light green in colour (Table 3).

Table 3: Agro-physiological data of brown seeded type *B. rapa* genotypes

Genotypes	Evapo-transpiration	Stomatal conductance	Photo-synthetic rate	SPAD= Chlorop hyll
DRMR-YS-17-01 (tetra-locular pods type)	6.34	21.66	17.56	21.8
DRMR-YS-17-02 (bi-locular pods type)	6.4	29.75	14.97	21.6
B. rapa (c.v NRCYS 05-02, parent)	6.4	28.66	13.43	45.7
B. tournefortii (parent)	6.62	53.33	8.83	40.4

Generation advancement/selection of F_4 segregating progenies of inter-specific hybrids obtained between *B. juncea* x *B. fruticulosa* (4x, Colchi-tetraploid):

From the F_4 progenies of inter-specific hybrids obtained between *B. juncea* cv. Rohini, Laxmi & Varuna x *B. fruticulosa* (Colchi-tetraploid), screening and scoring for mustard aphid infestation, selection of single plant progenies were done in progenies of F_4 generations. Screening for the mustard aphid infestation in the field conditions was performed against check BSH 1 and JMM 927. Based upon the field screening, 45 single plants selected on the basis of aphid injury symptoms and other component traits of economic impotance. Screening for Sclerotinia stem rot was also done using artificial stem inoculation technique with the help of pathologist and six lines showed resistance/tolerance against Sclerotinia stem rot. 25 lines of the above crosses F_3 progenies including parents were shared with Entomologist, Department of Genetics and Plant Breeding, Punjab Agriculture University, Ludhiana for proper screening of aphid infestation during the *rabi* season 2018-19 and data analysis is in process.

Generation advancement and selection from segregating generations of inter-specific crosses

During *rabi* 2018-19, three F_3 Segregating progenies (NRCDR-2 x GSL-1, RH 749 x *S. alba* and IJ-31 x *S. alba*) were planted and single plant selection were made for different component traits and yield attributes. Eight F_4 progenies of *B. rapa*, (cv. SKBR-1) x *S. alba* and four F_4 progenies of *B. rapa*, (cv. Pusagold) x *S. alba* were raised and single plant selection were made. From inter-specific cross *B. juncea* (cv. NRCDR-2) x *B. carinata* (cv. NRCKR-304), F_6 progenies were grown in 19 rows and 04m length during *rabi* season 2018-19 and about 85 single plants were selected. 25 lines (F_5) of inter-specific *B. juncea* (cv. Kranti) x *B. napus* (GCS-6) were sown for component traits such as siliqua density and other important economic component traits and 78 single plant selections were made.

Development of dwarf genotype (DRMR-C-16-6) in *B. carinata*

Widening of gene pool in *Brassicas* through Inter-specific hybridization was initiated at ICAR-DRMR in 2010-11 to exploit genetic diversity and development of introgression lines with desirable attributes. Indian mustard variety NRCDR-2 was crossed with NRCKR 304, a registered germplasm line of *B. carinata*. Segregants were advanced to F_7 generations using off-season nursery at Wellington (TN) and some lines of *B. carinata* were obtained possessing some desirable characteristics, such as dwarf height, <100 cm, fruiting zone length, long pod size, highest weight, early maturing etc., when compared with parental lines. Out of these lines one stable line designated as DRMR-C-16-6 was selected for dwarf height along with other desirable traits. This line was evaluated since 2016-17 along with parents and checks. Data of four environments is presented in table 4. Some of the salient characteristics of this line are dwarf plant height (85 cm) 1000 seed weight (4.7g), oil content (41.3%).



Fig. 1: Dwarf type *B. carinata genotype* (DRMR-C-16-6)

Table 4: Performance of dwarf type *B. carinata* genotype (DRMR-C-16-6) from 2016-17 to 2018-19 (Average data) along with parents

	2016-17, DRMR, Bharatpur				2017-18, DRMR, Bharatpur				2017-18, Bansur		2018-19, DRMR, Bharatpur				Pooled (4 Environment)			
Traits	DRMR-C-16-6	NRCKR 304	Kiran	NRCDR-2	DRMR-C-16-6	NRCKR 304	Kiran	NRCDR-2	DRMR-C-16-6	NRCKR 304	DRMR-C-16-6	NRCKR 304	Kiran	NRCDR-2	DRMR-C-16-6	NRCKR 304	Kiran	NRCDR-2
Days to maturity	130	136	156	145.6	131	132	164	140	125	130	125	140	168	145	127.8	134.5	162.7	143.5
Plant height	83	160	230	206	83	155	235	202	88	160	85	160	237	210	84.8	158.8	234.0	206.0
Primary branches	10.5	6.2	9.3	7.8	8.2	3.8	8.7	5.6	7.6	6.3	11.4	5.8	9.5	6.0	9.4	5.5	9.2	6.5
Secondary branches	19.8	16.5	22.5	21.4	23	10.4	20.9	9.6	21	14.5	23.6	14.2	20.5	15.6	21.9	13.9	21.3	15.5
Main shoot length	58	109	37	98.3	60	80.5	40	84	65	87.1	57	79.0	38	85	60.0	88.9	38.3	89.1
Siliqua length	3.6	3.5	3.4	5.7	3.5	4.0	3.6	4.9	3.2	4.0	4.5	3.6	3.2	5.2	**3.7**	3.8	3.4	5.3
Seeds per siliqua	13.8	16.1	12.4	16.1	16.5	17.0	12.7	15. 8	15.6	16.4	16.0	15.5	13.0	16.0	**15.5**	16.3	12.7	16.1
1000 seed weight(g)	5.5	5.7	2.8	5.1	3.8	5.5	3.9	5.36	4.3	5.2	5.0	4.3	3.0	5.3	**4.7**	5.2	3.2	5.3
Oil content (%)	41.3	40.03	39.2	41.7	41.2	41.5	39.3	41.2	41.0	40.5	41.8	39.8	38.5	41.3	**41.3**	40.5	39.00	41.4

Fresh inter-specific/inter-generic crosses attempted:

One inter-specific cross involving *B. juncea* (cv. JMM927) x Rohini, Laxmi & Varuna x *B. fruticulosa* (4x-colchi-tetraploid) and one inter-generic cross **(***B. juncea* cv. DRMRIJ-31, RH 749**) x** *Raphanus* and their reciprocals were attempted through sexual hybridization. Seeds were harvested from three successful inter-specific crosses.

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

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

Co-Investigator : R.S. Jat, Principal Scientist (Agronomy), M.S. Sujith Kumar, Scientist (Plant Biochemistry)

Contribution of entries in AICRP-RM trials

Two promising entries *i.e.* DRMRHT-13-13-5-4 and DRMRHT-13-13-5-6 were contributed for multi-location testing in AICRP-RM trials during *rabi* 2018-19 for early maturity and low light stress tolerance, respectively.

Relative performance of advanced early maturing breeding lines under heat stress situation

A total of eight early maturing thermo-tolerant lines were selected from a pool of lines. Selected advanced breeding lines and two checks i.e. NPJ 112 and BPR 543-2 were evaluated during *rabi* 2017-18 in RCBD in five rows of five metre length for their *per se* performance with respect to their high temperature stress tolerance at seedling stage. The analysis of variance of the selected lines revealed highly significant difference among the genotypes for all the traits studied. Estimation of mean and range for all the characters exhibited wide range of variation. The most pronounced range was obtained for seed yield (kg/ha), excised leaf water loss (%), membrane stability index (%), days to flowering and relative water content (%). On other hand, character like 1000-seed weight, oil content and oil yield exhibited narrow range of variations, significant difference were also observed between the genotypes for seed yield (kg/ha) which ranged from 2657.76 (NPJ-112) to 3528.87 (DRMRHT-13-28-8). However, oil yield (kg/ha) for these lines ranged from 1122.25 to 1509.67 9 kg/ha. Oil content was highest for DRMRHT-13-13-5-4 (43.14) and lowest for DRMRHT-13-28-16 (41.89). Thousand seed weight ranged from 4.59 (DRMRHT-13-22-9) to 7.5 g (DRMRHT-13-28-8). Significant estimates for days to maturity were observed among the different lines. The minimum days to maturity was recorded in DRMRHT-13-13-6-5 (115.5) while it was maximum for BPR-543-2 (126). Data for days to 50% flowering ranged from 38 (DRMRHT-13-13-5-4) to 57 (BPR-543-2). Membrane stability index ranged from 9.92 (DRMRHT-13-13-6-5) to 23.51 (DRMRHT-13-13-5-4). RWC ranged from 76.08 (NPJ-112) to 87.48 (DRMRHT-13-13-5-6) while ELEL ranged from 48.01 (DRMRHT-13-13-5-4) to 73.36 (DRMRHT-13-13-5-5). Water retention capacity of leaves ranged from 57.59 (DRMRHT-13-22-10) to 66.56 (DRMRHT-13-13-5-6). DRMRHT-13-13-5-4 recorded earliness in maturity (117.5) along with high oil content (43.14%), MSI (23.51%), minimum ELWL (48.01%), and seed yield 3132.82 (kg/ha). Similarly, DRMRHT-13-13-5-6 recorded early maturity (118.5 days along with maximum RWC (87.48 %), maximum water retention capacity of leaves (66.56%) and seed yield 2964.92 kg/ha among all the selected early maturing lines. The minimum days to 50% flowering and minimum ELWL for these 2 lines were found to be minimum as compared to early maturing check NPJ-112. On the basis of physiological parameters and yield potential, DRMRHT-13-13-5-4 and DRMRHT-13-13-5-6 identified as early maturing and heat stress tolerant.

Variability and Association studies for heat stress and agro-morphological traits in advanced early maturing lines

The estimates of genotypic and phenotypic coefficient of variation were considerably high for membrane stability index, 1000-seed weight, excised leaf water loss, days to 50% flowering, oil yield and water retention capacity of leaves. High heritability estimates (broad sense) were also observed for days to 50 % flowering (96.44%),

excised leaf water loss (79.00%), days to maturity (76.05%) and membrane stability index (65.11%). The high genetic advance was observed for membrane stability index (47.09%), excised leaf water loss (25.89%), days to 50% flowering (25.33%) and 1000-seed weight (21.72%), while other characters showed moderate to low genetic advance.

In the present study, heritability (broad sense) of MSI (96.44%) with maximum genetic advance (25.33%) was observed. Genotypic and phenotypic correlations were estimated for yield and physio-morphological traits in all possible combinations. The significant coefficient of correlation between seed yield and physio-morphological traits ranged from 0.521* to 0.976**. Seed yield (kg/ha) showed positive and highly significant correlation with RWC (r=0.899**). Seed yield showed positive and highly significant correlation with water retention capacity of leaves (r=0.759**). Water retention capacity of leaves showed negative and highly significant correlation with excised leaf water loss (0.886**). RWC water content showed positive highly significant correlation with MSI (0.945**). At the same time water retention capacity of leaves showed positive and highly significant correlation with MSI (r=0.955**).

Evaluation of promising crosses for high temperature stress tolerance and productivity

A total of 117 F_1 crosses, including 20 parents were evaluated in CRBD with 02 replications in 02 rows of 05 metre length for their *per se* performance with respect to their high temperature stress tolerance at seedling stage. Two hundred counted seeds of one hundred thirty seven crosses including twenty parents were sown in the field under heat stress (28th September) condition during *rabi* 2017-18. The crosses differed significantly for productivity, physiological and biochemical parameters namely; membrane stability index (%), relative water content (%), excised-leaf water loss (%), water retention capacity of leaves (%), total antioxidant capacity (mg/g AAE), seed yield per plant (g), days to maturity, 1000-seed weight (g) and oil content (%). Based on physiological and biochemical parameters, 11 best crosses .i.e. DRMRIJ-31X BPR-549-9, RH-555 X EC-541664, RH-555 X Core-4, JN032 X Core-4, TGP-20 X Core-50, BPR-541-4 X TGP-13, BPR-549-9 X TGP-13, TGP-13 X Urvashi, MRN-J-2001-3 X TGP-5, Core-50, and Urvashi X TGP-5 were identified. These best crosses will be grown in next rabi season in F_2 for further identification and single plant selections.

Evaluation of advanced late/medium maturing breeding lines under heat stress situation

A total of 34 advanced breeding lines (F_5/F_6) including two checks i.e. NRCHB-101 and NRCDR02 were evaluated in CRBD with two replications in three rows of five metre length for their *per se* performance with respect to high temperature stress tolerance at seedling stage. Two hundred fifty counted seeds of 34 genotypes were sown in the field under heat stress (28th September) condition during *rabi* 2017-18. Growth and morphological observations were recorded. The days to 50% flowering under early heat stress condition ranged from 42.5 to 56.5. 1000-seed weight (g) ranged from 4.06 g to 7.28 g. Oil content ranged from 40.74 to 43.25%.

While, oil yield (kg/ha) ranged from 1104.19 to 2243.92 kg/ha. Among the genotypes, DRMRHT-13-22-8 recorded the maximum seed yield 2243.92 (kg/ha) followed by DRMRHT-13-22-1 (2113.56 kg/ha), DRMRHT-13-28-10 (2054.30, kg/ha), DRMRHT-13-28-9 (2042.45 kg/ha) and DRMRHT-13-28-18 (1976.28 kg/ha) under high temperature stress situation. Rigorous selections were made for making a pool of earliness and late/medium maturity group of lines from F_5 and advanced to F_6.

Generation advancement and evaluation of F_3 material for earliness/high temperature stress tolerance

Progeny row yield trials of four selected crosses *i.e.* DRMRHT-14-1 (BPR549-9 x Core-50 (JBT-41/15), DRMRHT-14-2 (Urvashi x TGP-20 (SEJ-19); DRMRHT-14-3 (NRCHB-101 x TGP-5 (BT-

15); DRMRHT-14-4 (JN-032 x TGP-13 (HP-35) was conducted separately under early sown conditions. Two hundred counted seeds of each line were sown in 2 rows of 5 m length. BPR549-9, Pusa Agrani, BPR-543-2 and NPJ-112 were used as check varieties for high temperature tolerance and earliness.

Relative performance of heat tolerant/ susceptible (donors) parents under late situation for terminal heat stress tolerance and for cold tolerance

250 counted seeds of each 16 genotypes, including tolerant and susceptible, were sown in the field under late conditions (October 30, 2017) in RCBD with 02 replications in 03 rows of 05 metre length for terminal heat stress tolerance evaluation. Same experiment was conducted at SREC, Kangra (HP) for cold tolerance evaluation. Morphological observations, *viz*., days to 50% flowering, primary branches per plant, secondary branches per plant, main shoot length, siliqua on main shoot length, siliqua per plant, siliqua length, seeds per siliqua, days to maturity and seed yield per plant were recorded. The days to maturity under terminal heat stress and cold stress conditions ranged from 127.5 to 136 and 141 to 149 days, respectively. Among the genotypes, 1000-seed weight (g) was ranged from 3.7 g to 6.15 g at DRMR and 3.6 g to 5.3g at Kangra. Oil content ranged from 38.58 to 42.06% at Bharatpur. Among the genotypes, HPLM 06-25 (3145.67 kg/ha; 1715kg/ha) recorded maximum seed yield (kg/ha) followed by EC-511664 (2683.12 kg/ha; 1640 kg/ha) under terminal heat and cold environment, respectively.

Crossing Programme

Interspecific crossing programme was under taken by involving registered lines/varieties/ germplasm including different wild species *i.e. Brassica tournefortii* (DRMR-2191, DRMR2205, DRMR 2206), *Brassica carinata* (Pusa aditya, Kiran, DSLC-1, PC-5, PC-5-17) and *Brassica juncea* (DRMRIJ-31, NRCHB-101, NPJ-112, NRCDR-02, Urvashi, Pusa Agrani and BPR-543-2) during *rabi* 2017-18.

Development of mapping population for heat stress tolerance:

A set of mapping population comprising of 176 recombinant inbred lines derived from cross NRCHB101/BPR-549-9 was advanced from F_5 to F_6 stage through selfing during *rabi* 2017-18.

DRMR CI-15: Resynthesis of Indian mustard (*Brassica juncea* L. Czern. & Coss.) through inter-specific hybridization.

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

Co-Investigator : Arun Kumar, Pr. Scientist (Cyto-genetics), B.L. Meena, Scientist (Plant Breeding), P.D. Meena, Pr. Scientist (Plant Pathology)

Contribution and performance of entries in AICRP-RM trials

Four promising entries viz., DRMR 2017-26 (early mustard), DRMR 2017-16 (timely sown irrigated), DRMR 2017-8 (timely sown rainfed) and DRMR 2017-27 (late sown irrigated) were inducted for multilocation testing under AICRP-RM trials during 2018-19.

One entry DRMR 2017-15 (Late sown) was promoted to AVT-I for zone II. Entry DRMR 4005 (AVT-I, Early mustard, Zone-II) out yielded by 15.33% (2325 kg/ha) over earliest maturing check PM 25 (2016 kg/ha), 2.5% over best check PM 28 (2268 ka/ha). Entry DRMR 4005 was identified as high temperature (thermo) tolerant at seedling stage under AICRP-RM physiological trials and powdery mildew tolerant under pathological trials. Similarly, genotypes DRMRSJ 25 (14-1-2), DRMRSJ 31 (18-1-1) & DRMR 5206 were identified as resistant against white rust under pathological trials. Further, 4 entries were inducted in physiological trials for evaluation for heat & drought tolerance and 19 entries in pathological trials for evaluation for disease reaction under NDN/UDN trials of AICRPRM during 2018-19.

Re-synthesized *B. juncea* progenies

During *rabi* (2017-18), 292 S_4 and 27 S_5 single

plant progenies with 4 check genotypes (NRCHB 101, Giriraj, NPJ 112 & RH 749 repeated after every 10 entries) were planted in the field and data were recorded on various agro-morphological traits that revealed sufficient genetic variability for important traits (Table 5). Glucosinolates and erucic acid were estimated for selected 32 progenies. One progeny S_4/100-2-8-2 revealed GSL (48.7 µm/g of oil free meal) with erucic acid (28.55%). Two progenies S_4/108-2-5-1 (19.75%) and S_4/108-2-6-1 (15.47%) exhibited erucic acid <20%.

Table 5: Genetic variability for important traits in S_4 and S_5 re-synthesized *B. juncea* progenies (2017-18).

Trait Entry	PH (cm)	PB	SB	MSL (cm)	SMS	SL (cm)	S/S	OC (%)	1000-SW (g)	DF	DM
S_4 progenies	115.0-280.0	5.0-22.0	9.0-60.0	41.0-135.0	30.0-108.0	2.3-7.3	6.0-25.0	35.81-43.78	2.46-9.82	29.0-67.0	107-159
S_5 progenies	185.0-264.0	6.0-14.0	17.0-43.0	52.0-105.0	47.0-89.0	2.3-5.6	8.0-19.0	37.98-42.13	3.48-7.90	31.0-51.0	122-155
NRCHB 101	199.0	8.0	21.7	81.3	57.0	5.0	15.2	41.6	5.5	37.0	135.0
NPJ 112	171.7	7.0	18.7	74.3	55.3	4.2	14.3	41.1	5.2	30.0	118.0
DRMRIJ-31	195.2	6.4	17.1	84.6	62.0	5.4	16.3	42.3	6.6	40.0	139.0
RH 749	239.3	7.6	22.7	78.3	58.3	5.2	17.3	40.4	6.8	52.0	149.0

During *rabi* (2018-19), 269 S_5, 24 S_6 and 48 advance re-synthesized progenies were planted in three different sets using check genotypes NRCHB 101, DRMRIJ-31, Kranti, NPJ 112, RH 406 & RH 749 in the field for evaluation, selections and stabilization. The data were recorded on various agro-morphological traits and a considerable amount of genetic variability for maturity, plant type, branching pattern, height, siliqua density, seed size & yield and other desirable traits was observed (Fig. 2). Desirable progenies / lines were marked and single plant selections were made from different progenies for further studies. Oil content in S_5 (307 SPS) progenies ranges from 37.4- 43.5% and 39.2 - 42.05% in S_6. Likewise, 1000 seed weight ranges from 2.07 -7.32g in S_5 and 3.18-6.47g in S6 progenies.



Fig.2: Important plant types & traits in re-synthesized *B. juncea*

Similarly, 12 advance re-synthesized lines (DRMRSJ-1, DRMRSJ-18, DRMRSJ-20, DRMRSJ-21, DRMRSJ-22, DRMRSJ-25 (14-1-2), DRMRSJ-26, DRMRSJ-31 (18-1-1), DRMRSJ-32, DRMRSJ-33, DRMRSJ-34, DRMRSJ-42,), 5 advance lines (DRMR 2018-35, DRMR 2018-37, DRMR 2018-41, DRMR 2018-44, DRMR 5206) from inter-varietal crosses and SPS from segregating progenies which were selected as WR free (score=0) at Wellington (TN) during off-season *Kharif* 2018 were again screened at DRMR Bharatpur during *Rabi* 2018-19 along with check genotypes BIO-YSR (RC), PHR-2 (RC), DRMR 2019 (RC), DRMR 2035 (RC), Rohini (SC), Varuna (SC), NRCHB 101(SC). The data were recorded as per 0-9 scale. Most of advanced lines except DRMRSJ-32, DRMRSJ-33 and DRMR 2018-44 (scored=1-5) revealed resistance (score=0) for WR and SC checks scored 5-7 (Fig. 3) . Single plants selections were made from segregating progenies.



Fig. 3: Resistance for white rust at Bharatpur

Forty eight advance re-synthesized lines, 29 inter-varietal advanced lines and 11 F_5 (DRMR 2019 x NRCHB 101) progenies along with checks Rohini (SC), Varuna (SC), RH 1222-28 (TC) were artificially inoculated for Sclerotinia stem rot reaction. Stem inoculation was done to ensure SR infection and the data were recorded on percent disease incidence, lesion size and stem diameter. Among all tested genotypes / progenies DRMRSJ-20, DRMRSJ-21, DRMRSJ-22, DRMRSJ-25 (14-1-3), DRMRSJ-26, DRMR 5206, DRMR 2017-8 and three F5 progenies (2015-13-21-1, 2015-13-26-1, 2015-13-29-1) showed resistant / tolerant reaction with disease incidence <10% and lesion size <3.0 cm. Advanced line DRMR 2017-8 revealed 0.0 % disease incidence as compared to checks Rohini (73.3%), Varuna (66.6%), RH 1222-28 (26.6%). Genotypes which showed resistant / tolerant reaction will be further tested.

Seventeen F_4 progenies from *B. rapa* x *B. nigra* inter-specific crosses *viz*., Ragini x BN-2 (8), YSH-401 x BN-2 (7) and YSH-401 x SKJ-2 (2) were planted in field during *rabi* 2018-19 to advance progenies and selection for desirable new plant types. Sufficient variability was observed for important traits like dwarf yellow sarson with more number of siliqua / plant, bilocular siliqua with yellow sarson type plants; tetralocular siliqua with brown seeds toria type plants; brown sarson type plant with bold seeds, long main shoot & high siliqua density, bold seeds with hard stem toria type plants, *etc*. Desirable 25 plants were selected and harvested individually.

F_5 progenies from crosses of amphidiploids

During 2018-19, 31 F_5 single plant progenies from inter-specific cross between *B. carinata* & *B. napus* (NRCKR 304 x NRCGS-1) were planted in the field to derive improved *B. juncea* and *B. carinata* / *B. napus* genotypes with desirable traits. The progenies exhibited sufficient genetic variability for desirable traits *viz*; base branching, extra earliness (<110 days), extra dwarfness (<60 cm), highly branched, ideal medium height, long siliqua, long MS, bold seeds (7.08g); high oil (43.47%) *carinata* / *juncea* type;. Some segregation was still observed for *carinata*, intermediate, *juncea* type and sterile plants. About 59 individual plants from various progenies were harvested and data were recorded. Oil content ranges from 36.63 to 43.47%, 1000 seed weight from 2.91 to 7.08g and seed colour from yellow to black with some variations for seed colour.

Selection from inter-specific F_3 populations

Twenty six progenies from three inter-specific crosses NRCHB 101 x NRCKR 304 (8), NRCHB 101 x NRCGS-1 (5) and NRCHB 101 x *S. Alba* (13) were planted in the field during 2018-19 and desirable 18 single plants were selected for further advancement. Another 34 F_3 progenies from a cross (NRCHB 101 x Pusa Kalyani) between *B. juncea* and *B. rapa* (brown sarson) was planted in field. The progenies revealed a range of complete sterile, semi-sterile, fully fertile, *B. juncea* type, intermediate and *B. rapa* type of plants. Seeds from 21 single plants were harvested individually.

Evaluation of advanced breeding lines

Twenty five advance lines along with 5 checks (RH 749, DRMRIJ 31, NRCHB 101, NPJ 112 and Kranti) were evaluated in RCBD with 3 replications. The trial was sown on 17-10-2018 in 6 rows of 5m with row to row distance of 45 cm & the data were recorded on seed yield and contributing traits. Nine entries viz., DRMR 2017-27 (3520 kg/ha), DRMR 2017-15 (3324 kg/ha), DRMR 2017-26 (3213 kg/ha), DRMRSJ-47 (3212 kg/ha), DRMR 2017-17 (3205 kg/ha), DRMR 2017-20 (3174 kg/ha), DRMR 2018-25 (3071 kg/ha), DRMR 2018-16 (3034 kg/ha), DRMR 2017-16 (2982 kg/ha) over yielded best check RH 749 (2704 kg/ha) by 10% seed yield. Early maturing entries DRMR 2017-21 (125 days, 2942 kg/ha), DRMR 2018-27 (123 days, 2893 kg/ha) out yielded best check NPJ 112 (127 days, 2353 kg/ha).

Observation nursery

During *rabi* 2018-19, sixty seven advanced progenies / lines were planted in observation nursery along with checks (DRMRIJ 31, NRCHB 101, Kranti, NPJ 112, RH 406). Four entries *viz.,* DRMR 2018-24 (1653 kg), DRMR 2018-1 (1412 kg), DRMR 2018-2 (1360 kg), DRMR 2018-4 (1236 kg) revealed more oil yield / ha than best

check DRMRIJ 31 (1159 kg) and six entries DRMR 2018-17 (1123 kg), DRMR 2018-28 (1130 kg), DRMR 2018-15 (1080 kg), DRMR 2018-18 (1044 kg), DRMR 2018-23 (1036 kg) and DRMR 2018-19 (1014 kg) exhibited higher oil yield /ha over early maturing check NPJ 112 (882 kg/ha, 125 days) with similar maturity period (119 to 128 days).

Generation advancement and selection from segregating generations

During *rabi* 2018-19, seven F_2 populations of NRCHB 101 x DRMRIJ 31, NRCHB 101 x RH 1117, RH 555 x NPJ 112, DRMRIJ 31 x RH 749, RH 1222-28 x DRMRIJ 31, RH 1222-28 x NRCHB 101, RH 1222-28 x RH 555 crosses were planted in 35 rows of 5m each to derive desirable transgressive segregants. Similarly, 312 F_3 (23 crosses), 116 F_4 (10 crosses), 108 F_5 (10 crosses) and 7 M_5 (3 crosses) and M_6 (4 crosses) were grown for generation advancement and selection. A good genetic variability was observed for different component traits. A total of 191 SPS from F_2, 166 F_3, 107 F_4, 135 F_5, 3 M_5 and 2 from M_6 progenies were selected.

Raising inter-varietal F_1 crosses (*B. juncea*)

Thirty nine inter varietal F_1s / back crosses (*B. juncea*), one inter-specific cross (NRCGS-1 x GSC-6) and one inter varietal cross of *B. carinata* (Kiran x GSC-6) were raised in the field and data were recorded on important traits. These crosses were developed for various traits like high seed yield, bold seed, high temperature & drought tolerance, long siliqua, disease resistance and adaptation under various sowing conditions.

Generation and maintenance of breeding material

During 2018-19 a total of 14 inter varietal/inter-specific crosses were generated and 113 germplasm lines / donors / genotypes of different species (*B. juncea*, Toria, BS, YS, *B. napus*, *B. carinata*, *B. alba, B. nigra*) for various traits were maintained.

Evaluation of trait specific genotypes

Four trait specific advanced genotypes DRMR-WFYSM 15 (white flower, yellow seed & appressed) DRMR-WFBSM 15-1 (white flower, brown seed & open), DRMR-PMJ 17 (purple leaf) and DRMRTJ-2016 (tetra-locular siliquae and long main shoot) of *B. juncea* (Fig. 4) were evaluated with checks Kranti and Geeta. The data were recorded on different traits as sown in table 6.



Fig. 4: Trait specific genotypes

Table 6: Estimates of different quantitative characters in traits specific genotypes and checks

Traits	DRMR-WFYSM 15	DRMR-WFBSM 15-1	DRMR-PMJ 17	DRMRTJ -2016	Geeta	Kranti
Plant height (cm)	182.4	165.8	209.6	254.6	229.2	215.0
Primary branches/plant	6.4	7.8	5.6	12.6	9.4	6.2
Main shoot length (cm)	71.4	83.6	90.4	123.6	83.0	75.8
Siliquae on main shoot	52.8	62.0	65.2	128.4	76.2	57.8
Siliqua length (cm)	4.2	4.4	4.7	4.3	3.8	4.3
Seeds/ siliqua	15.8	16.0	15.2	19.5	18.2	14.7
1000 seed weight (g)	3.94	4.32	4.75	5.30	5.09	4.67
Oil content (%)	42.77	43.21	42.92	39.34	39.61	40.27
Seed yield/plant (g)	18.9	19.2	17.4	26.7	23.5	17.7
Days to maturity	121	118	139	152	150	147

Screening for resistance against white rust at off-season nursery, Wellington (TN)

During *kharif* 2018, 55 entries including 32 advanced re-synthesized *B. juncea* lines, 20 advanced lines from inter-varietal crosses along with 3 checks DRMR 2019 (RC), Rohini (SC) and Kranti (SC) were screened for white rust resistance at IARI Regional Station, Wellington during off season nursery (Fig. 5). Fifteen lines and resistant check DRMR 2019 exhibited complete resistance with WR score=0 (Table 7), five lines were susceptible (score=5 to 9), 16 lines revealed resistant with very few plants scored (=1 to 3) and 16 lines revealed mixed reaction. The susceptible checks showed high susceptibility scoring=9. Resistant plants were selfed and seed was harvested. Resistant plants from lines segregated for WR resistance were selected for further screening.

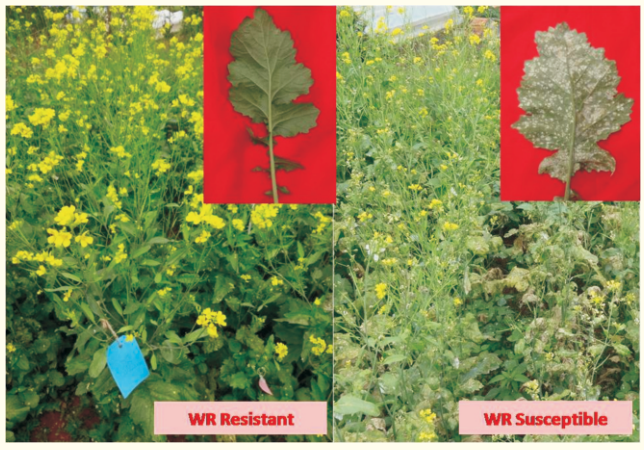


Fig. 5: Screening genotypes for white rust at Wellington

Table 7: Resistance against white rust for different genotypes at IARI-RS, Wellington (offseason 2018)

Genotype	Score	Reaction for WR
DRMR 2019 (RC)	0.0	R
Rohini (SC)	9.0	S
Kranti (SC)	9.0	S
Re-synthesized lines : DRMRSJ-1, DRMRSJ-18, DRMRSJ-20, DRMRSJ-21, DRMRSJ-22, DRMRSJ-25, DRMRSJ-31, DRMRSJ-32, DRMRSJ-33, DRMRSJ-34	0.0	R
Advanced lines: DRMR 2018-35, DRMR 2018-37, DRMR 2018-41, DRMR 2018-44, DRMR 5206	0.0	R

DRMR CI-16: Breeding for White Rust Resistance and Stem Rot Tolerance in Indian mustard

Principal Investigator: B L Meena, Scientist (Plant Breeding)

Co- Investigators: H S Meena, Sr. Scientist (Genetics), P D Meena, Pr. Scientist (Plant Pathology) , Pankaj Sharma Pr. Scientist (Plant Pathology) and Ajay Kumar, Sr. Scientist (Biotechnology)

Generation advancement and selection from segregating generations:

During the period 22 F_2 populations of DRMRIJ 31 X WR 2035, DRMRIJ 31X DRMR 2019, NRCDR-02 X DRMR 2035, NRCDR-02 X DRMR 2019, NRCDR-02 X BIO-YSR,RH 749 X DRMR 2019, RH 749 X DRMR 2035, RH 749 X BIO-YSR,NRCHB 101 X DRMR 2035, NRCHB 101 X DRMR 2019, NRCHB 101 X BIO-YSR, Basanti X DRMR 2035, Basanti X DRMR 2019, Basanti X BIO-YSR, Kranti X DRMR 2035, Kranti X DRMR 2019, Kranti X BIO-YSR,Pusa Bold X DRMR 2035, Pusa Bold X DRMR 2019, Pusa Bold X BIO-YSR. DRMR 2035 X DRMR IJ 31, DRMR 2019 X DRMR IJ 31 and DRMR 2019 X DRMR 2035 crosses were raised in 10 row of 5 m length each to select desirable plants for white rust resistance and yield related traits. A total of 489 F_2 plants were selected.

Raising F_1 crosses and generation of breeding material:

A total of 81 F_1s were selfed to get F_2 seed and data were recorded for yield and yield contributing

characters along with white rust resistance and stem rot tolerance. Fourteen back crosses were generated using F_1 with their parents P_1 &P_2 for the development of white rust resistance genotype. Parents included Bio YSR, DRMR 2035, DRMR 2019, DRMRIJ 31and NRCHB 101, in different crosses (Table 8). Eight back crosses were generated using F_1 with their parents P_1 &P_2 (RH 1222-28, RH 1034, DRMR 1542, DRMR1493 and DRMRIJ31) to derive genotypes tolerant to Sclerotinia rot. Resistant donors and high yielding genotypes were planted to screen for white rust and stem rot.

Table 8 : Back cross made for white rust & sclerotinia rot in *B. juncea*

Sl	Backcrosses for White Rust	Sl	Backcrosses for sclerotinia rot
1	(DRMRIJ 31X WR 2035)X DRMR 2035	1	(DRMRIJ 31X DRMR-1542)X DRMRIJ 31
2	(DRMRIJ 31X DRMR 2035)X DRMRIJ 31	2	(DRMRIJ 31X DRMR-1542)X DRMR-1542
3	(DRMRIJ 31X DRMR 2019)X DRMR 2019	3	(DRMRIJ 31X DRMR-1493)X DRMRIJ 31
4	(DRMRIJ 31X DRMR 2019)X DRMRIJ 31	4	(DRMRIJ 31X DRMR-1493)X DRMR-1493
5	(DRMRIJ 31X BIO-YSR)X BIO-YSR	5	(DRMRIJ 31X RH 1222-28)X RH 1222-28
6	(DRMRIJ 31X BIO-YSR)X DRMRIJ 31	6	(DRMRIJ 31X RH 1222-28)X DRMRIJ 31
7	(NRCHB 101X DRMR 2035)X DRMR 2035	7	(DRMRIJ 31X RH-1034)X RH-1034
8	(NRCHB 101X DRMR 2035)X NRCHB 101	8	(DRMRIJ 31X RH-1034)X DRMRIJ 31
9	(NRCHB 101X DRMR 2019)X NRCHB 101	12	(NRCHB 101X BIO-YSR)X NRCHB 101
10	(NRCHB 101X DRMR 2019)X DRMR 2019	13	(NRCHB 101X DRMR 2019)X DRMR 2019
11	(NRCHB 101X BIO-YSR)X BIO-YSR	14	(NRCHB 101X DRMR 2019)X NRCHB 101

Screening for white rust in off season nursery at wellington

During *kharif* 2018, 33 F_1s along with their parents and checks were planted in off season nursery at wellington for screening to white rust and speedy generation advancement. Data were recorded on WR reaction. Out of 33 crosses 9 crosses showed resistant reaction (score 0.0). Others were found moderately resistant to susceptible. Resistant plants were selfed and seeds were collected to further advance and screen during *rabi* season at Bharatpur. The same 33 crosses were again screened at Bharatpur and 25 crosses showed resistant reaction (score 0.0), where as remaining crosses scored=1 to 5.

Screening for sclerotinia stem rot

During *rabi* 2018, seventeen F1s, resistant and susceptible checks were artificially inoculated for sclerotinia stem rot and data were recorded on % disease incidence, lesion size and stem diameter. F1s - DRMRIJ 31X DRMR-1542, DRMRIJ 31 X DRMR-1493, DRMRIJ 31X RH 1222-28 and DRMRIJ 31X RH-1034 exhibited disease incidence <10% with <3 cm lesion size.

2.2 Designer Brassica for oil quality

DRMR CI-13: Genetic enhancement for quality traits in Indian mustard (*Brassica juncea*)

Principal Investigator: Priyamedha, Scientist (SS), (Plant Breeding)

Co-Investigator: Bhagirath Ram, Pr. Scientist (Genetics and Plant Breeding), H.K. Sharma, Scientist (SS) (Plant Breeding), M.S. Sujith Kumar, Scientist (Plant Biochemistry)

Development of breeding lines

A yellow seeded double low white rust resistant genetic stock, DRMR 1-5 (IC 625996/INGR 19020) was registered by PGRC, New Delhi. Two double low entries, DRMRQ1-16-27 and DRMRQ4-7-23, showing *at par* yield with respect to the checks were contributed in IVT trial in AICRPRM 2018-19. A line DRMRQ 5-5-1-15, derived from the cross JR042/ NRCDR-02

was identified and advanced to F_6 generation contains 43% oleic acid in oil. This line also showed low erucic acid content (<2%) in oil and low glucosinolate content (25 µM per gram defatted seed meal) with 42% oil content and 2.60 g test weight. One entry namely, DRMRQ-4, contributed for IVT trial under AICRPRM 2017-18, has been revaluated during this year and it showed low erucic acid content (1.05%) with glucosinolate content (29.45 µM per gram defatted seed meal). This strain also showed resistance against white rust.

Station trials of advanced double low lines (ADLLs)

Two station trials were conducted each consisting of 22 ADLLs with 4 checks i.e. NRCHB 101(non quality high yielding), PM-21 (low erucic), PDZ-1 (double low) and RLC-3 (double low) to evaluate the ADLLs for yield and yield attributing traits. Morpho-agronomical observations have been taken for 13 characters (Table 8,9). These lines as well as checks were also analyzed biochemically for nutritional quality of oil and seed meal (Table 9, Fig.6,7).

Table 9: Range of yield and attributing traits of 22 ADLLs and checks (ST-I)

Traits	PH (cm)	MSL (cm)	FZL (cm)	SMS	PB	SB	Twt (g)	SY/Plot (kg/ 4.5m^2)	SY (kg/ha)	HI	Oil (%)	Oil Yield (kg/ha)	D50F	DM
Maximum	194.7 (DRMRQ 4-6-54)	83.2 (DRMRQ 4-17-6)	82.2 (DRMRQ 4-17-6)	63.1 (DRMRQ 2-1-1, DRMRQ 4-17-6)	9.5 (DRMRQ 2-1-1)	29.7 (DRMRQ 2-1-1)	3.0 (DRMRQ 1-22)	1.12 (DRMRQ 1-16-27)	2511.1 (DRMRQ 4-7-23)	34.9 (DRMRQ 4-7-23)	43.1 (DRMRQ 2-2-7)	1061.4 (DRMRQ 1-16-27)	68.7 (DRMRQ 4-6-54)	138.0 (DRMRQ 4-5-26)
Minimum	156.5 (DRMRQ 1-8-34)	58.5 (DRMRQ 2-11-10)	64.5 (DRMRQ 4-5-26)	50.6 (DRMRQ 2-11-10)	6.4 (DRMRQ 4-7-24, DRMRQ 4-6-54)	13.0 (DRMRQ 4-7-23)	2.1 (DRMRQ 4-7-24, DRMRQ 4-7-23, DRMRQ 4-5-25)	0.7 (DRMRQ 4-1-58, DRMRQ 4-6-54)	1459.3 (DRMRQ 4-10-51)	17.9 (DRMRQ 4-5-25)	41.7 (DRMRQ 2-1-1)	628.6 (DRMRQ 4-10-51)	56.0 (DRMRQ 4-10-51)	125.7 (DRMRQ 2-1-1, DRMRQ 4-10-51, DRMRQ 1-12-31)
NRCHB 101	161.27	76.93	77.60	49.00	6.6	16.2	5.76	1.33	2962.96	30.37	41.33	1224.59	56.67	128.67
PM-21	196.27	74.13	77.47	44.53	6.60	14.13	5.84	1.58	3511.11	31.45	37.78	1326.50	57.33	128.33
PDZ-1	173.53	67.40	68.13	54.07	6.73	13.00	3.85	1.01	2237.04	29.40	42.52	951.26	54.33	126.00
RLC-3	189.60	65.47	79.80	55.93	8.73	20.80	4.04	0.85	1896.30	25.91	41.65	789.87	55.67	130.33

Table 10: Range of yield and attributing traits of 22 ADLLs and checks (ST-II)

Traits	PH (cm)	MSL (cm)	FZL (cm)	SMS	PB	SB	Twt (g)	SY/Plot (Kg/ 4.5m^2)	SY (Kg/ha)	HI	Oil (%)	Oil Yield (kg/ha)	D50F	DM
Maximum	205.0 (DRMRQ 4-14-48)	83.1 (DRMRQ 5-4)	86.5 (DRMRQ 1-20-24)	62.5 (DRMRQ 5-4)	8.5 (DRMRQ 1-20-24)	19.1 (DRMRQ 2-11-2)	3.2 (DRMRQ 2-11-2)	1.2 (DRMRQ 5-4)	2763.0 (DRMRQ 5-4)	30.8 (DRMRQ 1-20-24)	43.0 (DRMRQ 1-2-37)	1177.6 (DRMRQ 5-4)	66.7 (DRMRQ 2-1-8-6)	139.7 (DRMRQ 2-1-8-6)
Minimum	163.4 (DRMRQ 2-1-2-7)	62.9 (DRMRQ 2-1-8-6)	60.3 (DRMRQ 2-1-8-6)	46.2 (DRMRQ 2-1-8-6)	6.3 (DRMRQ 4-14-48)	13.9 (DRMRQ 1-18-25)	2.1 (DRMRQ 4-7-55)	0.6 (DRMRQ 2-1-2-7)	1429.6 (DRMRQ 2-1-2-7)	16.6 (DRMRQ 2-1-8-6)	41.7 (DRMRQ 4-16-47)	606.4 (DRMRQ 2-1-2-7)	52.3 (DRMRQ 2-3-17 DRMRQ 1-13-30)	123.3 (DRMRQ 2-3-17)
NRCHB 101	161.27	76.93	77.60	49.00	6.6	16.2	5.76	1.33	2962.96	30.37	41.33	1224.59	56.67	128.67
PM-21	196.27	74.13	77.47	44.53	6.60	14.13	5.84	1.58	3511.11	31.45	37.78	1326.50	57.33	128.33
PDZ-1	173.53	67.40	68.13	54.07	6.73	13.00	3.85	1.01	2237.04	29.40	42.52	951.26	54.33	126.00
RLC-3	189.60	65.47	79.80	55.93	8.73	20.80	4.04	0.85	1896.30	25.91	41.65	789.87	55.67	130.33

Table 11: Range of different quality parameters of 44 ADLLs and checks

Traits	Glucosinolate (µmole/g)	Saturated Fatty Acid (%)	Oleic Acid (%)	LinoleicAcid (%)	Linolenic Acid (%)	Ecosenoic Acid (%)	Erucic Acid (%)	Antioxidant (AAE mg/g)	Flavanoid (QE mg/g)	Beta carotene (ppm)
Maximum	35.9	5.5	41.9	40.0	29.4	10.1	5.3	46.4	1.5	4.6
Minimum	19.3	3.8	19.3	26.5	14.2	3.1	1.9	22.9	0.3	1.7
NRCHB 101	106.5	3.8	11.4	19.2	16.0	11.2	39.4	47.35	0.64	3.26
PM-21	94.2	4.1	36.2	17.5	24.0	5.5	2.5	39.85	0.66	3.42
PDZ-1	22.6	3.2	29.1	34.0	24.1	7.8	1.7	29.35	0.42	2.77
RLC-3	23.1	4.1	35.4	34.6	27.3	6.6	3.2	24.85	0.35	2.61

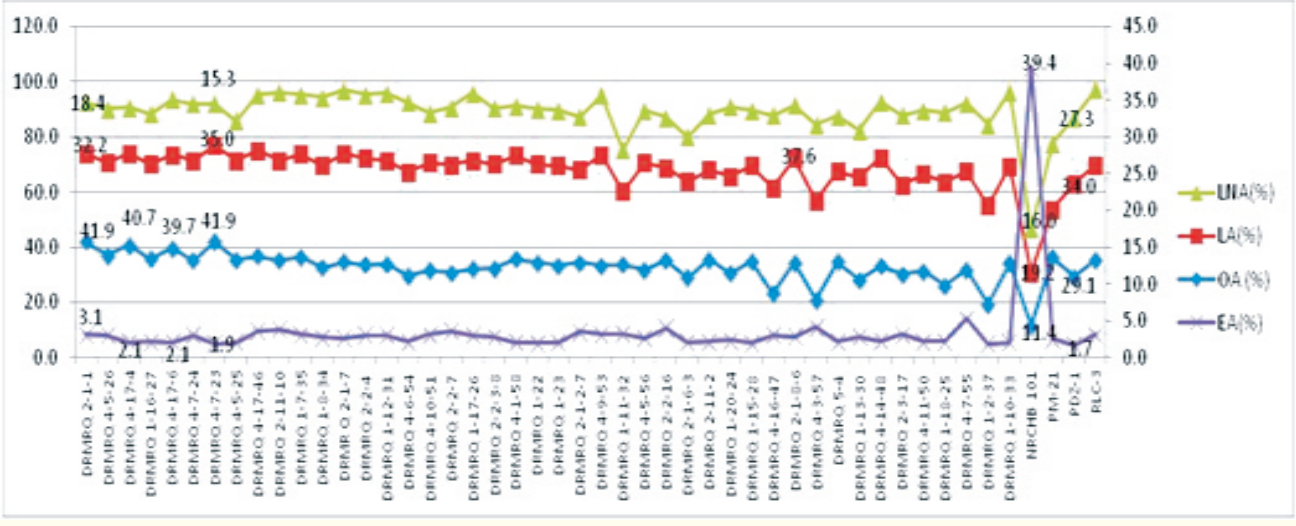


Fig. 6 : Fatty acid profiling of 44 ADLLs and checks

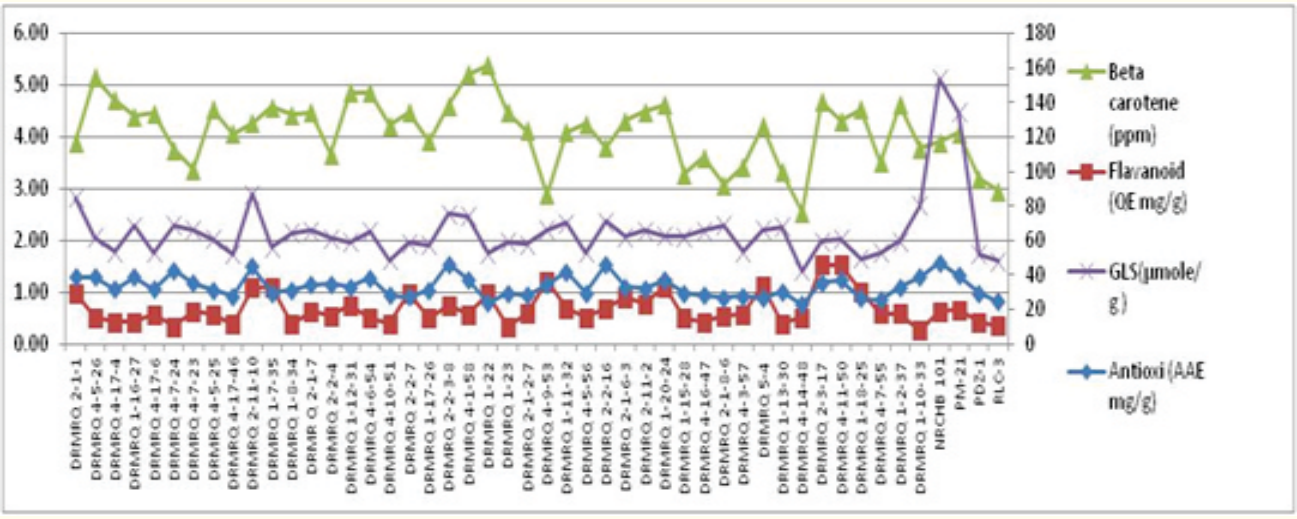


Fig. 7: Glucosinolate, beta carotene, flavanoid and antioxidants of 44 ADLLs and checks

Molecular marker aided double low trait confirmation

Presence of low erucic acid content in oil (Fig. 8) and low glucosinolate content in seed meal (Fig. 9) in 44 ADLLs have further been confirmed by using quality trait specific molecular markers. DNA profiling of 44 advanced double low lines was done with 30 polymorphic SSR markers.

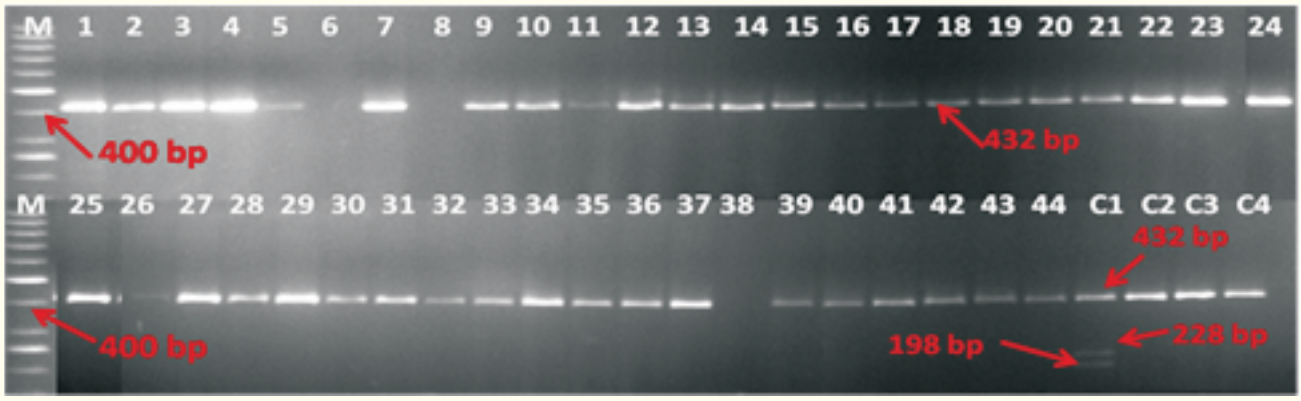


Fig. 8: Genotyping of ADLLs (1-44) for low erucic acid in oil using FAE II (E1) marker C1-NRCHB101, C2- PM-21, C3-PDZ-1, C4-RLC3

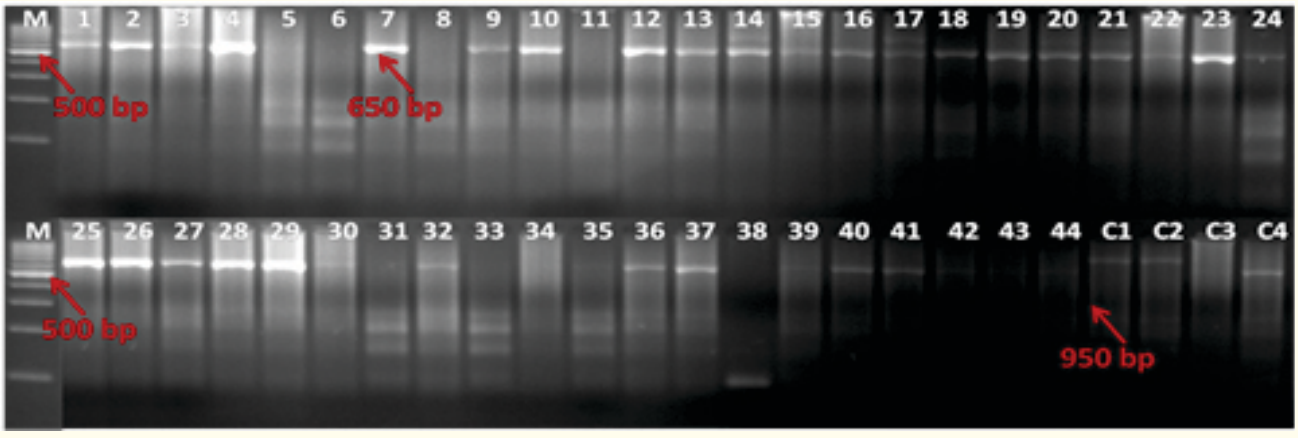


Fig. 9: Genotyping of ADLLs (1-44) for low glucosinolate content using GER-1MRPR+ IP3GER-1F (Q1) (Bisht *et al*., 2009) marker, C1-NRCHB101, C2- PM-21, C3-PDZ-1, C4-RLC3

Generation advancement and evaluation of advanced and segregating lines

Fifteen advanced low erucic acid lines were evaluated in RBD with 3 replications for yield and attributing traits along with 3 checks (RH-749, PM-29 and RGN-73). Agro-morphological observations were taken for 13 traits in these lines and checks. These lines were further evaluated biochemically for fatty acid profiling of oil and glucosinolate content in seed meal. All 16 lines showed low erucic acid content in oil. The fatty acid profile and glucosinolate content of these lines are presented graphically in fig.10.

Further nine large F_2 populations generated from the crosses involving quality parents (ADLLs/PDZ1) were grown and 943 single plants were selected for different agronomic traits for further biochemical analysis of quality traits. A total of 5 large F_2 populations generated from the crosses involving quality (PDZ-1, RLC-3) and high yielding parents (NRCHB 101, DRMRIJ-31, RH 749) were grown and 450 single plants were selected for different agronomic traits for further biochemical analysis of quality traits. Ninety four single plant progeny lines in F_3 generation of the cross involving NRCHB101 and PM-21 as parents were advanced and 315 single plants were selected for further biochemical analysis of quality traits. A total of 54 single/double low lines of F_6

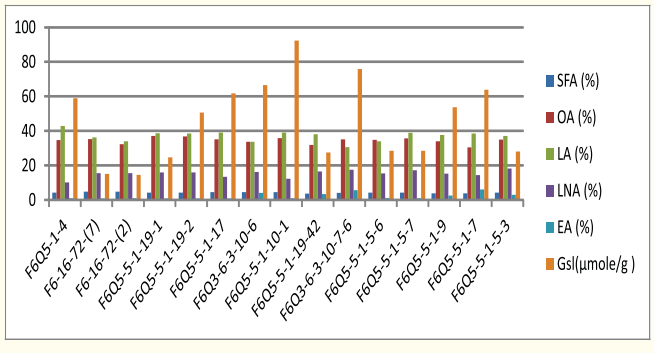


Fig. 10: Fatty acid profile and glucosinolate content of 15 advanced single low lines

generation of different crosses involving NRCHB 101, NRCDR-02, LES1-27, LET 17 and Heera as parents were maintained.

Generation of breeding materials

Backcrossing for second generation was done with the objective to transfer genes governing low erucic and /or low glucosinolate traits in high yielding varieties, involving BC_1 of crosses (DRMRIJ31/PM-24, DRMRIJ31/PM-30, NRCHB 101/ PM-24, NRCHB 101/ PM-30, RH 749/ PM-24, RH 749/PM-30) with their respective parents. Backcrossing for first generation was done with the objective to transfer genes governing high oleic acid content in advanced double low line, involving F_1s (GSC-5/DRMR Q1-11-32 & DRMR Q1-10-33) and respective parents. Single crosses were generated to transfer genes governing double low trait and white rust resistance involving the registered line DRMR 1-5 and high yielding varieties (NRCHB 101 & DRMRIJ-31) as parents.

DRMR B-07 : Proteomic Studies in Oilseed Brassica

Principal Investigator: Ibandalin Mawlong, Scientist (Plant Biochemistry)

Co-investigators: MS Sujith Kumar, Scientist (Biochemistry), OP Premi, Pr. Scientist (Agronomy), Reema Rani, Scientist (Biotechnology)

Extraction and relationship studies between oil storage bodies and its structural protein

Extraction of oil bodies (OB) was done by flotation method following a standard protocol. The presence and integrity of oil bodies was confirmed using compound light microscope. The size of OB ranged from 0.58 (Maya) to 1.05 (HB207). Purification of structural proteins was done by altering the time of urea (8M) treatment. The proteins isolated from the oil bodies showed multiple bands in SDS-PAGE that included oleosin protein. Downstream purification of oil body proteins was standardized to remove further unspecific bands by additional urea treatment with time of incubation 30 min, 1h and overnight at room temperature. Out of the three, overnight incubation showed less appearance of unspecific bands. Comparative study was also made showing oil content to be inversely related to oil body size and positively correlated to oleosin content. Hence by manipulating the oleosin proteins, it may be possible to increase the oil content.

DRMR B-08 : Screening of oilseed brassica germplasm for value addition

Principal Investigator: MS Sujith Kumar, Scientist (Biochemistry)

Co-investigators: Ibandalin Mawlong, Scientist (Biochemistry), Prashant Yadav, Scientist (Biotechnology), Hariom Kumar Sharma, Scientist (Plant Breeding)

Germplasm core collection consisting of 147 accessions was analyzed for total glucosinolates, total antioxidant capacity and total flavonoids. The glucosinolate content ranged from 50.37 (CIII-21) to 166.14 (CIV-2) µmol/g defatted seed meal. None of the accessions were found to be low glucosinolate type (< 30 µmol/g).

Total antioxidant capacity was found to be between 15.58 (CIV-22) and 62.25 (CIV-16) mg/g AAE.

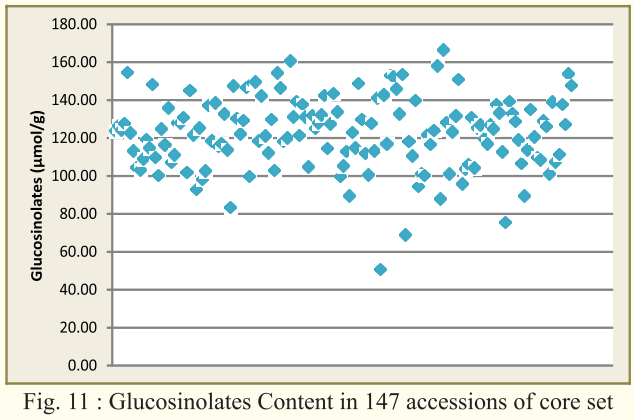


Fig. 11 : Glucosinolates Content in 147 accessions of core set

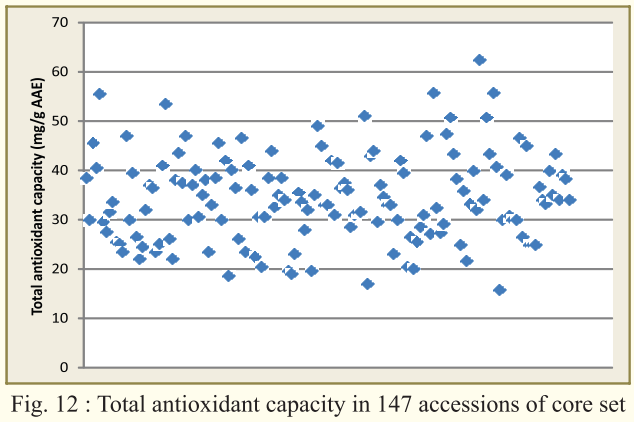


Fig. 12 : Total antioxidant capacity in 147 accessions of core set

α and δ Tocopherol content in 17 accessions that had total antioxidant capacity > 45 mg/g AAE was done. Highest level of α Tocopherol was found in CIV-28 (8.66 mg/g seed). Highest level of δ Tocopherol was also found in CIV-28 (12.39 mg/g seed). Total flavonoid content was in the range of 0.12 (CI-3, CI-15, CI-18) to 1.76 (CIII-38) mg/g

QE. types of glucosinolates also using specific purification method. HPLC analysis showed that 2-Propenyl, 4-methylsulfinyl-3-butenyl, 4-methylsulfinylbutyl and p-hydroxybenzyl are the major compounds identified on the basis of retention time of sample and standard (Figure 16; Table 12). Apart from aliphatic glucosinolates, studies to isolate

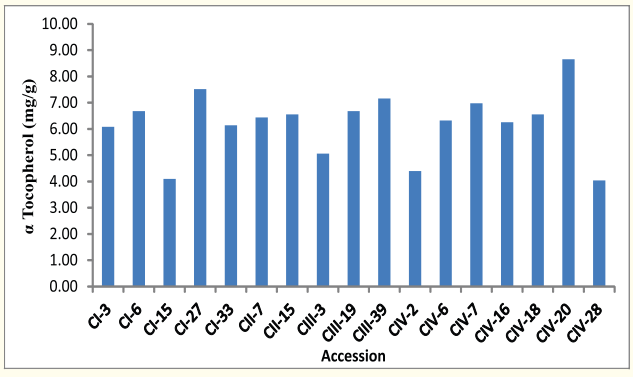


Fig. 13 : α Tocopherol in 147 accessions of core set

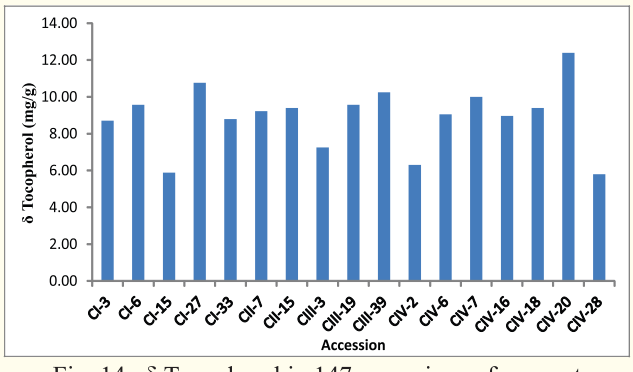


Fig. 14 : δ Tocopherol in 147 accessions of core set

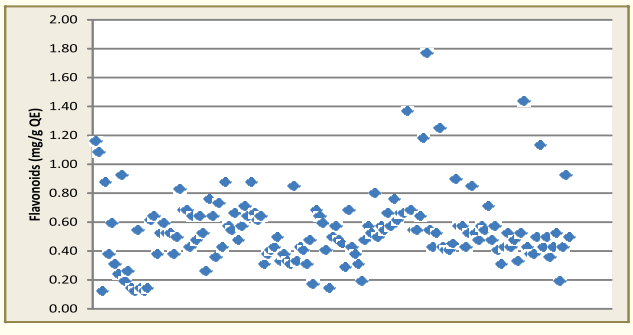


Fig. 15 : δ Flavonoids in 147 accessions of core set

bioactive compounds e.g. indole, aromatic glucosinolates are going on. Effect of different solvent extraction methods on fatty acid profiling in oil was also studied taking hexane, methanol, ethanol and acidified methanol. However higher percentage of fatty acids (linoleic acic, linolenic acid, oleic acid etc) was found in hexane and methanol treated extracts. Work is under progress.

DRMR B 9: Quantitative & Qualitative estimation of Glucosinolates & Fatty acids in Oilseed Brassica

Principal Investigator: Anubhuti Sharma, Senior Scientist (Biochemistry)

Co-Investigator: Arun Kumar, Pr. Scientist, (Genetics and Plant Breeding)

Aliphatic glucosinolate was characterized in two selected varieties i.e. Giriraj & PDZ4. Using thin layer chromatography (TLC), different secondary metabolites e.g. cinnamic, ferulic, vanillic, p-coumaric, glucosinolates etc. were identified. However, HPLC techniques confirmed the presence of different types of glucosinolates also using specific purification method. HPLC analysis showed that 2-Propenyl, 4-methylsulfinyl-3-butenyl, 4-methylsulfinylbutyl and p-hydroxybenzyl are the major compounds identified on the basis of retention time of sample and standard (Figure 16; Table 12). Effect of different solvent extraction methods on fatty acid profiling in oil was also studied taking hexane, methanol, ethanol and acidified methanol. However, higher percentage of fatty acids (linoleic acic, linolenic acid, oleic acid etc) was found in hexane and methanol treated extracts.

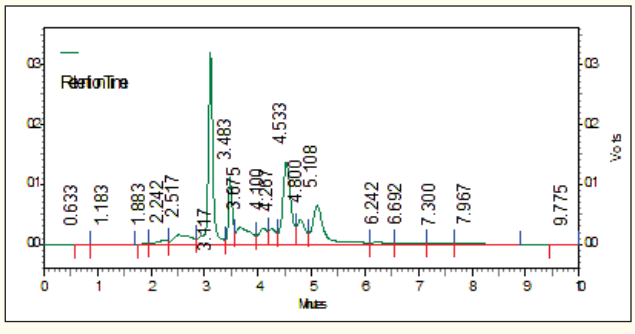


Figure 16: HPLC analysis of crude glucosinolate

Table 12 : Identification of bioactive compounds using HPLC

Peak no.	Retention time	Integration area	Tentative identification	Concentration, µg gfw^{-1}
1	3.003	634371	*	0.032
2	3.068	967952	2-Propanyl	0.037
3	3.117	613313	*	0.031
4	3.277	224963	*	0.011
5	3.403	332173	*	0.017
6	3.577	271446	*	0.014
7	3.675	1158440	4-Methylsulfinyl-3-butenyl	0.048
8	3.913	2703331	p-Hydroxybenzyl	0.149
9	4.570	1907838	*	0.116

(* unidentified compounds)

2.3 Breeding for yield and quality enhancement in rapeseed-mustard

DRMRCI 05: Development of hybrids in Indian mustard

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

Co- Investigators : P.K. Rai, Pr. Scientist (Plant Pathology), Bhagirath Ram, Pr. Scientist (Genetic and Plant Breeding), Ajay Kumar, Sr. Scientist (Biotechnology), H.S. Meena Sr. Scientist (Genetic and Plant Breeding)

Forty four experimental hybrids were evaluated in three different trials. Station Trial 1 comprised of 12 experimental hybrids and four check cultivars (Table 13). Highest yield was recorded from check hybrid cultivar 45S46 (3541 kg/ha) followed by variety Giriraj (3496 kg/ha).

Table 13: Evaluation of experimental hybrids under Station Trial 1

Entry Name	SY (kg/ha)	DFI	DFS	DM	PH (cm)	MSL (cm)	OC (%)	1000- SW (g)	S/S
HJ 1403	2963	43	97	131	206	80	41.7	4.8	14.1
HJ 903	3304	41	95	131	205	83	41.2	4.9	13.8
HJ 2403	3333	41	97	131	208	87	40.7	4.5	13.6
HJ 503	2948	45	99	139	226	87	41.0	4.6	13.9
HJ 1103	2978	51	109	142	227	85	41.1	4.3	14.2
HJ 918	3348	43	96	127	211	95	41.3	4.8	14.5
HJ 2518	3407	43	100	134	213	86	41.5	4.3	13.4
HJ 418	2681	43	98	137	209	87	40.8	4.9	15.9
HJ 3818	2622	41	96	132	206	90	41.4	4.8	15.0
HJ 1417	3037	44	99	128	208	80	41.4	4.6	15.5
HJ 917	3170	44	96	131	208	79	41.5	5.2	16.3
HJ 517	3333	43	98	127	207	91	40.5	5.1	14.2
DMH- 1	2815	45	100	125	217	71	40.4	3.5	15.6
Pioneer 45S46	3541	38	91	123	173	86	42.3	5.0	14.0
NRCHB 506	3170	43	100	137	228	72	40.2	5.5	14.5
Giriraj	3496	42	94	131	192	89	42.5	6.2	15.5
General Mean	3231								
CV(%)	9.64								
LSD at 5%	504								

Fifteen early maturing experimental hybrids were tested in MLT 1 along with 3 checks. Only one hybrid Pusa MH 41 was *at par* for maturity duration (124 days) with early maturing check Pusa Mustard 25, though the seed yield of Pusa MH 41 (2741 kg/ha) was seven percent higher than the check Pusa Mustard 25 (2568 kg/ha). Among other experimental hybrids, HJ 2418 (3249 kg/ha) had marginal superiority over best check NRCHB 101 (3180 kg/ha). Twenty experimental hybrids were evaluated along with 4 checks under timely sown conditions. Experiment was laid out in alpha lattice design with 3 replications. Highest seed yield was recorded from check variety Giriraj (3437 kg/ha) followed by HJ 1117 (3407 kg/ha).

In addition, 13 pureline/ inbred entries were evaluated alongwith 3 checks; Giriraj, RGN 73 and Pusa Mustard 25 (Table 14). DRMRIJ 1353 produced highest seed yield (3560 kg/ha), which was 26 percent higher than the best check Giriraj (2830 kg/ha). BCPRT 18-45 (3165 kg/ha), derived from MCB 1-2—7-3 X MCR 1-6, DRMRIJ 17-92 (3037 KG/HA), DRMRIC 16-38 92993 KG/HA), excelled the best check Giriraj (2830 kg/ha) by a margin of 11-8, 7.3, 5.8 percent, respectively. DRMRIJ 16-9-7 matured earlier (118 days) than Pusa Mustard 25 (121 days) and also produced 9.2 percent more seed yield (2583 kg/ha) over the best early maturing check Pusa Mustard 25 (2365 kg/ha).

Evaluation of F_1 Crosses: 228 F_1 crosses were evaluated in four different experiments; Line X Tester 1, Line x Tester 2, Test Crosses and MLT3. Out of 228 crosses, 10 heterotic crosses were identified (Table 15). Extent of heterosis ranged from 8 % (MJB 9 X RGN 73) to 27.2 % (MJB 11 X Heera). Extent of heterosis was higher in sterile crosses than fertile crosses. Among sterile crosses, heterosis ranged from 20.5 to 39.8 percent (Table 15).

Table 14: Evaluation of promising inbreds/pureline entries under Station Trial 2

Entry Name	SY(kg/ha)	DFI	DFS	DM	PH(cm)	MSL (cm)	OC	1000 SW (g)
DRMRIJ 1353	3560	43	96	131	191	94	42.3	5.3
DRMRIJ 17-92	3037	37	94	127	201	94	41.2	5.1
DRMRIC 16-38	2993	41	97	128	197	99	42.2	5.5
BJST18-9 (DR 1 X DR 3)	2973	41	96	129	200	92	42.4	5.7
BJST18-10(F2 7-1)	2558	39	98	127	200	91	42.3	4.1
BJST 18-11 (F3-3)	2810	38	99	127	196	90	42.0	5.2
DRMRIJ 16-66	2657	43	100	135	210	87	41.9	5.2
BJIPSE18-7	2914	44	100	135	230	89	42.4	3.6
DRMRIJ 16-9-7	2583	38	87	118	177	93	41.8	4.7
BJPRT 18-5	2800	45	99	128	225	89	42.6	3.7
BNIPS 18-42	1798	51	109	137	225	87	41.3	4.6
BC PRT 18-45	3165	44	97	129	202	89	41.7	5.1
BCPRT 18-77	1867	60	103	135	167	27	42.0	3.6
Giriraj	2830	43	95	129	198	92	40.8	6.4
RGN 73	2667	51	109	142	237	79	41.0	4.4
Pusa Mustard 25	2365	37	89	121	174	83	41.6	4.4
General Mean	2726							
CV(%)	13.3							
LSD at 5%	606							

Table 15: Characterization of promising F_1 crosses

Entry Name	DFI	DFS	DM	PH (cm)	MSL (cm)	SY (kg/plot)	Heterosis (%)
LT1							
MJB 11/ Heera	60	112	149	249	88	2.06	27.2
MJB 9/ RGN 73	48	100	148	215	87	1.75	8.0
DMH 1 (Check)	45	98	135	227	70	1.62	
LT 2							
MJA 25 / MJR 20	55	105	144	212	76.4	1.45	19.8
MJA 25/ RP 10-2-1-10	49	97	144	207	56.4	1.33	9.9
MJA 9/ MJR 20	48	95	139	192	69.8	1.38	14
MJA 5/ MJR 20	56	77	146	229	68.4	1.42	17.4
MJA 39-3-2-2/ MJR 8	52	98	147	198	61.2	1.39	14.9
MJA 37/ MJR 20	48	95	147	192	51.4	1.34	10.7
DMH 1 (Check)	53	97	140	237	70.8	1.21	

Table 15 Cont.

Entry Name	DFI	DFS	DM	PH (cm)	MSL (cm)	SY (kg/plot)	Heterosis (%)
TC							
OJA3/39-3-2-2 X NAJ-R-30	49	103	148	227	83.6	1.23	8.8
OA 630/ NAJ-R-30	51	105	148	219	77.2	1.83	16.6
DMH 1 (Check)	60	111	149	231	69.4	1.13	
Sterile crosses							
OJA1 / OR-515	50	101	148	214	89.2	1.58	39.8
OJA4/NRCHB101 X OR-518	50	106	148	226	84.2	1.41	24.8
MJA2/ PRT 17-108	58	101	137	209	71	1.59	20.5
F2 -12-2S/ NRCHB 101 x PRT17-108 (MCR1-1)	52	103	148	186	73.2	1.76	33.3
F2-12-2S/ NRCHB 101 X PRT17-113(MCR1-1)	49	90	147	219	81.8	1.67	26.5
DMH 1 (Check)	60	107	145	229	70	1.32	

Conversion of CMS :

Table 16 : 33 Back cross were attempted for conversion of CMS Line

S.No.	CMS line name	Back cross	S. No.	CMS line name	Back cross
1	MH 12-12/EC 597309 S	BC5	18	MJA 27	Advanced
2	MH 12-12/juncea YS	BC_5	19	OJA 1	BC_8
3	MJA 9918	BC6	20	OJA 2/HB 9925	BC_8
4	MJA 36	BC7	21	OJA 3/39-3-2-2	BC_8
5	MJA 3	BC8	22	OJA 4/NRCHB 101	BC_8
6	MJA 10	BC_8	23	OJA/ 4-4-7	BC_8
7	MJA 15	BC_8	24	OJA/EC 399307 S	BC_7
8	MJA 37	BC_8	25	F2-12-1S/IJ 31	BC_5
9	MJA 39-3-2-2	BC_8	26	F2-12-2S/NRCHB 101	BC_5
10	MJA 14	Advanced	27	F2-12-3S/HB 9925	BC_5
11	MJA 2	Advanced	28	M 67 NA	NA
12	MJA 8	Advanced	29	M 78 NA	NA
13	MJA 11	Advanced	30	OJA 1	F_1
14	MJA 25	Advanced	31	OJA 2/HB 9925	F_1
15	MJA 34	Advanced	32	OJA 3/39-3-2-2	F_1
16	MJA 9	Advanced	33	OJA 4/NRCHB 101	F_1
17	MJA 5	Advanced			

Conversion of R line: Following thirteen backcrosses and nine F_1 crosses were attempted to advance the generation of following restorer lines under conversion programme

Table 17 : Conversion of R line

Name	Generation	Name	Generation
MJR/EC 597309	BC_5	OJR (F2-12-3F/EC 597341)/EC597326	BC_1
MJR/EC 597313	BC_5	OJR (F2-12-4F/EC 552577)/EC 597337	BC_1
MJR9-1/EC597341	BC_4	MJR 3/ IJ 16-1	F_1
MJR 9-2/EC552577	BC_4	MJR 3/ Heera	F_1
MH 07-9 OJR/EC399307	BC_7	OJR 2/ Heera	F_1
OJR 2 (F4-5/ZEM2)	BC_6	OJA 1	F_1
OJR (F2-12-1F/EC 597313)	BC_3	OJA 1	F_1
OJR (F2-12-2F/EC 597344)	BC_3	OJA 1	F_1
OJR (F2-12-3F/EC 597341)	BC_3	OJA 1	F_1
OJR (F2-12-4F/EC 552577)	BC_3	OJA 3	F_1
OJR (F2-12-5F/EC597309)	BC_3	OJA 3	F_1

Evaluation of inbreds : 136 inbred lines were evaluated in augmented block design with 04 check cultivars for seed yield and other agronomic traits. Each inbred line was grown in paired row of 3 m length. Highest variability was recorded for seed yield followed by biological yield, while lowest variability was recorded for days to maturity. Mean estimates and range for 08 traits are presented below:

Table 18 : Perfomance of inbred lines

Parameter	DFI	DFS	DM	BY (kg/plot)	SY (kg/plot)	HI (%)	PH (cm)	MSL (cm)
Mean	47.2	90.5	135.1	2.9	0.8	26.6	189.0	79.9
CV (%)	12.4	10.3	5.3	23.1	23.5	12.6	11.8	15.0
Range	32.0	63.0	44.0	3.4	1.0	17.8	127.6	55.6
Minimum	35.0	56.0	110.0	1.2	0.3	16.4	126.8	53.0
Maximum	67.0	119.0	154.0	4.6	1.3	34.2	254.4	108.6

Individual plants were selfed (S_1) to advance the generation from F_3 to F_4 for development of inbred lines. 63 progeny rows were grown from individual plants selected during 2017-18 from segregating generations for their evaluation and further selection.

Screening for resistance against white rust

Out of 117 entries of rapeseed-mustard were screened against white rust at IARI regional station Wellington during May - October, 2018, 25 lines expressed uniformly resistant reaction.

Maintenance programme

197 inbred lines, 54 maintainer lines, 16 R lines and 55 advanced breeding lines were maintained.

Multiplication of seed

Seed of 16 A lines was multiplied under net. Seed of 39 experimental hybrids was produced in four isolated plots.

Generation of new crosses

193 new F_1 crosses including 105 in Line x Tester design, 64 test crosses and 24 earlier identified crosses were attempted.

Line x Tester (15 x 7): Lines: EC 597309, juncea YS, HB 9918, Heera, MJB 3, MJB 10, MJB 15, MJB 37, IJ 31, MJB 14, NRCHB 101, MJB 8, MJB 11, MJB 24, MJB 25;Tester: Donskaja, RE 8, RE 13, RE 14, RE 35-4, RE 44, RE 551

Selection from segregating generation

Individual plant selection for desired traits was practiced from segregating population of 07 crosses: F_2 population: MJA11 X MJR34, MJA8 X MJR13, MJA8 X MJR34;

F_3 population: PEMH 8; F_4 population: IJ 31 X EH 2, NRCHB 101 X EH 2; F_5 population: IJ 31 X LET 36.

2.4 Oilseed *Brassica* genetic resource management

DRMR CI-06 : Collection, evaluation, characterization and conservation of rapeseed-mustard germplasm

Principal Investigator: Hariom Kumar Sharma, Scientist SS, (Genetics and Plant Breeding)

Co-Investigators: V.V. Singh, Pr. Scientist (Genetics and Plant Breeding), Arun Kumar, Pr. Scientist (Cytogenetics), Priyamedha, Scientist SS, (Genetics and Plant Breeding), Pankaj Sharma, Pr. Scientist (Plant Pathology)

Germplasm acquisition

Acquired 30 varieties of rapeseed-mustard from different developing centers for conservation in DRMR gene bank

Regeneration, maintenance and conservation

Regenerated 456 accessions of rapeseed-mustard including varieties, germplasm lines of Indian mustard (*B. juncea*), yellow sarson (*B. rapa* var. *yellow sarson*), brown sarson (*B. rapa* var. *brown sarson*), toria (*B. rapa* var. *toria*), gobhi sarson (*B. napus*), taramira (*Eruca sativa*), black mustard (*B. nigra*) and other wild species by following proper pollination technique. Deposited 424 accessions of Indian mustard for long term conservation in NBPGR, gene bank and received IC number of these accessions.

Evaluation, characterization and selections

Evaluation for heat tolerance in Indian mustard

89 lines of Indian mustard were evaluated in ABD with 04 checks (NPJ112, Urvashi, BPR541-4, NRCDR-02) in 05 blocks for screening of heat tolerance at seedling stage. Sowing was done on 28 Sept., 2017. 09 lines (DRMR 1222, DRMR 1469, DRMR 1470, DRMR 2275, DRMR 2425, DRMR 2427, DRMR 2522, C-II-6, DRMR 2246), significantly superior over best check Urvashi (16.64 g/plant) in terms of seed yield/ plant (30.8g), were identified.

A total of 604 Indigenous accessions of Indian mustard were sown on 24 November, 2017 for evaluation to terminal heat tolerance. 145 lines were selected, based on seed yield (>16.0g), thousand seed weight (>4.0g), oil content (>40.0%), for revalidation in year 2018-19. From 604 accessions, 14 single plant selections were also made based on visual observation. These 14 SPS were further evaluated along with 145 lines in ABD with seven checks for terminal heat tolerance in *rabi*, 2018-19. Sowing for terminal heat tolerance was done on 19 November, 2018. Apart from these lines fresh set of 190 exotic lines of Indian mustard were also evaluated for terminal heat tolerance in 2018-19 for first year. Trait most affected was seed size.

Evaluation and selection for higher yield in Indian mustard

Evaluated 09 promising accessions (DRMR 1222, DRMR 1469, DRMR 1470, DRMR 2275, DRMR 2425, DRMR 2427, DRMR 2522, C-II-6, DRMR 2246) of Indian mustard under timely sown irrigated conditions for yield in RBD with two replications. Another set of 64 promising accessions of Indian mustard selected from accessions evaluated in 2017-18 were evaluated along with checks in RBD with 02 replications under timely sown conditions. About 150 single plant selections of rapeseed-mustard were made based on siliqua bearing, siliqua length, plant height to be evaluated in next growing season for yield.

Evaluation and characterization of yellow sarson germplasm

In year 2017-18, 141 yellow sarson accessions were evaluated for different agro-morphological traits. Based on data of 2017-18, 20 lines of yellow sarson with seed yield> 40g/ plant and oil content (43-46%), 13 lines with siliqua bearing > 300/ plant and 08 lines with TSW > 5.25 g were identified and grown for revalidation in year 2018-19 in replicated trials. In year 2018-19, 99 accessions of yellow sarson were evaluated for different agro-morphological traits for second consecutive year along with four checks (YSH401, Pitambari, NRCYS 05-02, Benoy) in Augmented block design.



Glossy deep green type yellow sarson line, DRMRYS-Sel-17-01 | Tetra-locular siliqua type brown sarson line, DRMRBS-Sel-17-04

Fig.17: Yellow sarson and brown sarson lines selected in year 2017-18

Two unique plants with distinct moprophology was selected in yellow sarson (glossy deep green, DRMRYS-Sel-17-01) and brown sarson (tetralocular siliqua type, DRMRBS-Sel-17-04) in year 2017-18 (Fig.17). These lines were evaluated in 2018-19 for different agro-morphological traits. Segregation was observed for seed colour in line DRMRBS-Sel-17-04 and brown seeded tetralocular type plants were selected. 150 single plant selections of rapeseed-mustard were made based on siliqua bearing, siliqua length, plant height and will be evaluated in next growing season for yield.

Screening of Indian mustard germplasm for stem rot tolerance

388 germplasm accessions of Indian mustard were screened for resistance to stem rot disease through artificial were screeched stem inoculation technique. 137 Indian mustard accessions, identified through artificial stem inoculation technique during 2017-18, were grown into sick plots in RBD with 2 replications for further screening. Plants in sick plots were also stem inoculated. Based on leision lenght (<3.0cm) and percent disease incidence (<10.0%), 03 genotypes DRMR 506, DRMR 1396 and DRMR-1099-SR-1 showed tolerant reactions.

Hybridization

Crosses were attempted among promising accessions of Indian mustard (DRMR-66, DRMR-69, DRMR-88, DRMR-436, DRMR-1322, DRMR-1162, DRMR-1255, DRMR-1233) and 11 crosses were harvested. Likewise, crosses among accessions of yellow sarson (DRMR-510, DRMR-509, DRMR-235, DRMR-647, DRMR-518, DRMR-520, DRMR-528, DRMR-250, DRMR-522, DRMR2842, DRMR2044, DRMR-501, DRMR-241, DRMR496, DRMR-493, DRMR-645, DRMR-2379, DRMR2844, DRMR-638, DRMR-2385, DRMR-2381, DRMRYS-sel-17-01, DRMR-2691 DRMR-2844, DRMR-2584, DRMR-2828) were attempted and 38 F_1s were harvested.

Germplasm distribution

Distributed 1977 accessions of rapeseed-mustard to different organizations.

2.5 Biotechnological interventions to improve rapeseed-mustard productivity

DRMR-BT-07: Enhancing the repertoire of microsatellite markers for genomics intervention in Indian mustard (*Brassica juncea* L. Czern. & Coss) crop improvement

Principal Investigator: Ajay Kumar, Senior Scientist (Biotechnology)

Co-investigator: K.H. Singh, Pr. Scientist (Genetics and Plant Breeding)

Genome-wide spanning of microsatellite markers in Indian mustard covering all the linkage groups and evaluating their polymorphic potential

Whole genome sequence of *B. juncea* var. *tumida* (var. T84-86 from NCBI GenBank: LFQT00000000 (Bio Project PRJNA285130) had been retrieved. Alignment of genome sequence of *B. juncea* var. PBR 357 (obtained by resequencing, PAU, Ludhiana- through personal communication) to the reference sequence of *B. juncea* var. *tumida* using Bowtie2.0 software was done and mining for microsatellite sites using MIcroSAtellite (MISA) identification tool (http://pgrc.ipk-gater sleben.de/misa/) was carried out. All SSR-containing sequences were used for primer designing using BatchPrimer3 software (http://probes.pw.usda.gov/cgibin/batchprimer3/batchprimer3.cgi). Further, physical mapping of genomic microsatellite markers on all the 18 linkage groups of Indian mustard was carried out. A total

of 1,546 SSR markers covering all the 18 chromosomes (80-85 SSRs/chromosome) of Indian mustard were identified. Primer sequences were designed for 108 SSR markers (6 SSRs/linkage group). Polymorphic potential of genome-wide spanned SSR markers is being evaluated in a representative set of genetically diverse Indian mustard genotypes. So far, 50 SSRs had been evaluated and 31 SSRs resulted into polymorphic amplicons (Fig.18).

To develop a highly saturated linkage map of Indian mustard using SSR markers and mapping of QTL(s)/gene(s) governing yield component traits, RIL populations (348 individuals) of the cross Giriraj and Heera (F_4 population) were sown in field following standard package of practices (Fig. 19) and advanced to F_5 generation using SSD method and F_5 seeds had been harvested. Further, initiated SSR genotyping of both the parents to find out polymorphic SSR markers for future genotyping of the RIL population.



Fig. 18 RIL population (F4 generation) of Giriraj x Heera cross

Candidate gene-based Marker-Assisted Breeding for improvement of white rust resistance

During 2018-19, crosses were attempted between Giriraj and DRMRMJB 35 for introgression of both the WR loci into Giriraj background. F_1 seeds were harvested. Also parental polymorphism survey for SSR markers between both the parents to find background markers for Giriraj, was initiated.

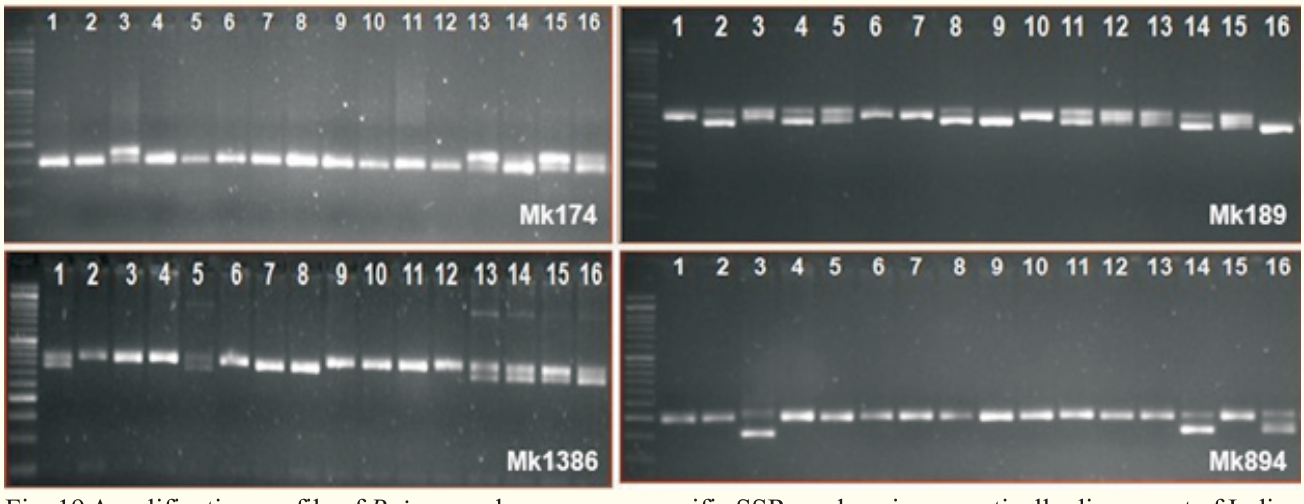


Fig. 19 Amplification profile of *B. juncea* chromosome-specific SSR markers in a genetically diverse set of Indian mustard germplasm and varieties

DRMR BT-05: Biotechnological interventions for development of *Orobanche* tolerance in Indian Mustard (*Brassica juncea L.*)

Principal Investigator: Reema Rani, Scientist (Biotechnology)

Co-investigator: Ajay Kumar, Sr. Scientist (Biotechnology), Ibandalin Mawlong, Scientist (Biochemistry), O.P. Premi, Pr. Scientist (Agronomy)

Screening of germplasm lines for the Glyphosate tolerance

During Rabi season of 2018-19, 1794 germplasm lines of Brassica spp. were sown at ICAR-DRMR to identify the lines tolerant to glyphosate herbicide. Glyphosate was sprayed using sprayer at 40 DAS *i.e.* during post-emergence period to study the effect of herbicide on growth of plants. Out of 1794 lines, 24 lines failed to germinate. Phytotoxicity response and days to survival after

treatment was recorded for each line in which 26 lines showed fair amount of tolerance to glyphosate, 74 lines showed moderate amount of tolerance to glyphosate, 79 lines were highly susceptible and died completely. Lines which have exhibited good tolerance to glyphosate were DRMR-22, DRMR-287, DRMR-290, DRMR-299, DRMR-362, DRMR-735, DRMR-877, DRMR-1097, DRMR-1261, DRMR-1479, DRMR-1497, DRMR-1963, DRMR-1964, DRMR-2076, DRMR-2308, DRMR-2452, DRMR-2456, DRMR-2461, DRMR-2465, DRMR-2477, DRMR-2637, DRMR-2664, DRMR-1419, DRMR-1629, DRMR-2014.

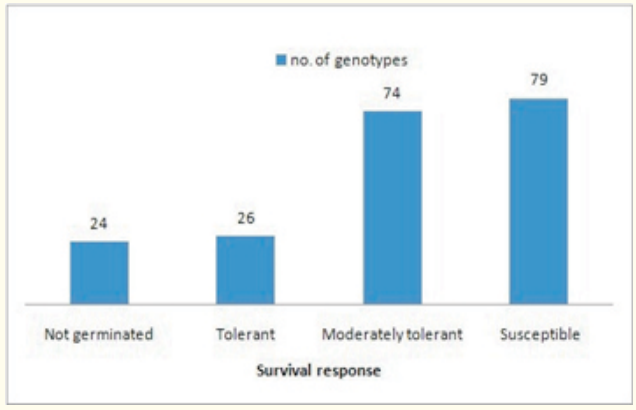


Fig. 20: Graphical representation of the survival response of germplasm lines for glyphosate

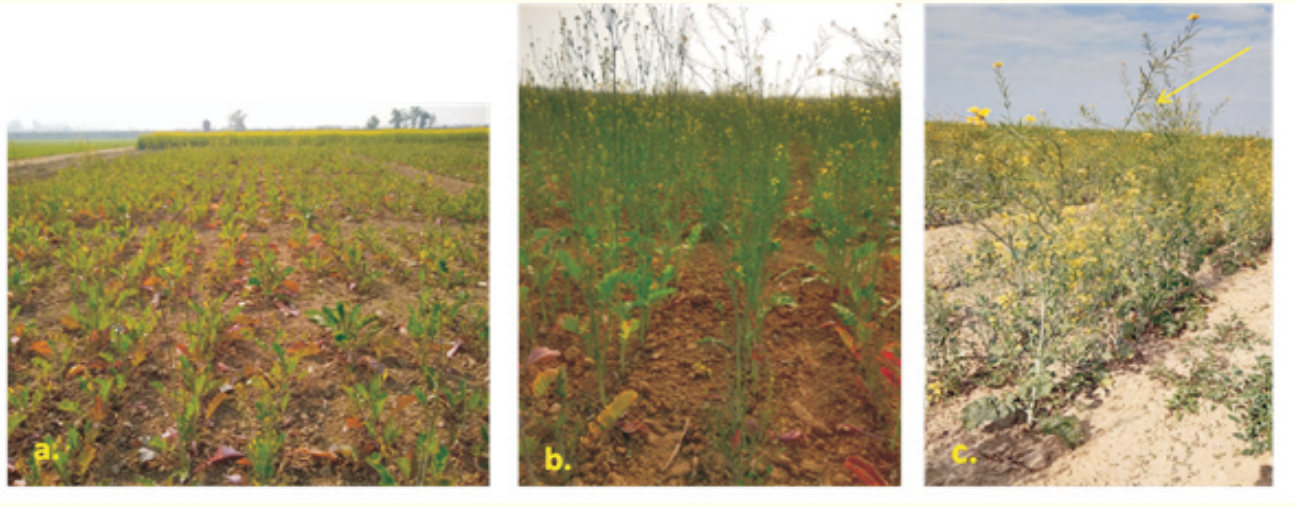


Fig. 21: Illustrating the effects of glyphosate doses on the germplasm lines of *Brassica.*
(a) Germplasm lines after spraying of Glyphosate (b) & (c) showing the survival response of germplam lines

In-vitro studies on optimization of Tissue culture conditions in *Brassica juncea var.* RH749 and DRMR IJ 31

Two cultivars of *Brassica juncea* and two types of explant (hypocotyl and cotyledon) were tested for their potential to regenerate under *in vitro* conditions. Hypocotyl and cotyledon explants from 10-12d-old seedlings were sub cultured on to different callus induction media based on Murashige and Skoog (MS) basal medium supplemented with 1% sucrose and different concentrations and combinations of plant growth regulators (BAP, Kinetin, 2-4-D, IBA, IAA, and NAA) and $AgNO_3$. Hypocotyl explants were found to be more suitable for callus induction and direct organogenesis than cotyledon explants for both cultivars tested. Moreover, among different types of media tested, MS+3mg/l 6-benzyloaminopurine (BAP) + 0.1mg/l α-naphthylacetic acid (NAA)+ 25 µM $AgNO_3$ was found to be most effective for shoot regeneration in the *var.* RH749 whereas treatment MS+ 2mg/l 6-benzyloaminopurine (BAP) +0.1 mg/l α-naphthylacetic acid (NAA)+ 20µM $AgNO_3$ was found effective for *var.* DRMRIJ31. MS medium containing the standardized concentration of phytohormones produced the maximum number of strong and healthy roots. This high frequency plant regeneration protocol could be suitable for a wide range of mustard cultivars and will be further utilized for the transformation purposes.

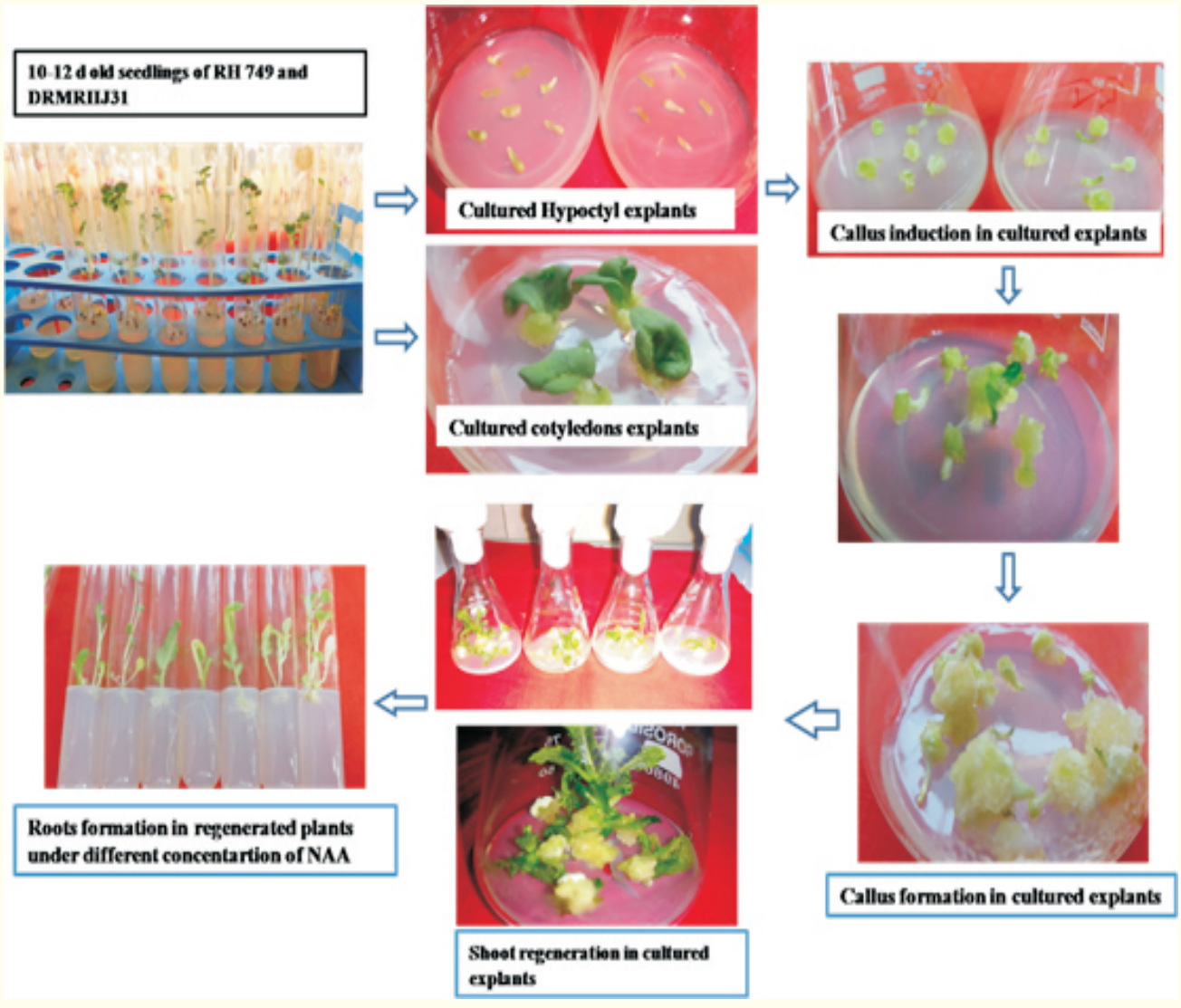


Fig. 22: Illustrating the high frequency plant regeneration protocol in *Brassica juncea var.* RH749 and DRMRIJ31

2.6 Enhancing resource use efficiency and abiotic stress management for resilient rapeseed-mustard production

DRMR CP-06: Enhancing soil resilience under mustard based systems through integrated crop management practices

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

The long- term replicated experiment under fallow-mustard (*Brassica juncea*) system is in progress since 2005-06 at ICAR-DRMR, keeping conventional practices (CP), *Sesbania* Green Manuring (SGM) and 2.5 t/ha mustard straw recycle + SGM (MSGM) as main plot and eight combinations of NPK fertilizers in subplot. The 13th harvest of mustard crop indicated that green manuring with Sesbania significantly increased mustard seed yield by 21.3% over control. Supplementary incorporation of MSGM @ 2.5t/ha further augmented the seed yield by 20.4% over SGM alone and by 46.1% over control (Table 19). Application of balance fertilizer (F_8) increased the seed yield atleast by 26.7% over sub-optimal doses F_1, F_2, F_3 and F_4. Adoption of MSI + MSGM system further augmented the seed yield at F_8 atleast by 33.8% over sub-optimal doses (F_1 to F_4) indicating better nutrient recycling and availability for sustainable higher yields. The productivity trend over the years is presented in Fig 1. In general, MSGM improved the microbial biomass carbon by 52.5% and 71.9% over SGM and CP, respectively.

Table 19. 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	1773	1656	1719	2006	2001	2063	2054	2133	1926
Sesbania (SGM)	2005	2131	2337	2111	2244	2639	2496	2692	2337
Mustard straw @ 2.5 t/ha + Sesbania (MSGM)	2414	2397	2543	2650	2887	3005	3273	3347	2815
Mean	2064	2076	2200	2256	2378	2569	2608	2724	-
CD (P=0.05)	CS: 174, Fertility level: 179								

*F_1: N_{40} $P_{8.7}$ K_0, F_2: N_{40} $P_{8.7}$ $K_{33.3}$, F_3: N_{40} $P_{17.4}$ K_0, F_4: N_{40} $P_{17.4}$ $K_{33.3}$, F_5: N_{80} $P_{8.7}$ K_0, F_6: N_{80} $P_{8.7}$ $K_{33.3}$, F_7: N_{80} $P_{17.4}$ K_0, F_8: N_{80} $P_{17.4}$ $K_{33.3}$ (kg/ha)

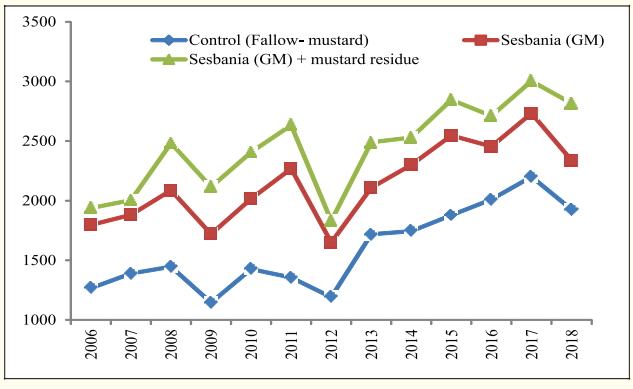


Fig. 23 Temporal effect of various mustard production systems

Evaluation of nutrient management strategies for sustainable mustard production

Under this project a long term field experiment was initiated in 2005-06 to evaluate the resilience capacity of 4 oilseed *Brassica* (OSB) production systems. However, the experiment was refined during 2011-12, keeping 3 fertilizer management levels (CFM: conventional-100% RDF, MFM: moderate – 50% RDF and SFM: subsistence- no fertilizer) in main plot and six organic sources (SGM: Sesbania green manuring, MSI: 2.5t/ha mustard straw incorporation, MSI+SGM, MSM: 2.5t/ha mustard straw mulch, FYM: 2.5t/ha farm yard manure and VC: 2.5t/ha vermicompost) in sub plot. The trial was conducted in AxB+2 control randomized design keeping absolute control and conventional control (100% RDF) as checks. Conventional fertility management recorded significantly higher seed yield than moderate and subsistence fertility management practices. Overall, use of organic source increased the seed yield by 50.6% over conventional control. Supplementing organic source with chemical fertilizers further augmented the seed yield of OSB by 14.2% due to MFM (Table 20). Among the organic sources, MSI + SGM produced significantly higher seed yield followed by SGM and VC.

Role of soil microbes on mustard productivity under moisture stress conditions.

To mitigate moisture stress in Indian mustard, three cultures were tested in split plot design keeping three irrigation levels (one irrigation, two irrigation, no irrigation) in main plot and cultures (NAD7, MRD17, MKS 6, without inoculation) in sub plots replicated thrice under collaborative research with ICAR-IARI. Two cultures were isolated from rhizospheric soils of this region and identified as *Bacillius sp.* and an endophyte, which were isolated at ICAR-IARI, New Delhi.

The yield data presented in Table 21 indicated that one irrigation schedule produced statistically similar seed yield of mustard as produced with two irrigations. One irrigation could be saved by using these cultures. Among the cultures, MRD17 and MKS6 gave 29.7% and 24.7% higher productivity over no inoculation, respectively. The other parameters such as relative water content, membrane stability index and chlorophyll content were also higher in these treatments.

Table 20. Effect of fertilizer management strategy and organic sources on mustard productivity (kg/ha)

Fertilizer management strategy (FMS)	Organic Sources (OS)						Mean
	SGM	MSI	MSI + SGM	MS mulch	FYM	VC	
CFM: Conventional (100% RDF)	2841	2567	3033	2664	2602	2540	2708
MFM: Moderate (50% RDF)	2373	1794	3032	1877	2141	2319	2256
SFM: Subsistence (no fertilizer)	2046	1941	2251	1709	1900	2002	1975
Mean	2420	2101	2772	2083	2214	2287	-
AC: Absolute control- 410 CC: Conventional control (100% RDF)-1798	CD 5%: FMS 290, OS:: 231						

Table 21. Effect of microbes and irrigation level on mustard productivity (kg/ha)

Irrigation level	Culture				Mean
	No Inoculation	NAD 7	MRD 17	MKS 6	
Rainfed	1529	1662	1855	2035	1770
One irrigation	1959	2156	2852	2484	2363
Two irrigation	2105	2478	2549	2453	2396
Mean	1864	2098	2418	2324	-
CD 5% :Irri. Level:339, Culture: 281, Interaction :NS					

DRMR CP-16: Sustainable intensification of Brassica production system (SIBPS)

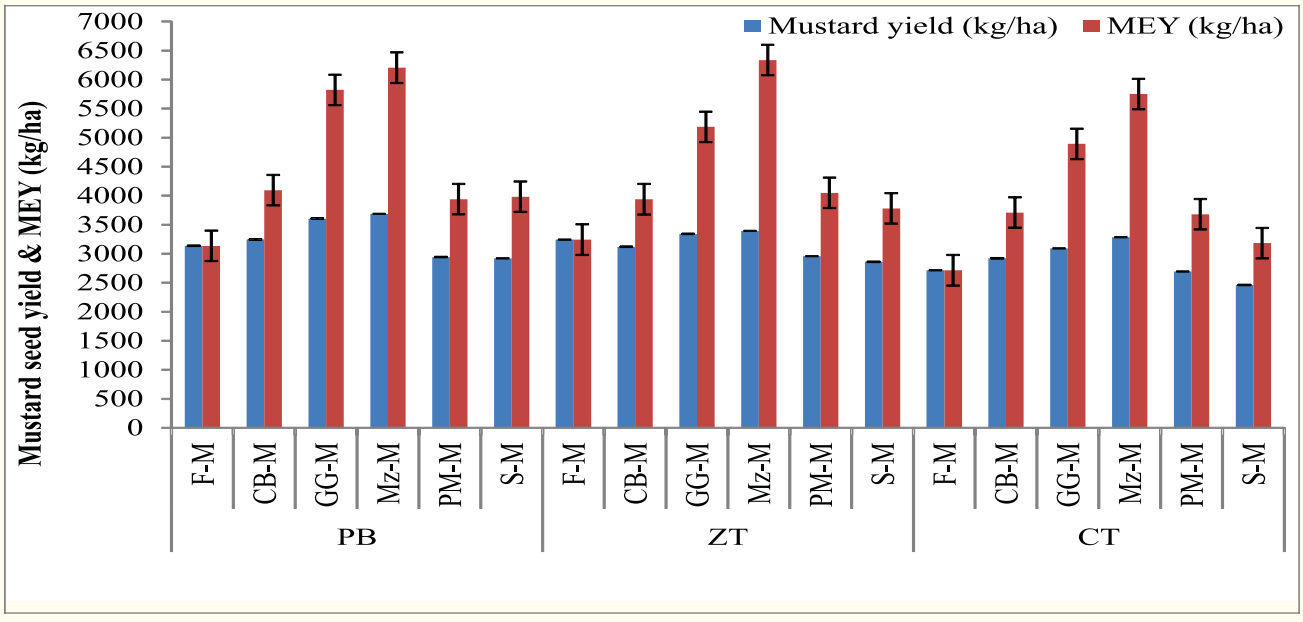
Principal Investigator: R.S. Jat, Pr. Scientist (Agronomy)

Co-Investigators: M.K. Meena, Scientist (Soil Science), Har Vir Singh, Scientist (Agronomy), Pankaj Sharma, Pr. Scientist (Plant Pathology)

Developing resource use efficient and resilient rapeseed-mustard based cropping systems for enhancing rapeseed-mustard production and farm income under the current and future climates:

Conservation agriculture practices (No tillage, permanent beds and residue retention) were studied in five Indian mustard based cropping systems; pearl millet-mustard, sesame-mustard, green gram-mustard, maize-mustard, cluster bean-mustard and weighed against fallow-mustard with conventional tillage (a predominant business as usual system in the region). Among different CA practices, sowing on permanent beds under previous crop residues (anchored kharif crop stubbles), though *at par* with zero tillage, recorded significantly higher mustard seed yield (3256 kg/ha) compared to conventional tillage (2861 kg/ha) in the third year of experimentation. The mustard seed yield was recorded highest in maize-mustard system (3455 kg/ha) which was *at par* with green gram-mustard and significantly higher over fallow-mustard, cluster bean-mustard, pearl millet-mustard and sesame-mustard systems. The tillage practices were assorted for kharif crops and found higher seed yield in CA practices compared to conventional tillage in the system. The seed yield of maize (7273 kg/ha) and pearl millet (2350 kg/ha) were higher under zero tillage, whereas, cluster bean (914 kg/ha), green gram (1336 kg/ha) and sesame (709 kg/ha) were higher under permanent beds with residue retention. The system productivity

based on mustard equivalent yield was highest in permanent beds (4530 kg/ha) followed by zero tillage (4423 kg/ha) and significantly higher over conventional tillage (3989 kg/ha). Among the cropping systems, the system productivity was higher in maize-mustard system (6098 kg/ha) followed by green gram-mustard (5301 kg/ha), cluster bean-mustard (3914 kg/ha), pearl millet-mustard (3889 kg/ha), sesame-mustard (3649 kg/ha) and the lowest in fallow-mustard system (3031 kg/ha).



MEY: Mustard equivalent yield, F-M: Fallow-mustard, CB-M: Cluster bean-mustard, GG-M: Green gram-mustard, Mz-M: Maize-mustard, PM-M: Pearl millet-mustard, S-M: Sesame-mustard, PB: Permanent beds, ZT: Zero tillage, CT: Conventional tillage

Fig. 24 :Tillage practices and mustard based cropping systems

DRMR CP-17: Role of micro and secondary nutrients and their fortification on Rapeseed-Mustard productivity and quality

Principal Investigator : M.K. Meena, Scientist (Soil Science)

Co- Investigators : M.D. Meena Scientist (Soil Science), R.S. Jat, Pr. Scientist (Agronomy), Ibandalin Mawlong, Scientist (Plant Biochemistry)

The experiment was conducted to enhance the micro and secondary nutrient availability to Indian mustard in arid and semi-arid regions where, it is often found deficient in soils. Experiment, comprising 15 treatment combination replicated thrice, was laid out in split plot design with three treatments of FYM level (Control, @5 t ha^{-1} and @10 t ha^{-1}) and five treatment of sources of nutrient (control, 2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S ha^{-1}, 5 kg Zn + 2 kg B+ 10kg Fe +20 S kg ha^{-1}, 2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S Enriched FYM @ 500 kg ha^{-1} and 5 kg Zn + 2 kg B+ 10kg Fe+20 kg S Enriched FYM @ 500 kg ha^{-1}). Result showed that significantly highest seed yield (2982 kg ha^{-1}) was observed under the treatment in which micro and secondary nutrient applied at the rate of 5.0 kg Zn + 2 kg B+ 10 Kg Fe +20g S Enriched FYM @ 500 kg ha^{-1}($Zn_2B_2Fe_2S_2$ En) but *at par* with micro and secondary nutrient application @ of 2.5 kg Zn + 1 kg B+ 5 Kg Fe +10g S Enriched FYM @ 500 kg ha^{-1}($Zn_1B_1Fe_1S_1$En).Interactive effect of different level of FYM and sources of nutrient on seed yield of mustard revealed that half dose (@5 t ha^{-1}) of FYM is sufficient to obtained significantly highest seed yield of mustard when micro and secondary nutrient were applied by enriching FYM. Results revealed that fortification of micro and secondary nutrients has increased their availability in soils solution. Availability of S, Zn, Fe and boron was increased by 17.74, 127.68, 43.41 and 52.76 % under the treatment in which

these nutrients were applied @ of 5.0 kg Zn + 2 kg B+ 10 Kg Fe +20g S Enriched FYM @ 500 kg ha^{-1} ($Zn_2B_2Fe_2S_2$ En) over control ($Zn_2B_2Fe_2S_2$). The treatment in which nutrient applied @ of 5.0 kg Zn + 2 kg B+ 10 Kg Fe +20g S enriched FYM @ 500 kg ha^{-1}($Zn_2B_2Fe_2S_2$En) increased the seed yield by 31.59 and 3.07 % over control and $Zn_1B_1Fe_1S_1$En, respectively.

DRMR CP-19 : Nutrient transformation in soil as influenced by enriched composts and their effect on yield and quality of mustard

Principal Investigator : M.D. Meena, Scientist (Soil Science)

Co- Investigators : M.K. Meena, Scientist (Soil Science), M.L. Dotaniya, Scientist (Soil Science), M.S. Sujith, Scientist (Plant Biochemistry), R.S. Jat, Pr. Scientist (Agronomy)

Recently composting of waste mica, rock phosphate and gypsum as low cost source of nutrients with mustard stover is getting importance as an organic fertilizer for improving mustard productivity and soil health. The aim of this research is to develop low cost alternative to costly chemical fertilizers for sustainable mustard production. Nutrient enriched compost was prepared by low grade sources of mineral and chemical characterization of compost was done. Mustard grain yield was higher in soil amended with enriched compost along with recommended doses of chemical fertilizers as compared to alone use of compost. However, soil treated with organic fertilizers had slightly lower values of soil pH and EC in comparison to chemical fertilizers. Significantly higher mustard yield had reported in treatments received 100% RDF over control. Soil organic carbon was slightly higher in organically treated soil in comparison to alone use of chemical fertilizers. Application of 25% recommended dose of chemical fertilizers along with 1.5 t ha^{-1} enriched composts had 8% higher grain yield of mustard over control during first year of experiment.

DRMR CP-20 : Management of Poor Quality Water for sustainable Mustard Production

Principal Investigator : M.L. Dotaniya, Scientist (Soil Science)

Co- Investigators: M.D. Meena, Scientist (Soil Science); R.L. Choudhary, Scientist (Agronomy); M.K. Meena, Scientist (Soil Science); O.P. Premi, Pr. Scientist (Agronomy)

An experiment was formulated to identify the soil salinity status of Bharatpur region and to find out the available option to reduce it for sustainable mustard production. Soil fertility status data was collected from state department, published reports, papers etc. Geo-referenced soil samples were collected from experimental (B8, B7, B6, B5, A4) as well as general field of ICAR-DRMR research farm to assess the physico-chemical properties. In most of the soil samples, pH ranged 7.70 to 8.77. The higher pH mediated the plant nutrient dynamic and reduced the uptake pattern in mustard. Soil EC ranged 0.373 to 0.882 dS m^{-1} showing higher concentration of soluble salt in soils.

DRMR CP 21 : Yield maximization through best crop management strategies in mustard based cropping systems

Principal Investigator : Har Vir Singh, Scientist (Agronomy)

Co-Investigators : R.L. Choudhary, Scientist (Agronomy); M.K. Meena, Scientist (Soil Science); M.S. Sujith Kumar, Scientist (Biochemistry); M.L. Dotaniya, Scientist (Soil Science)

To maximize the yield of mustard through best management strategies, a field experiment was conducted during 2018-19. The experiment was laid down in split plot design comprising 5 main plots and 03 sub plots with 03 replications. The main plot included 05 treatments viz., recommended dose of fertilizers (RDF) (T1), recommended dose of fertilizers + farm yard manure (T_2), RDF + FYM+ biofertilizers (T_3), RDF + FYM + biofertilizers + mustard straw (T_4), RDF + FYM + biofertilizers + mustard straw+Jivamrat (T_5) and sub plot treatments were

RDN 100% (N_1), RDN 125% (N_2), RDN 150% (N_3). Recommended fertilizer dose (N:P:K:S) 80:40:40:40 was applied. The sources of N and P were urea (46% N) and di-ammonium phosphate (18% N & 46 % P_2O_5), respectively. All the P and half of the N were applied basally before sowing; the other half of N was top-dressed at 35 DAS. Other package of practices for insect pests and weed control were followed according to local agronomic practices unless otherwise indicated. Pre and post harvest observations in the field were recorded. Pre harvest observations included plant height at different dates, chlorophyll content at 60 and 90 DAS. Post harvest observations included plant height (cm), primary branches/plant, secondary branches/plant, main shoot length (cm), siliquae/plant, seeds/silique, siliquae length (cm), biological yield, seed yield and test weight.

To evaluate best nitrogen and sulphur levels for obtaining high yield and quality in mustard, an experiment was conducted during 2018-19. The experiment was conducted in split plot design with 03 replications. There were 05 N levels and 04 S levels. The N levels were N_0 (Control), N_1 (60 kg N/ha), N_2 (80 kg N/ha), N_3 (100 kg N/ha), N_4 (120 kg N/ha) and S levels were S_0 (Control), S_1 (20 kg S/ha), S_2 (40 kg S/ha), S_3 (60 kg S/ha). In this experiment, Pre and post harvest observations in the field were recorded. Pre harvest observations included plant height at different dates, chlorophyll content at 60 and 90 DAS. Post harvest observations included plant height (cm), primary branches/plant, secondary branches/plant, main shoot length (cm), siliquae/plant, seeds/silique, siliquae length (cm), biological yield, seed yield test weight and oil content.

DRMR CP-22 : Climate Smart Agro-techniques for enhancing Water Productivity of Mustard based Cropping Systems under Moisture Stress

Principal Investigator : R.L. Choudhary, Scientist (Agronomy)

Co-Investigators: Har Vir Singh, Scientist (Agronomy), M.S. Sujith Kumar, Scientist (Biochemistry), M.D. Meena, Scientist (Soil Science), M.L. Dotaniya Scientist (Soil Science)

To mitigate the impact of deficit moisture stress in mustard based cropping systems, two field experiments were conducted. The potential drought mitigation approaches such as conservation agriculture, use of super absorbent polymer and plant bioregulators were utilized to alleviate deficit moisture stress in mustard based cropping system. Preliminary results indicated that under the limited supply of soil moisture, the performance of mustard crop in terms of growth and yield attributing traits was found superior with the application of salicylic acid and Pusa hydrogel. Soil and plant parameters were recorded for further assessment of these agro-techniques for mitigation of drought stress in mustard based cropping systems.

2.7 Management of biotic stresses in Indian mustard

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

Principal Investigator: Pankaj Sharma, Pr. Scientist (Plant Pathology)

Co-Investigators: P.D. Meena, Pr. Scientist (Plant Pathology), Anubhuti Sharma, Sr. Scientist (Plant Biochemistry)

Maintenance of geographical isolates of S. sclerotiorum

10 isolates of *S. sclerotiorum* were collected from different geographical regions of oilseed Brassica growing areas in the country and total 75 isolates were maintained for further study.

Screening of *Brassicas* germplasm for stem rot tolerance

Total 466 oilseed Brassica germplasm screened at ICAR-DRMR during 2018-19 cropping season. After artificial stem inoculation the lesion size and per cent infection was recorded. Among all the tested germplasm, 87 accessions showed

tolerance (lesion size <3.0 cm), and will be further evaluated under sick plot during next season.

Total 354 Brassica lines including core set, already identified tolerant, exotic and mutation were screened under sick plot at ICAR-DRMR. Sowing was done on 24 Oct 2018 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 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. Among all the tested germplasm accessions, DRMR 11, DRMR 2249, DRMR 2356, DRMR 364, DRMR 1309, DRMR 496, DRMR-1099-SR-1 and DRMR 1396 showed tolerant reaction (lesion size <3.0 cm and disease incidence<10%). Based on three years observations (2015-16 to 2018-19) , RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695 and IC 511651 were found tolerant (Table 22).

Table 22 : Performance of tolerant sources in *Brassica juncea* against Sclerotinia stem rot

Genotype	Source	Origin	2016-17		2017-18		2018-19		Mean	
			SLL (cm)	DS (%)*	SLL (cm)	DS (%)*	SLL (cm)	DS (%)*	SLL (cm)	DS (%)*
RH 1222-28	*B. juncea*	India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EC 597328	*B. juncea*	China	1.8	6.1	0.0	0.0	0.0	0.0	0.6	2.2
EC 766553	*B. juncea*	India	0.0	0.0	0.0	0.0	0.2	4.7	0.1	1.6
EC 766620	*B. juncea*	India	0.0	0.0	0.0	0.0	0.3	8.9	0.1	3.0
EC 765048	*B. juncea*	India	0.0	0.0	0.0	0.0	0.5	3.2	0.2	1.1
IC 492687	*B. juncea*	India	0.0	0.0	0.0	0.0	0.4	3.1	0.1	1.0
IC 492680	*B. juncea*	India	0.0	0.0	0.0	0.0	0.5	6.1	0.2	2.0
IC 492695	*B. juncea*	India	0.0	0.0	0.0	0.0	0.4	5.4	0.1	1.8
IC 511651	*B. juncea*	India	0.0	0.0	0.0	0.0	0.3	6.6	0.1	2.2
Rohini (Sus. check)	*B. juncea*	India	13.3	32.5	17.5	45.2	13.7	37.1	14.8	38.2

SLL: Stem lesion length; DS: Disease severity

Epidemiology

Epidemiological study was done using seven dates of sowing starting from Oct 8, 2017 at weekly intervals with three replications in plot size of 4.5x5 m using cultivar DRMRIJ 31 of Indian mustard. Data on soil moisture at weekly intervals, and disease incidence were recorded apart from petal infection and weather data to identify the suitable conditions for disease development.

During the cropping season, Sclerotinia stem rot incidence was low as weather conditions was not much favourable for disease development. Data analysis revealed that maximum incidence was observed in 29 Oct (13.0%) followed by 22 Oct while it was minimum in 19 Nov (4.6%) sown crop. Incidence of Sclerotinia rot was positively correlated with soil moisture, maximum and minimum temperature and bright sun shine hours (BSSH) and combination of these variables during critical stage of plant growth *i.e.* 60-70 DAS (flowering period) favoured higher Sclerotinia rot incidence. The highest seed yield was recorded in 8 Oct (35.4 q/ha) sown crop followed by 15th Oct (32.0 q/ha) while it was lowest in 19th Nov (15.1 q/ha) sown crop. Per cent

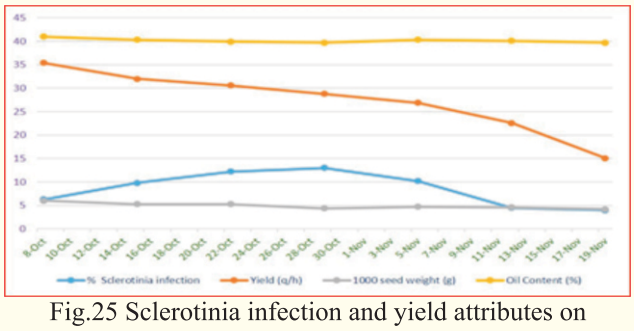


Fig.25 Sclerotinia infection and yield attributes on different dates of sowing

petal infection (PPI) resulted initiation of SR incidence in first standard week but later, disease did not progressed due to unfavourable weather conditions for disease development.

IDM module for major rapeseed-mustard diseases

An experiment on testing of IDM module for major rapeseed-mustard diseases was laid out in randomized block design with three replications on Sclerotinia infested plot at experimental farm, ICAR-DRMR. The crop var. DRMRIJ 31 was sown on 24 Oct 2018 in plot size 15 x 7m. The module consisted of combination of seed treatment (ST) with *Trichoderma harzianum* @10g/ kg seed, soil application of *Trichoderma* (1 kg/ 50kg FYM), basal application of zinc sulphate @ 15 kg/ ha+ S (dose location specific)+ boron (10 kg borax/ ha), line sowing 45X20 cm (RxP), no irrigation during 25th December to 15th January and control was (farmer's practice). Integrated disease management module given maximum seed yield, 1000 seed weight and oil content (26.3 q/ha; 5.6g; 40.5%) as compared to control (22 q/ha; 5.1g; 40.4%). Disease severity in IDM module was 6.9% as compared to control (16.0%).

Mustard residue management with *Trichoderma*

Lignocellulolytic microorganisms are the key agents in depolymerizing the lignin present in organic materials. *Trichoderma* spp. are widely known as a lignocellulose decomposer as they are filamentous and have the ability to produce prolific spores which can invade substrates quickly. isolated from the related ecological habitats. A study was carried out to analyze the colony forming units (cfu) of *Trichoderma* on mustard straw and its application in field to observe the effect on Sclerotinia disease severity and mustard seed yield.

Under *in vitro* experiment, mustard straw inoculated with *Trichoderma* sp (TS 2) as well as sclerotia of *Sclerotinia sclerotiorum* resulted $29.5x10^4$ cfu of TS2 and sclerotia were degraded. *In vivo* experiment was laid out on plot having mustard straw (2.5 t/ha). Variety DRMR IJ 31 was sown on 24 Oct. 2018 on plot size 9x5m with spacing 45x20cm (RxP) and 3 replications. After first irrigation (35DAS), straw was inoculated with *Trichoderma* sp. (TS 2) (multiplied on sorghum grains). Farmer practice was taken as control. The disease severity was low (7.8%) in plot having mustard straw+*Trichoderma* inoculation as compared to control 15.4%. Mean seed yield was higher in treated plots over farmer practice 27.3 and 21.8 q/ha, respectively.



Fig.26. *In vitro* mustard straw inoculated with Trichoderma (TS 2); colonized straw with degraded sclerotia and field experiment.

Development of RILs

Using identified tolerant sources development of recombinant inbreed lines (RILs) was initiated in 2015-16 involving RH 749 x RH 1222-28, RH 749 x EC 597328 and RH 406 x RH 1222-28. 217 Plants from F_3 population were advanced through



Fig 27. Susceptible and tolerant reactions

single seed descent (SSD) method. 153,283 and 122 F_2 population of respective crosses sown under sick plot condition and selfed. In artificial stem inoculation, more than 90% population showed tolerance (lesion size < 3.0 cm) against Sclerotinia rot.

DRMR PP-5 : Epidemiology and management of white rust

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

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

An experiment was laid out with seven dates of sowings, starting from Oct 08, 2018 to Nov 19, 2018 for epidemiological observations. The experiment was laid out under RBD (plot size 5 x 4.8m) with spacing 30x10 cm and 04 replications using susceptible variety 'DRMR IJ 31 (Giriraj). Data on disease incidence was recorded thrice and disease severity 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 severity (91.8%) was observed on late sown (19th Nov) crop followed by 5th Nov

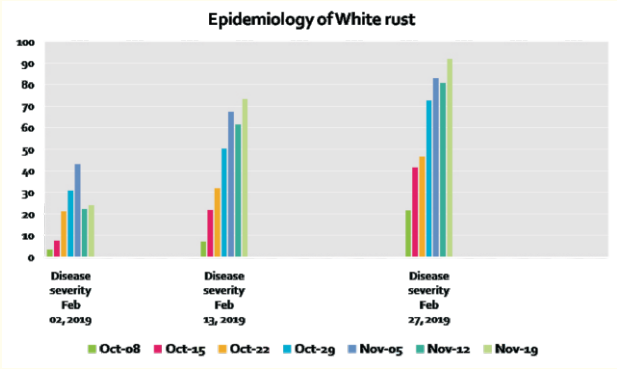


Fig. 28 Epidemiology of white rust

(82.9%) and 12th Nov sown crop (80.7%). However, disease severity on 5th Nov and 12th Nov sown crop was *at par*. The minimum disease severity (21.4%) was observed on early sown (8th Oct) crop. High incidence of staghead was observed in late sown crop. High relative humidity during January, 2019 favored the rapid increase in disease incidence in both, early and late sown crop (Fig. 28).

An experiment was planned to observe the effect of seed/soil and bud inoculation on white rust staghead formation with 4 treatment i.e. sowing with oospores infested seeds, sowing in soil inoculated with oospores, bud inoculation at 50 DAS without seed treatment and bud inoculation 50 DAS comprised treatment in 4x3 m plot size with 4 replications. The sowing was done on Oct 31, 2018 with 30x10 cm spacing. Observations on disease severity; No. of infected leaves/plant; total number of pustules on all infected leaves on 20 randomly selected plants/ plot was recorded (Verama and Petrie, 1979). The maximum number of pustules per plant (6.93) was recorded in bud inoculation without seed treatment followed by bud inoculation with seed treatment (5.86) and oospore infested soil (5.66). Similarly, the maximum white rust disease severity (57.0%) was recorded on bud inoculation without seed treatment followed by bud inoculation with seed treatment (56.2%) (Fig. 29 & 30).

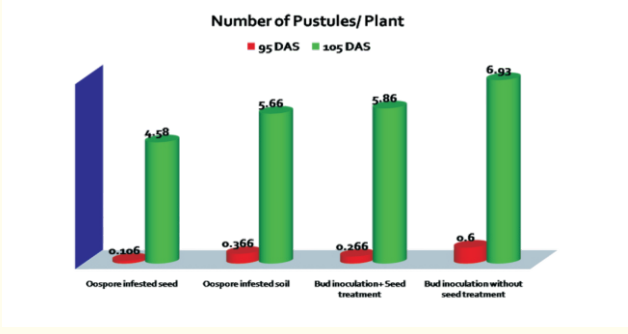


Fig. 29. Effect of soil/ seed infestation and flower bud inoculation on number of pustules/plant

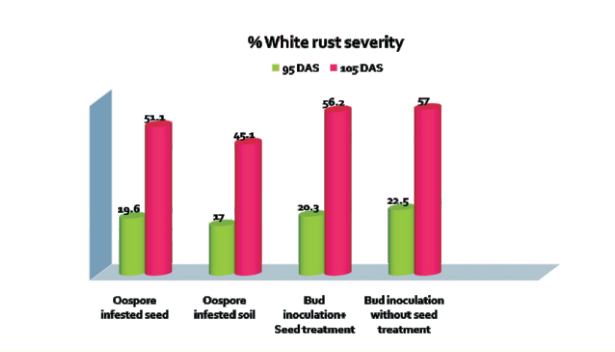


Fig. 30. Effect of soil/ seed infestation and flower bud inoculation on white rust severity

In order to standardize differential hosts for identification of *A. candida* races, an experiment was conducted in 5 x 3m plot size with 30 x 10cm spacing. Plant were inoculated twice, 45 and 60 DAS with spore suspension of Bharatpur isolate of *A. candida* on 11 genotypes of *B. juncea* (EC 399301, EC 399299, Rohini, Basanti, BioYSR, RH-30, DRMRIJ 12-28, DRMRIJ 12-40, DRMR 2035, DRMR 2019, RLC-3, DRMRAB 753). Disease reaction was observed twice, 90 & 115 DAS. DRMR 2019, EC 399301, BioYSR, EC 399299, RH 30 and DRMRAB 753 showed susceptible reaction whereas, DRMRIJ 12-40, DRMRIJ 12-28, DRMR 2035, Basanti and RLC 3 showed resistant (Fig. 31).

For effective management of white rust with minimum use of chemical fungicides, seven

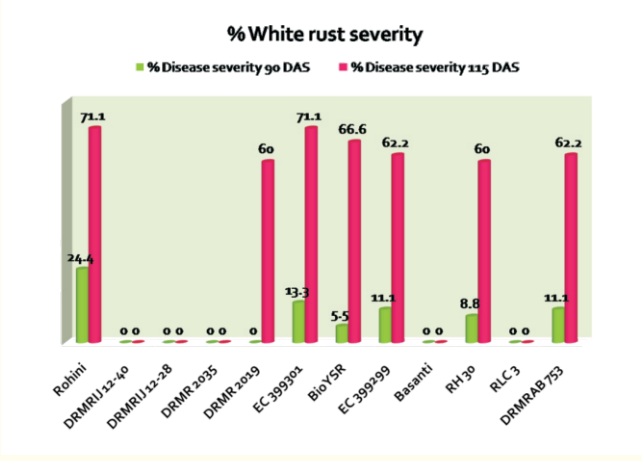


Fig. 31. Reaction of B. juncea genotypes to Bharatpur isolate of A. candida

treatments involving PGPR and new generation fungicides alone and in different combinations viz., seed treatment with metalaxyl 35@ 6g/kg seed+ FS metalaxyl 8%+ mancozeb 64% @ 0.2%, seed treatment with mefenoxam 33.3 @ 3 ml/ 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 (109 cfu), seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of P. fluorescence (109 cfu) and control were tested under field conditions. The experiment was planned in RBD with 04 replications. Plot size was 5x3m with 30x10 cm spacing. Sowing was done Nov 01, 2018. The crop was sprayed twice with fungicide/PGPR wherever required. Disease severity on leaves was recorded 90, 105 and 115 DAS. The maximum (71.5%) disease reduction was observed in T1 (ST metalaxyl 35@ 6g/kg seed+ FS metalaxyl 8%+ mancozeb 64% @ 0.2%) followed by T2 (seed treatment with mefenoxam 33.3 @ 3 ml/ kg seed+ foliar spray of metalaxyl-M @ 0.2%) and T4 (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 P. fluorescence (109 cfu was least effective (30.6% disease reduction) in controlling the disease followed by seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of *Bacillus subtilis* (109 cfu) (Fig. 32).

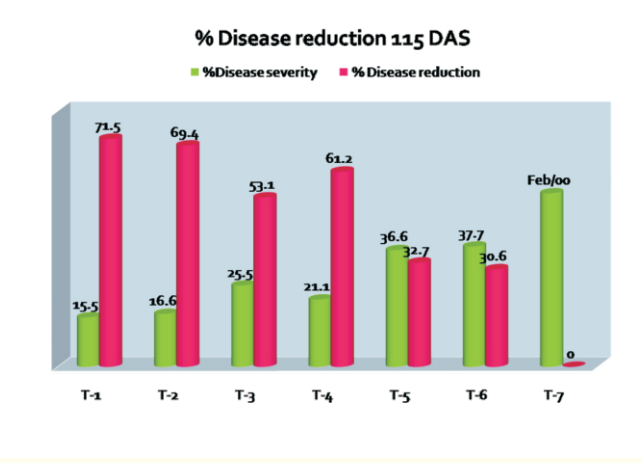


Fig. 32. Management of white rust

Under gene pyramiding for white rust resistance project, the parents and F5 population of different crosses were raised in plot size 4 x 3m with 30 x 10cm spacing in paired row. Sowing was done on

Oct 31, 2018. The observation on disease severity was observed twice, 105 & 115 DAS. Some of the plant of cross crosses of Heera with Pusa bold, Bio 902, Laxmi, Varuna, NRCDR 2, Maya, Vasundhara and Rohini were showed immune reaction to *A. candida* (Table 23).

Table 23 : White rust reaction on F_5 population different crosses

Crosses	% Disease severity (115 DAS)	Crosses	% Disease severity (115 DAS)
Pusa bold x Heera	82.2	NRCDR -02 x Heera	60
Pusa bold x Heera	0	NRCDR -02 x Heera	0
Pusa bold x Heera	82.2	NRCDR -02 x Heera	60
Pusa bold x Heera	64.4	NRCDR -02 x Heera	64.4
Pusa bold x Heera	64.4	NRCDR -02 x Heera	0
Bio - 902 x Heera	0	Maya x Heera	0
Bio - 902 x Heera	64.4	Maya x Heera	0
Bio - 902 x Heera	60	Maya x Heera	0
Bio - 902 x Heera	0	Maya x Heera	0
Bio - 902 x Heera	64.4	Maya x Heera	0
Laxmi x Heera	64.4	Vasundara x Heera	0
Laxmi x Heera	60	Vasundara x Heera	60
Laxmi x Heera	73.3	Vasundara x Heera	0
Laxmi x Heera	0	Vasundara x Heera	0
Laxmi x Heera	64.4	Vasundara x Heera	0
Varuna x Heera	0	Rohini x Heera	0
Varuna x Heera	0	Rohini x Heera	0
Varuna x Heera	0	Rohini x Heera	0
Varuna x Heera	60	Rohini x Heera	0
Varuna x Heera	60	Rohini x Heera	0

DRMR PP-6: Management of Collar rot caused by *Sclerotium rolfsii* in rapeseed-mustard crops

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

Co - Investigators : B.L. Meena, Scientist (Genetics and Plant Breeding), Sujith Kumar, Scientist (Biochemistry), M.K. Meena, Scientist (Soil Science)

As per the proposed technical programme, an experiment was conducted under controlled conditions under screen house to avoid the further spread of the pathogen as per recommendation of IRC. Simultaneously, a survey on appearance of the disease was conducted with the help of the different AICRP-RM centre. The appearance of collar rot disease was reported from Pahadi tehsil (31 Dec 2018) of Bharatpur and KVK, Bansur (2 Jan 2019) apart from ICAR-DRMR, Bharatpur (22 Dec 2018). Non occurrence of collar rot was reported from Pantnagar, Morena, Dholi, Guwahati and different locations.

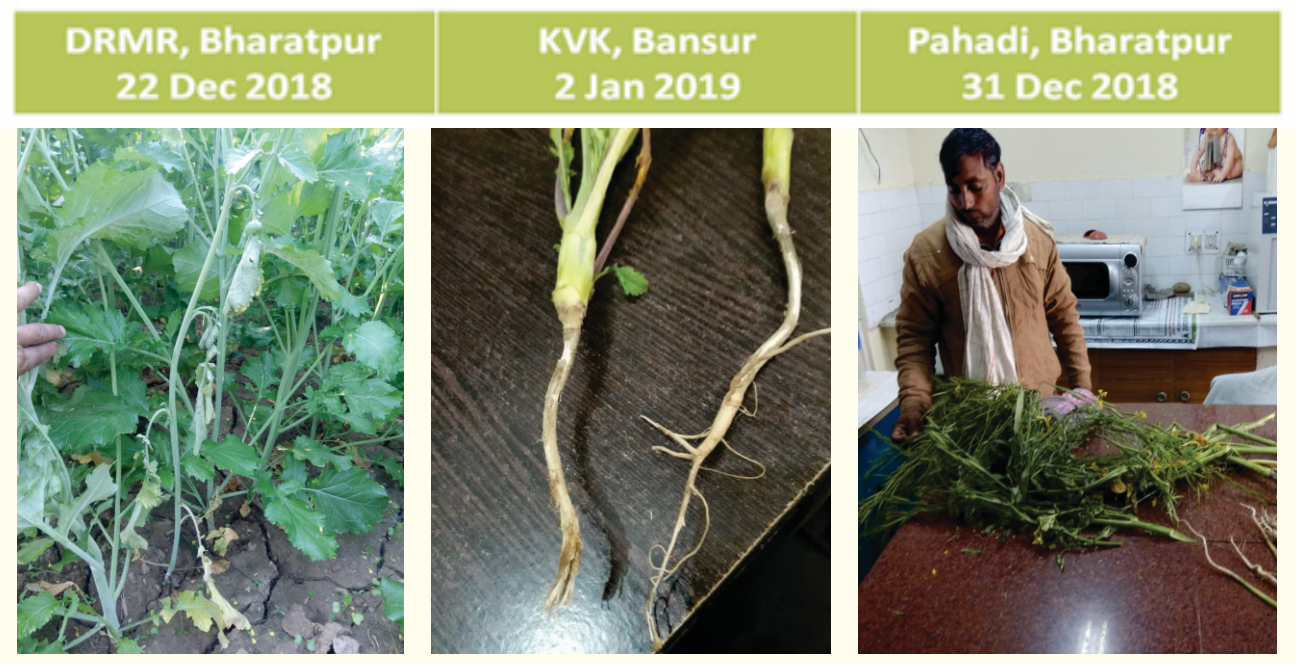


Fig 33. Appearance of collor rot at different locations

Mycelial growth of pathogen on different media

Seven media including Czepak-Dox agar, Potato Dextrose agar, mustard leaf extract, chick pea agar, oat meal agar, mustard stubble agar and corn meal agar were used for growth of the fungus. All media gave almost similar growth trends except PDA (Fig. 33).

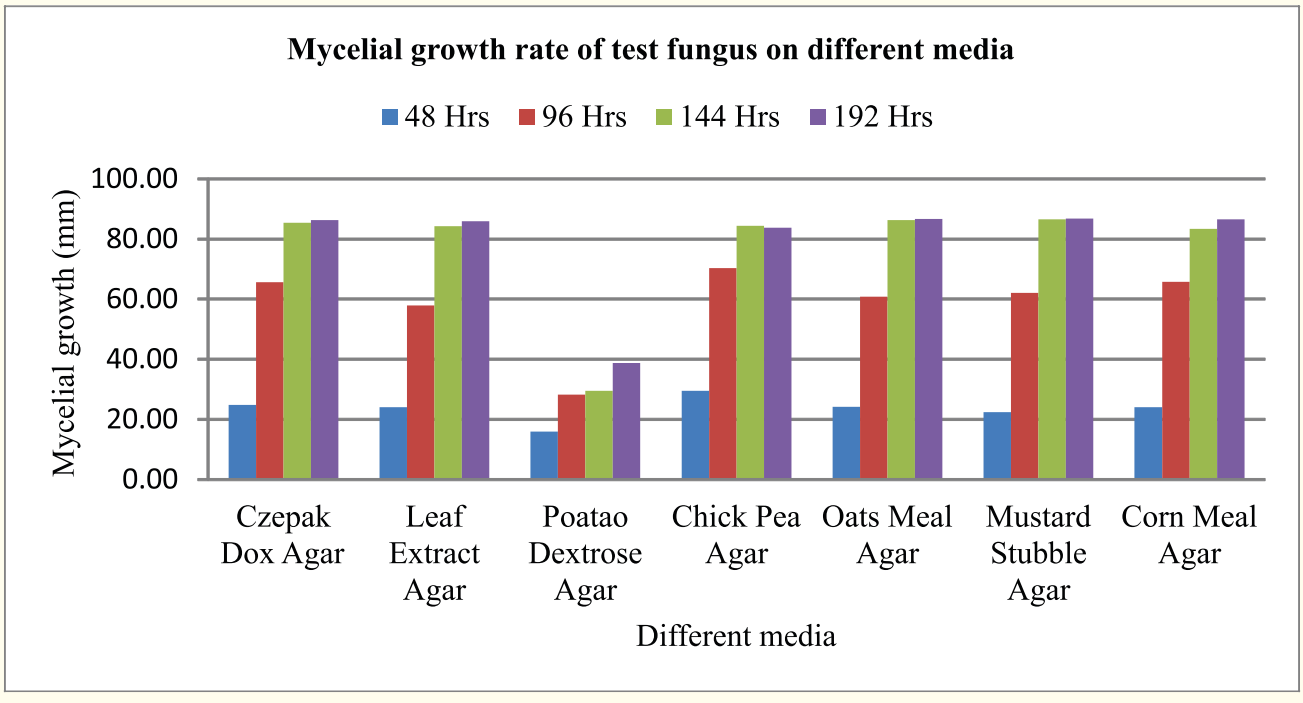


Fig 34. Mycelial growth of pathogen on different media

Pathogenecity test

Pathogenecity of collor rot fungus on *Brassica juncea* was tested using seed inoculation, stem inoculation, seed+stem inoculation, soil inoculation method in pot experiment sown on 5 Nov 2018. Disease free clean seeds of Indian mustard cultivar NRCHB 101 grown by adding recommended dose of fertilizers and FYM in cemented pots. The test fungus was grown on sterilized millet seeds and seeds were mixed with growth medium to create the infection court. The healthy seedlings were inoculated on 31 Dec 2018 with test fungus and allowed to growth for 3 to 6 weeks taking periodic reading on the symptoms. Results indicated that maximum infection occured in seed inoculation method (13.04%) followed by seed+soil inoculation (10.0%) in comparision to control (0.0%).



Fig 35. Pathogencity test in pot conditions

Identification of fungus

A fungal pathogen causing wilting of leaves and twigs and necrosis of stem, crown and roots at ICAR-DRMR since 2011, 5 to 10% incidence was isolated, purified and sent to the Agarkar Research Institute, Pune for morphological and molecular identification.

Analysis of the sequences of different fragments of the ribosomal genes demonstrated that this species belongs to the Nectriaceae and that this species is genetically different from other morphologically similar species of *Fusarium*. This new species is unique in having colonies on PDA at 25°C± 2°C, fast growing, rosy pink to vanacous, reverse pell leuteus to light ochraceous. Hyphae hyaline, smooth, pigmented, 2.75-4.77µm wide. Chlamydospores are intercalary, fusoid, hyaline, smooth walled and microconidia abundantly produced, fusoid, smooth walled, hyaline, foot cell present, and sickle shaped, 2-septate, 14.59-45.48 x 2.88-4.10µm. Microconidia fusoid, 1-septate, 2.5-2.67 x 2.67-13.7 µm. The fungus was morphologically identified as *Fusarium equiseti* (Corda) Sacc.

Molecular identification of isolated pathogen

To confirm the identity at the molecular level, the internal transcribed spacer (ITS) region and the translation elongation factor (*tef-1*) were amplified using the respective primers. Genomic DNA was isolated in pure form from the culture isolated from Indian mustard plant. The ITS-rDNA partial gene was successfully amplified using primers ITS4 & ITS5. The sequencing PCR was set up with ABI-BigDye® Terminatorv3.1 Cycle Sequencing Kit. The raw sequence obtained from ABI 3100 automated DNA sequncer was manually edited for inconsistency. The sequence data was aligned with publicly available sequences & analyzed to reach identity. The tested fungal strain showed 100% sequence similarity with *Fusarium euiseti*. Sequnce analysis with NCBI accession number EU326202.1, *Fusarium euiseti* isolate XSD-80 resulted in subsequent alignment statistics.

2.8 Technology Assessment and Dissemination

DRMR TAD-4 : Participatory extension for dissemination of Rapeseed-Mustard technology

Principal Investigator : Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension)

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

A study was conducted based on data collected from 240 selected farmers as key informants that represented different villages of selected districts viz., Bharatpur (No. 80) and Alwar (No. 40) of Rajasthan; Kanpur (No. 20) Banda (No. 20), Jhansi (No. 30) of Uttar Pradesh; Morena (No. 30) of Madhya Pradesh and Rewari (No. 20) of Haryana for studying the level of adoption of improved mustard production technology and identifying the major constraints faced by the farmers. The data were collected through group discussion, personal interview and triangulation methods.

Level of adoption of recommended mustard production technology by the farmers.

For studying adoption level, a standardized adoption scale was developed and used to collect the data for 12 major cultivation practices viz. i) variety, ii) field preparation, iii) soil treatment, iv) seed treatment, v) sowing time, vi) seed rate and spacing, vii) fertilizer management, viii) irrigation management, ix) weed management, x) pest management, xi) disease management and xii) harvesting and threshing. Each major practice was further divided into sub-practices and score was assigned against each practice according to its importance. After assigning the scores to different adopted practices by the farmers, adoption index were computed for selected 12 practices as mean per cent scores (MPS).

$$\text{Adoption index (MPS)} = \frac{\text{Total adoption score obtained by respondents}}{\text{Maximum obtainable score}} \times 100$$

On the basis of adoption index, the adoption of different practices were categorized into low (< 40), medium (40-60), high (61-80) and very high (> 80) level.

Table 24: Level of adoption of recommended mustard production technology by the farmers in different states

Adoption of practices	RJ (120)	UP (70)	MP (30)	HR (20)	Total (240)	Rank
	MPS					
Improved variety	81.7	68.6	83.3	90.0	78.8	I
Field preparation	58.3	54.3	60.0	70.0	58.3	III
Soil treatment	16.7	8.6	10.0	25.0	14.2	XII
Seed treatment	60.0	42.8	53.3	70.0	55.0	V
Time of sowing	63.7	57.1	60.0	75.0	62.1	II
Seed rate & spacing	31.7	35.7	36.7	60.0	35.8	VIII
Fertilizer management	52.5	34.3	40.0	65.0	46.7	VI
Irrigation management	41.7	32.8	36.7	70.0	40.8	VII
Weed management	25.0	21.4	23.3	35.0	24.6	X
Pest management	30.8	22.8	26.7	35.0	28.3	IX
Disease management	21.7	14.3	20.0	30.0	20.0	XI
Harvesting & threshing	66.7	44.3	43.3	65.0	57.1	IV

The table 24 reveals that majority of respondents were using improved varieties for sowing as reported with highest MPS 78.8 by all the groups of respondents followed by sowing the crop in time as adoption of "time of sowing" aspect was reported as second rank with MPS 62.1. The technology practices where level of adoption was medium (MPS 40-60) were "field preparation", " harvesting & threshing"; "Seed treatment", "fertilizer management" and irrigation management" with MPS 58.3, 57.1, 55, 46.7 and 40.8 respectively. The majority of respondents had low adoption (MPS < 40) of "seed rate & spacing", "pest management", "weed management, "disease management" and "soil treatment" with MPS 35.8, 28.3, 24.6, 20.0 and 14.2, respectively.

Constraints faced by the farmers in mustard production in major mustard producing states

A pre-structured schedule was used to collect the data for identifying constraints faced by the farmers in adoption of improved mustard production technology. Constraints were classified as economic, infrastructure, agro-climatic & technological. Mean per cent scores were worked out for each constraint in different categories to prioritize them for ranking on the basis of importance. The study reported that 5 economic, 8 infrastructural, 5 agro-climatic and 5 technological constraints were affecting the adoption of mustard technology among different groups of farmers in different magnitude.

i. Economic constraints

Among the economic constraints, low selling price of mustard was ranked first with MPS 87.7 by all groups of farmers. The high cost of cultivation was reported second most important economic constraint with MPS 73.8. The integrated fertilizers management plays the important role in balance nutrition of the plants resulting in the yield increase. Similarly, appropriate application of pesticides and weedicides reduce the loss of crop due to insects, diseases, pest and weeds.

The third and fourth most serious constraints reported by them were high cost of fertilizers (MPS 68.8) and pesticides & weedicides (MPS 60.4). The lack of profitable marketing system was reported as fifth most important economic constraint with MPS 60.4 by the respondents.

ii. Infrastructural constraints

It can be inferred that problems of stray animals has emerged as one of the most important problems being faced the farmers not only for mustard crops but many other crops. This constraint got first rank with MPS 88.3. The respondents reported that most of their crucial time is being exhausted in protecting crops from stray animals. The non-availability of pure/improved seed at the time of sowing was ranked second by the farmers with MPS 84.2. Timely supply of improved seed through co-operatives at village level is essential, quality control of improved seed is a must, to safeguard from dealers of spurious seeds which causes severe yield and economic loss to farmers. The performing all the required agricultural operations timely is crucial for proper plant growth and to get the higher yield, but shortage of labourers at the vital time was expressed third important infrastructural constraint with MPS 83.3 which adversely affects the production. Many agricultural tools and equipments have been developed to perform different agricultural operations especially seed drill, weeders, sprayers, threshers, harvesters, etc for mustard cultivation. To promote the mechanization may reduce the demand of labourers. Lack of irrigation facilities was ranked fourth important infrastructural constraint by the respondents with MPS 77.9. Fertilizer is the important input for higher crop but non-availability of chemical fertilizers and labourers at the vital time was expressed fifth important infrastructural constraint which led to low production with MPS 71.7. Therefore, timely and required supply of fertilizers should be ensured to the farmers. The lack of visit by extension personnel to the villages was reported by sixth ranked constraints by the respondents with MPS 70.8.

The farmers reported inadequate supply of electricity at time of sowing and irrigation as seventh ranked serious constraint with MPS 69.6.

These two stages are very crucial for crop growth, therefore continuous supply of electricity at these stages is essential.

A number of improved agricultural implements have been developed but they are beyond the reach of majority of the farmers due to their high cost. The inability to purchase improved agricultural implements by the majority of farmers as they were small and marginal was reported as eighth ranked constraint with MPS 66.3. These implements have to be low cost and may be provided on hired basis to the farmers through the co-operative society. Large number of farmers may benefit from timely credit facilities and simple procedures of the financial institutions.

iii) Agro-climate constraints

The study also highlights the agro-climatic constraints as reported by the mustard growers. High temperature at the time of sowing, poor soil fertility and salinity/alkalinity in the soil were ranked as I, II and III constraints with MPS 82.1, 73.8 and 68.8, respectively; by all the groups of farmers. The poor water quality and occurrence of frost and hailstorms were ranked as IV and V with MPS 61.3 and 57.9, respectively, by the respondents. The focus should be on development of high temperature tolerant varieties of rapeseed-mustard and agronomic practices to lower the effects of high temperature on the crop. The farmers should be motivated to improve soil fertility by using more of green manure and farm yard manure, compost use of amendments for treatment of salinity and water to improve its quality. For compensation of losses due to occurrence of frost, hailstorms and other climatic effects, farmers should be made aware to get the crop insured.

iv) Technological constraints

The adoption of technology requires knowledge and resources with the farmers. The study reported that lack of resources to adopt the technology as most important technological constraint with MPS 80.8 followed by lack of knowledge and skill about latest technologies advances with MPS 75.4. These two constraints reported by the farmers, reiterate the fact that if the extension personnel had visited regularly and identified the farmer's needs and problems and organized skill based training programme, the question of lack of knowledge of technological know-how would not have aroused. The unusual heights of plants was not preferred by the farmers as it was reported as third ranked constraint with MPS 70.0. Efforts should be made to develop short-height plant which facilitate harvesting and thrashing of the plant.

The researcher's working on mustard crop may strive for developing pest and disease resistant varieties as it was ranked the fourth most serious constraint by farmers with MPS 66.3. Efforts should also be made to develop and popularize suitable equipment which can be used in mustard cultivation like seed-cum fertilizer drill, weeding and hoeing machine, sprayers, harvester, etc as unavailability of suitable equipment was also reported as fifth ranked important constraint by the farmers with MPS 64.6.

On the basis of the findings, 5 economic, 8 infrastructural, 5 agro-climatic and 5 technological constraints were affecting the adoption of mustard technology among different groups of farmers in different magnitude. The study shows that non-availability of pure seeds/improved varieties/required inputs locally, problems of stray animals, low selling price of mustard, shortage of labourer at the time of agriculture operations, high temperature at the time of sowing, high cost of crop cultivation, lack of resources to adopt the scientific recommendations, lack of irrigation facilities, lack of knowledge and skill about latest technological advances, unusual heights of plants, poor fertility of soil and salinity/alkalinity in the soil were important constraints which were reported by more than 70% respondents of the study area in order of priority.

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

Principal Investigator: Vinod Kumar, Pr. Scientist (Computer Application)

Co-Investigator: Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension)

Number of web pages were developed and added covering activities, structure, projects, achievements, publications, collaborations, awards, reports, events, news, achievements of scientists, KVK web page, etc. Further, interface for database driven application for uploading events, news information were developed and required information were uploaded.

The online web based tool developed for rapeseed-mustard information management and disseminations have been updated. Latest data of Rapeseed-Mustard area, production and yield collected and complied for updation of Rapeseed-Mustard APY Information system. Information on newly developed Rapeseed-Mustard varieties were collected and complied for updation of the online tool RMSelect developed for selecting desired rapeseed-mustard variety.

Updation and maintenance of web site

Services:

- Scientists were facilitated in statistically analyzing their research data and plotting graphs using MS Excel and other statistical software.
- All the computers of centre are running on MS Window VISTA, MS-Window XP, Windows 8, Windows 10, operating system and MS-Office 2007, MS-Office 2003, etc application software. The main server of DRMR running on Linux. Problems related to these operating system and application software were solved by Computer cell.
- To receive the hardware/ software, arrange pre-installation requirements, satisfactory installation and maintenance of Hardware/ Software.
- Establishment, management and administration of campus LAN/ WAN
- Also provided services to the publications and to develop various electronics presentation using multimedia tools.
- Times to time on terminal (PC) trainings were given to the employees of ICAR-DRMR to enhance the computer skill and improve their work efficiency.

Externally Funded Projects

DRMR EA-2: Characterization of Rapeseed-mustard varieties for DUS testing

Principal Investigator: Priyamedha, Scientist SS (Genetics and Plant Breeding)

A total of 31 candidate varieties (3 hybrids, 28 farmers) of rapeseed-mustard were grown as per guidelines of PPV&FRA for testing of 24 DUS characters with 8 reference varieties. Eight farmer's varieties were characterized during first year for any species variation and/or mixture of species. 137 rapeseed-mustard varieties (95 varieties of *Brassica juncea*, 2 varieties of *B. campestris* var *brown sarson*, 7 varieties of *B. napus*, 5 varieties of *B. carinata*, 12 varieties of *B. campestris* var *yellow sarson* and 16 varieties of *B. campestris* var *toria* were maintained through appropriate mating systems. 42 rapeseed-mustard varieties were also characterized for 24 DUS characters to generate data base for reference varieties for PPV&FRA.

DRMR EA-4: ICAR Seed Project on seed production in agricultural crops

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

Co-Investigators: Pankaj Sharma, Pr. Scientist (Plant Pathology), Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension)

A total 335.85 q TL seeds of rapeseed-mustard varieties and hybrid were produced during *rabi* 2017-18. The improved varieties, DRMRIJ31, NRCHB101, NRCDR-02, DRMR 150-35 and hybrid NRCHB 506 of Indian mustard were included in the seed production programme. Quality seed production programme was conducted at different locations *i.e.* at ICAR-DRMR, Bharatpur, KVK Kumher, Madhurikund (DUVASU) farm, and ICAR-IIMR, Ludhiana in participatory mode. After seed processing, grading, treating and packing, the quality seeds

were sold to farmers and government agencies in the month of September and October, 2018.

Breeder seed production of Rapeseed-Mustard

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

Breeder seed of DRMRIJ31 (2.66 q), NRCDR02 (1.40q), NRCHB101 (6.54 q), and NRCYS 05-02(0.30q) was produced during 2017-18 and will be supplied during *rabi* 2018-19 to indenters as per DAC & FW guidelines.

DRMR EA-17: Creation of Seed-Hubs for Enhancing Quality Seeds Availability of Major Oilseed Crops- Rapeseed-Mustard, Funded by DAC & FW, GOI

Nodal Officer : P.K. Rai, Director, ICAR-DRMR, Bharatpur

Co-Nodal Officers : Bhagirath Ram, Pr. Scientist (Genetics and Plant Breeding), R.L. Choudhary, Scientist (Agronomy)

Rapeseed-Mustard seed hub project was initiated from *rabi* 2018-19 by involving eight seed hub centres *i.e.* KVK, Kamrup, Kahikuchi (AAU, Jorhat), Assam; RRS, Bawal (CCSHAU, Hisar); ZARS, Morena (RVSKVV, Gwalior); KVK, Kota (AU, Kota); ARS,Srigangangar (SKRAU); RLBCAU, Jhansi; KVK, Mirzapur (BHU) and DKVK, Ramkrishna mission, Saragachi, Murshidabad (WB). A target of 3850 qt certified seed production was allotted to these seed hub centers for *rabi* 2018-19. A budget of Rs. 8 crores was sanctioned during the financial year 2018-19 including Rs 50 lakhs for infrastructure and Rs. 50 Lakhs for revolving fund to each seed hub. The breeder seed of improved rapeseed-mustard varieties DRMRIJ-31, NRCHB101, RH-749, PM-30, RH-406 and YSH-401 was made available from ICAR-DRMR, Bharatpur to all seed hub centres. Effective monitoring of certified seed production programme was conducted under the guidance of Director, ICAR-DRMR during the cropping season. A total of 3135.71q certified seed was produced during 2018-19.

DRMR EA-18: NEH component, Enhancement of Rapeseed- Mustard Production in Tripura and Imphal

Nodal Officer: P.K. Rai, Director, ICAR-DRMR

Co-Nodal Officer: Bhagirath Ram, Pr. Scientist (Genetics and Plant Breeding)

A total of 104 demonstrations of Rapeseed-Mustard in an area of about 91ha in 4 clusters in Kakching Lourel, Kakching district (84); Khoirentak Khuman, Churchandpur district (15); Thoubal district (1); Sangaithel, Imphal West (4) of Manipur region were conducted during *rabi* 2018-19. The cluster demonstrations were conducted with the help of Central Agricultural University, Imphal, Manipur. The seeds of improved rapeseed-mustard varieties, NRCHB-101, YHS-401 and TS-38 were made available from ICAR-DRMR and CAU, Imphal.

DRMR EA-12: Pre-breeding for genetic enhancement of Indian (*Brassica juncea* Czern & Coss) and Ethiopian mustard (*Brassica carinata* A Braun) gene pool

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

Co-Investigator: Ajay Kumar, Sr. Scientist (Biotechnology)

Seventy inbred/germplasm lines, 36 progeny rows and 60 F_1 crosses and F_2 generation of 10 crosses of *B. carinata*, 15 inbred and 18 progeny rows of *B. napus* were raised and observations were recorded. 70 lines of *B. carinata* and 15 of *B. napus* were maintained. 80 F_1 crosses were attempted in *B. carinata*.

Evaluation of inbred/ germplsm lines of *B. carinata*: Seventy inbred/germplasm lines of *B. carinata* were evaluated in augmented block design keeping paired rows of 3 m length for each entry. Highest variability was recorded for main shoot length followed by seed yield and biological yield. Low variability was recorded for days to maturity and days to flower senescence. Mean estimates and range for agronomic traits are presented in table 25.

Table 25 : Performance of inbred lines

Parameter	DFI	DFS	DM	PH (cm)	MSL (cm)	BY (kg)	SY (kg)	HI (%)
Mean	83.6	129.3	158.5	192.2	40.8	3.1	0.5	20
CV (%)	26.8	10	4.9	25.3	43.8	38.4	39.3	21.8
Range	67	47	33	161	95.4	5.25	1.05	17
Minimum	52	103	136	114	19.6	0.79	0.12	10
Maximum	119	150	169	275	115	6.04	1.17	27

Generation of new crosses

80 new F_1 crosses in Line (16) x Tester (5) design were attempted. Lines: MCB 1-1-6-3, MCB 1-2-3-5-1, MCB 1-2-3-1-1, MCR 1-6-2, B.CARINATA IPS-14, OJR 2-2-1, IPS 31, MCB 1-2-3-12, Kiran Selection, MCB 1-2-3-13-3, IPS 30, MCB 1-2-3-2-5, Pusa Swarnim selection, IPS 23, MCB 1-2-5, F2 6-1; Tester: MCB 1-1-4-1, F2 11-2, K16, IPS-PRT.Carinata-72, IPS-PRT.Carinata-25

Selection from segregating generation

Individual plant selection was practiced from F2 segregating populations: K26 X IPS-20, K3 X MCB1-2-3-2-5, K14 X IPS20, K1 X IPS20, K5 X IPS20 BC PRT 18-44, IPSBC 18-6, IPSBC18-23, IPSBC18-35, IPSPRTCarinata-25

DRMR EA-14: Incentivizing Research in Agriculture - Indian Mustard

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

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

Co-Investigators: Ibandalin Mawlong, Scientist (Plant Biochemistry), Pankaj Sharma, Pr. Scientist (Plant Pathology), R.S. Jat, Pr. Scientist, (Agronomy), Ajay Kumar, Sr. Scientist (Biotechnology), Reema Rani, Scientist (Biotechnology)

Heat tolerance

Evaluation of Recombinant Inbred Lines (RILs) for high temperature tolerance received from IARI

RILs population (277) developed from IARI, New Delhi for heat tolerance were evaluated at ICAR-DRMR, Bharatpur. RILs were sown in 2 m row length on Sept 28, 2018 with two replications. Data were recorded on seedling emergence and seedling survival after 3rd, 5th, 7th, 9th and 11th day of seedling emergence. On the basis of comparative seedling survival after 5th days, RIL no. 22, 35, 91, 101, 104, 105, 110, 115, 144, 155, 156, 184, 225, 228, 230, 258, 263, 264, 273, 275, 276 were identified as heat tolerant. However, the experiment is vitiated due to heavy rainfall after 6-7 days of emergence.

Contribution in AICRP-RM

Two germplasm lines viz., DRMR 2059 and DRMR 2300, based on low seedling mortality (<20%) and high seeding dry weight (>4.0g) during 2017-18 at ICAR-DRMR Bharatpur, were contributed in AICRP-RM physiological trial.

Advancement of RILs

Two RIL populations, derived from the crosses NRCDR 02 x BPR 541-4 and NRCHB 101 x BPR 543-2, were advanced to F_4 stage through single seed descent method. A Total of 241 F_3 seeds (NRCDR 02 x BPR 541-4) and 270 F_3 seeds (NRCHB 101 x BPR 543-2) were sown in single row of 2m length spaced 30cm. The individual plants were selfed for advancing the populations to F_4.

Genotyping of F_2 population (NRCHB101 x BPR-543-2) for QTL mapping

F_2 population of the cross (NRCHB101 x BPR-543-2) was genotyped for QTL mapping. A total of 190 individuals along with parental lines were taken for the QTLs mapping. Genomic DNA was isolated from F_2 population with their parents i.e. NRCHB 101(P1) and BPR-543-2(P2) and quantified using agarose gel electrophoresis (Fig.36).



Fig. 36: Agarose gel showing genomic DNA of few selected F_2 population

Parental polymorphism survey

A total of 350 polymorphic SSR markers were used for screening the parental lines to identify the polymorphism among them. Out of these markers, 55 SSR markers were polymorphic and 250 were found monomorphic and rest of the SSR markers did not amplified. These 55 polymorphic markers were further used for genotyping the 190 individuals of F_2population.

Genetic relationship among NRCHB101 x BPR543-2 F_2 plants

Similarity coefficient data based on the proportion of shared alleles using 55 SSR markers was used to calculate the coefficient values among the 190 F_2 plants of cross NRCHB101 x BPR543-2 and parental *B. juncea* genotypes and subjected to UPGMA tree cluster analysis. The allelic diversity was used to produce a dendrogram (cluster tree analysis, NTSYS-PC), to demonstrate the genetic relationship among them. All the 190 F_2 plants clustered in two major groups. It was observed that the parental varieties NRCHB101 and BPR 543-2 had low similarity coefficient. Genetic relationship was also assessed by PCA analysis (NTSYS-PC). Two dimensional and three dimensional PCA scaling exhibited that two parental genotypes were quite distinct whereas all 190 F_2 plants interspersed between the two parental lines.

Linkage analysis, map construction and QTL mapping for heat tolerance and other related traits in *B. juncea* using NRCHB101 x BPR543-2 F_2 population

Mapping population (190 F_2 population developed from a cross NRCHB101 x BPR543-2) was screened with the co-dominant subset of 55 putative polymorphic SSRs. Data for SSR markers was obtained in the form of ABH scoring which was then used for map construction and QTL analysis. Linkage analysis and map construction were performed using Mapmaker software. The most possible order of marker in each group was determined using 'compare' and 'ripple' commands. In case of more than one possible arrangement of linkage groups, the one with smallest genetic linkage distance between adjacent marker loci of the linkage groups was chosen to construct the genetic map. Map was drawn with the help of QTL Cartographer after determining the best possible order by Mapmaker. Data analysis for mapping the QTLs associated with heat tolerance, yield and yield attributes related traits and phenological parameters is under progress.

Screening of new diverse lines/germplasm of Oilseed Brassica for stem rot tolerance

A total 1523 oilseed Brassica germplasms were screened at ICAR-DRMR, Bharatpur during 2017-18 by artificial stem inoculation. Among all the tested germplasm, RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695, IC 511651 and JM 6012 showed tolerant reaction (lesion size <3.0 cm and disease incidence<10%).

Two hundred forty nine germplasm lines of *Brassica juncea* sown for screening under sick plot at ICAR-DRMR, Bharatpur during 2018-19 season in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot and

border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design. Artificial stem inoculation was done for disease development.

Development of RILs for stem rot tolerance based upon available information

Based upon already identified resistance sources development of recombinant inbred lines (RILs) was initiated using EC 597328 (*B. juncea*, China) and RH749 F_2 population (256 RILs) was sown under sick plot condition and selfed. After artificial stem inoculation, >80% population showed tolerance (lesion size <3.0 cm and disease incidence<10%) against Sclerotinia rot. F_2 population was advanced through single seed descent (SSD) method. During 2018-19, F_3 seeds were raised in single 3 m length row. F_2 population of RH 406 x RH 1222-28 and RH 749 x RH1222-28 were also raised, selfed and artificial stem inoculation was done for disease reaction.

Molecular analysis of RIL population

F_2 population of RIL (EC 597328 x RH 749) was genotyped for the QTL mapping. A total of 160 individuals were genotyped along with parents *i.e.* EC 597328 (P_1) and RH 749 (P_2) for the QTL mapping. Genomic DNA of F_2 and parents was isolated and quantified using agarose gel electrophoresis. Parental screening is under progress for further genotyping of the population.

DRMR EA-15: CRP 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, Pr. Scientist (Genetics and Plant Breeding)

Co-Investigators: Ibandalin Mowlong, Scientist (Plant Biochemistry), P.K. Rai, Pr. Scientist (Plant Pathology), Priyamedha, Scientist (Genetics and Plant Breeding), Pankaj Sharma, Pr. Scientist (Plant Pathology)

Foreground selection of BC_3F_1 using markers linked to Glucosinolate loci and CAPS markers for Erucic Acid loci

A total 506 plants of BC_3F_1 crosses of DRMR150-35 x PDZ-1, DRMR-150-35 x RLC-3, NRCHB101xPDZ-1, NRCHB101 x HEERA were screened for quality trait (low glucosinolate and low erucic acid). Out of 506 plants, 105 were found low for glucosinolate and 12 were low for glucosinolate and erucic acid traits using markers linked to glucosinolate and erucic acid loci derived from above mentioned crosses. These 12 plants were selfed for generation advancement.



Fig. 37 : Agarose gel showing validation of markers linked to quality (low Glucosinolate); GER-1MRPR+ IP3GER-1F (Q1) M-100bp ladder plant NO.1-8 BC_3F_1 (DRMR150-35XPDZ-1), plant NO.9-14 BC_3F_1 (DRMR150-35xRLC-3),), PLANT NO.15-20 BC_3F_1 (NRCHB101xPDZ-1),H-Heera, D-DRMR150-35, N-NRCHB101 and P-PDZ-1

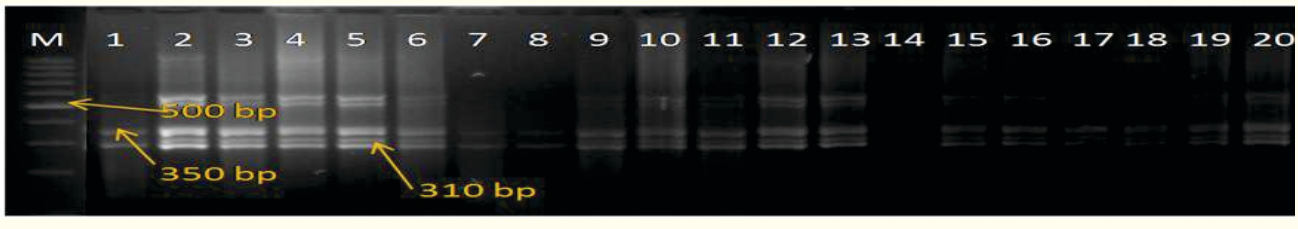


Fig. 38 : Agarose gel showing validation of markers linked to quality (low Glucosinolate);GER-5FPF + GER-5MRPR (Q5).M-50bp ladder plant no.1-8 BC_3F_1 (DRMR150-35XPDZ-1), plant no.9-14 BC_3F_1 (DRMR150-35xRLC-3),), plant no.15-20 BC_3F_1 (NRCHB101xPDZ-1)

Total glucosinolate estimation of selected plants (BC_2F_1)

About 400 plants were screened using markers for low glucosinolate and low erucic acid. A total of 18 plants from BC_2F_1 generation of cross NRCHB101xPDZ-1 and NRCHB101xHEERA were found to have glucosinolate content in the range of 50-70 µmol/g. However, range of glucosinolate in the plants derived from DRMR-150-35xRLC-3 and NRCHB101xHEERA was 70-80 µmol/g defatted seed meal. The parents i.e. NRCHB101, DRMR-150-35, PDZ-1, RLC-3 and Heera were found to have glucosinolate content of 131.2, 122.84, 26.73, 14.07 and 33.19 µmol/g defatted seed meal, respectively.

Glucosinolate estimation using UV-spectrophotometer

Glucosinolate content was estimated in F_3 generation derived from the crosses NRCHB101 x RLC-3,NRCHB101 x HEERA and DRMR150-35 x RLC-3 using standardized protocol at absorbance 425. F_3 populations showed the the glucosinolate content in the range of 10.82-123.26 µmol/g defatted seed meal. The crosses having total glucosinolate content < 30 µmol/g were reconfirmed by molecular markers. In F_3 generation, glucosinolate content was found in variable ranges i.e. < 20 µmol/g (6 plants), 21-40 µmol/g (39 plants), 41-60 µmol/g (117 plants), 61-100 µmol/g (154 plants),> 100µmol/g (13 plants) respectively.

Erucic acid estimation of F_3 using Gas Chromatography

The F_3 generation were harvested separately for estimation of erucic acid by using Gas Chromatography. Erucic acid content among parents is shown in table 26.

Table 26 : Total glucosinolate concentrations (T-GSL) in *µ*moles/g defatted seed meal and erucic acid content in F_3 generation

Crosses	Total glucosinolate content (µmole/g defatted seed meal) range					Erucic acid content (%)					
	0-20	21-40	41-60	61-100	>100	Samples	<2	2-20	21-40	>40%	Samples
NRCHB101x RLC-3	3	23	62	121	8	217	0	98	101	0	199
NRCHB101x HEERA	2	15	55	32	5	109	0	79	36	1	116
DRMR150-35 x RLC-3	1	1	0	1	0	3	0	1	2	0	3

Validation of samples using low glucosinolate markers

The samples which were found to have glucosinolate content < 30 µmol/g defatted seed meal in F_3 generation, and < 80 µmol/g in Bc_2F_1 defatted seed meal were validated using low glucosinolate molecular marker i.e. GER-1MRPR + IP3GER-1F(Q1) and GER-5FPF+GER-5MRPR(Q5).

White rust screening at off season nursery in Wellington

A total 39 lines (20 lines of BC_2F_2, 1 line of Bc_2F_3 and 18 lines of BC_3F_1 generation) were sown in off season nursery at Wellington for white rust screening and the resistant plants were selfed for further advancement. 32 lines of crosses namely DRMRIJ-31xDonskaja and NRCDR-02xDonskaja of generation BC_3F_3 and BC_3F_2 were also sown at off season nursery, Wellington for white rust screening and resistant lines were selected for further screening.

Foreground selection for white rust in BC_3F_1 using markers linked

Foreground selection of BC_3F_1 using white rust resistant markers (At5g41560 and At2g36360) of the crosses namely DRMR-150-35XBioYSR, DRMR-150-35XBEC-144 and NRCHB101 x BioYSR was done. Out of 450 plants, 64 were found resistant for white rust using markers.

White rust screening at ICAR-DRMR, Bharatpur

The white rust resistance plants of BC_3F_1, BC_2F_2, BC_3F_3, BC_2F_3 and BC_3F_4 generation were sown under late sown conditions at ICAR-DRMR, Bharatpur for screening. Fungal inoculum was sprayed at weekly interval. Three lines derived from the cross NRCDR-02xDonskaja (BC_3F_4) and one line derived from NRCHB101xBEC-144 (BC_2F_3 were found resistant at ICAR-DRMR, Bharatpur and off season nursery Wellington.

Similarly, white rust resistant plants selected at off season nursery, Wellington were screened at ICAR-DRMR, Bharatpur. One line derived from the cross DRMRIJ-31xDonskaja (BC_3F_3), one line from NRCDR-02xDonskaja (BC_3F_4), two lines from NRCHB101XBioYSR (BC_2F_3) and two lines from DRMR-150-35XBEC-144 (BC_3F_2) were found white rust resistant. These lines will be further confirmed at off season nursery Wellington.

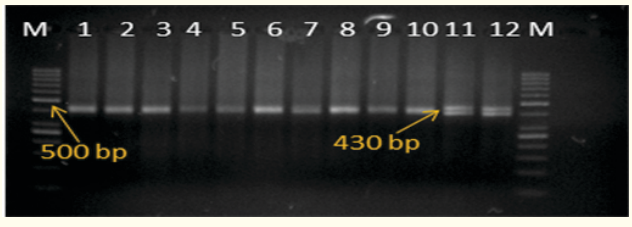


Fig. 39: Agarose gel showing validation of markers linked to white rust At5g41560 (AcB1-A4.1) loci, with an expected product size 430bp .M-50bp ladder 1-6 BC_3F_1 (DRMR150-35xBioYSR), 7-11 BC_3F_1 (DRMR150-35xBEC-144) and 14-Heera(Control).

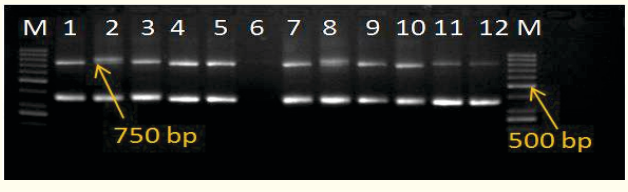


Fig. 40: Agarose gel showing validation of markers linked to white rust At2g36360 (AcB1-A5.1) loci, with amplified product size of 730bp M-50bp ladder. 1-DRMR150-35(Recipient parent) 2-Donskaja(Control), 3-7 BC_3F_1 (DRMR150-35xBioYSR), 8-12 BC_3F_1 (DRMR150-35xBEC-144)

DRMR EA-16: Creating a fully characterized genetic resource pipeline for mustard improvement programme in India (NASF)

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

Co-Investigators: Ajay Kumar, Sr. Scientist (Biotechnology), Har Vir Singh, Scientist (Agronomy)

Under NASF project, 289 genotypes provided by PAU, Ludhiana were raised in replicated trial with two replications. Observations on different agronomic traits, days to flowering started in 50% plants, 100% plants flowered, completion of flowering, days to maturity, height at initiation of flowering, height at first primary branch, height at maturity, height at Initiation of flowers, main raceme length, Number of primary branches, number of secondary branches, pods on main shoot, pods / plant, pod length , seeds / pod, 1000-seed weight, biological yield, seed yield, and SPAD data were recorded.

SR/WOS-A/LS-484/2017: Genome-wide association mapping for yield contributing traits in Indian mustard (*Brassica juncea* L. Czern & Coss.)

Principal Investigator: Nehanjali Parmar

Mentor: Ajay Kumar, Sr. Scientist (Biotechnology)

Trait-specific germplasm set of Indian mustard (145 genotypes) sown in the crop season 2018-19. Data was recorded for various agronomic traits including days to flowering initiation, days to maturity, plant height, main shoot length, No. of silique on main shoot, siliqua length and No. of seeds/siliqua. All the germplasm accessions were selfed to obtain genetically pure seeds using SSD method (Fig. 41).



Fig. 41 Trait specific Reference set of Indian mustard (145 germplasm accessions)

DRMR EA-9: Induced Mutagenesis for isolation of Alternaria blight resistant mutant in *Brassica juncea* (Sanction No. 35/14/44/2014 BRNS/2176)

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

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

Total 425 promising mutants of M_5 generation were evaluated for different traits during 2018-19. Total 29 mutants were screened for Alternaria blight tolerance under artificially created epiphytotic conditions. Experiment was conducted in two rows of each mutant with 3 m row length taking 45cm row to row spacing sown on 24 Oct 2018. BRNS-M-17-163, BRNS-M-17-174, and BRNS-M-17-177 (BRNS-M-18-63, BRNS-M-18-71 and BRNS-M-18-74) respectively were observed promising. Laboratory screening at cotyeldonary stage and true leaf stage for Alternaria blight tolerance under controlled conditions was done. Out of 29 mutants, 3 mutants BRNS-M-18-63, BRNS-M-18-71, BRNS-M-18-74 were found tolerant to Alternaria blight in detached leaf method, BRNS-M-18-63 and BRNS-M-18-64 were observed tolerant to Alternaria blight. Among 29 mutants screened for white rust, M_4 generation advanced to M_5 generation for white rust resistant under severe disease pressure at Bharatpur and all 29 mutants showed resistance against white rust under field condition. Biochemical analysis of 3 promising mutants BRNS-17-14 (11.7 µmole/g defatted seed meal), BRNS-17-15 (82.4 µmole/g defatted seed meal) and BRNS-17-16 (85.5 µmole/g defatted seed meal) showed that higher glucosinolate content might be responsible for resistance to white rust which is maximum in check BIOYSR (124.3 µmole/g defatted seed meal) that biochemically confirmed available resistance in this mutant. However, Total antioxidant capacity (8.35 mg/g AAE) and Radical scavenging activity (29.8 %) was lower than check 17.1 mg/g AAE and 41.9% respectively. Flower initiation appears 41 to 70 DAS while 50% flowering appears 44 to 74 DAS.

A total of 125 promising mutants were screened against sclorotinia rot dieses using stem inoculation method. Due to low disease, incidence, non significant result was observed. Among 26 high yielding mutants, BRNS-M-18-109 (29gm) and BRNS-M-18-110 (28gm) were selected on the bases of higher yield per plant. On the basis of per cent oil content > 43% two mutants were found promising BRNS-M-18-45 (43.07%) and BRNS-M-18-44 (43.69%) and selected for high oil content having yellow seed coat, seeds per siliqua (>18) and white rust resistance.

DRMR EA-10: Development of low glucosinolates and low phytic acid mutations for improving nutritional value of low erucic acid genotypes in Indian mustard (Sanction No. 35/14/42/2016-BRNS/35021)

Principal Investigator: Anubhuti Sharma, Sr. Scientist (Biochemistry)

Co-Investigators: H.S. Meena, Sr. Scientist (Genetics and Plant Breeding); Arun Kumar, Pr. Scientist (Cytogenetics)

Two low erucic acid varieties i.e. PM-21 & PM-30 were selected for mutagen treatment and irradiated with 1000 Gy & 1200 Gy doses of gamma ray. Three doses viz. 0.25, 0.50 and





Fig. 42: Variation A: Flower color variation B: Heavy load of siliqua and short height

0.75%. Chemical mutagen i.e. EMS was used to treat the seeds of same varieties. Combined treatment of radiation & chemical mutagen was also used.

M1 generation mutagen was raised dose wise also with control. In the experimental field, M1 seeds were sown in the month of Oct 2017. All the single plants of M2 generation from all treatments were harvested. Numbers of plants in each dose were counted to determine the dose effect on germination percentage. A large variation was seen in the treatments.



Fig. 43 : Single Plant variations

DRMR EA-13: XII Plan scheme National Agriculture Innovation Fund/ Intellectual Property Management and Technology Transfer/ Commercialization of Agriculture Technologies.

Principal Investigator : Vinod Kumar, Pr. Scientist (Computer Application)

Co-Investigator : Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension)

Technologies commercialization and revenue generation

The research outcomes were disseminated in the form of technology licensing and commercialization to various end users. During 2018-19, DRMR signed two MoA for licensing the Indian mustard hybrid NRCHB 506 with Genesis Seed Company, Belanganj, Tikonia, Agra on August 27, 2018 and VNR Seeds, Pvt. Ltd. Gomchi, Tendua, Raipur, Chhattisgarh on October 03, 2018. An amount of Rupee 3.0 Lakh was generated by licensing of NRCHB 506 with above mentioned seed companies.

Interaction cum Technology Demonstration

Interaction cum technology demonstration was organized at ICAR-DRMR, during 2018-19 the performance of mustard varieties/ hybrid *viz.* NRCHB 506, Giriraj (DRMRIJ 31), NRCHB 101, DRMR 1160-40 and NRCDR 02 were demonstrated to the representatives of various seed companies, farmers origination, Govt. officials, farmers and other visitors. The number of representatives from these organizations visited the demonstration, the participants/visitors were made aware with system of licensing for commercialization of varieties/technologies developed by ICAR-DRMR, Bharatpur.

Registration/renewal of varieties with PPV&FR: DRMR has registered

During the period, 05 rapeseed-mustard varieties (namely Pant Pili Sarson- 1, Nav Gold (YRN-6), NRCDR-02, Ashirwad (RK-01-3), NRCHB-506) were renewed and the annual fee Rs. 10000/- was submitted to PPV&FR as annual registration renewal charges.

DRMR NMOOP 1: Frontline demonstrations and other related activities of oilseeds

Nodal Officer: Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension).

Co-Nodal Officers : Pankaj Sharma, Pr. Scientist (Plant Pathology), Vinod Kumar, Pr. Scientist (Computer Application)

Frontline Demonstrations

Under the scheme "Frontline demonstrations and other related activities of Oilseeds" 27 cooperating centres of AICRPRM/ ICAR institutes/ Ag. Universities conducted 2080 frontline demonstrations (FLDs) on rapeseed-mustard in 67 districts across 14 states during 2018-19. Rajasthan had maximum (533) followed by Manipur (450), Assam (320), Uttar Pradesh (236) and Madhya Pradesh (129) FLDs. Four hundred nine FLDs were conducted on rapeseed and 1671 on mustard. All the demonstrations were conducted under whole package demonstrations in two different situations viz., irrigated (1129) and rainfed (951).

Also organized 6 Review Meetings of FLDs on RM to discuss about the performance of varieties/technologies demonstrated in FLDs at ZARC, Morena; RLBCAU, Jhansi; BUA&T, Banda; CSAUAT, Kanpur; KVK, Bansur and ZRS, Bawal during the period.

The maximum average yield of 2,754 kg/ha from the IP under irrigated conditions was in Haryana followed by 2,443 kg/ha in Rajasthan; 2,093 kg/ha in Punjab; 1,999 kg/ha in Gujarat and 1,858 kg/ha in Madhya Pradesh. The maximum yield gap of 62.7% was recorded in Jammu and Kashmir followed by 60.3% in Odisha; 60.0% in Himachal Pradesh; 37.8% in Uttar Pradesh; 18.8% in Madhya Pradesh and 17.8% in Maharashtra. The maximum ANMR/ha were Rs 22,544; Rs 16,503; Rs 15,343;, Rs 13,532; and Rs. 12,457 in Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Haryana and Rajasthan, respectively. The cost of cultivation ranged from Rs. 13,273/ha in Maharashtra to Rs. 34,462 /ha in Haryana in IP under irrigated whole package demonstrations.

The maximum average yield of 1,590 kg/ha from the WP under rainfed conditions was in Rajasthan followed by 1,167 kg/ha in Assam; 1,128 kg/ha in Jammu & Kashmir; 1,047 kg/ha in Jharkhand; 1,037 kg/ha in Himachal Pradesh; 1,016 kg/ha in Uttarakhand and 1,007 kg/ha in Manipur. The maximum yield gap of 47.7% was recorded in Jharkhand followed by 46.2% in Assam, 39.2% in Himachal Pradesh; 28.1% in Manipur, 21.8% in Uttarakhand, 18.2% in Jammu & Kashmir and 16.3% in Rajasthan. The maximum ANMR/ha were Rs 11,803; Rs 9,687; Rs 9,056; Rs 8,207; Rs. 7,998; Rs 6197 and Rs 5,524 in Assam, Jharkhand, Himachal Pradesh, Rajasthan, Manipur, Jammu & Kashmir and Uttarakhand, respectively respectively. The cost of cultivation ranged from Rs. 11,072/ha in Rajasthan to Rs. 26,152/ha in Jammu & Kashmir in IP under rainfed Whole package demonstrations.

A total of 20 improved varieties of Indian mustard, 3 of yellow sarson, 2 of toria and one of gobhisarson were used in WP covering eleven states under irrigated condition. Under irrigated condition, improved variety RH 725 of Indian mustard demonstrated in 30 FLDs in Haryana recorded highest average yield of 790 kg/ha with a yield improvement of 16.3% over local (FP) followed by DRMR 1165-40 demonstrated in 10 FLDs in Rajasthan with average seed yield of 2,650 kg/ha with yield improvement 13.7%. The minimum yield improvement of 4.4% was reported from RH 406 variety from 19 FLDs in Rajasthan, while minimum average seed yield of 933 kg/ha was reported from NRCHB 101 variety from 15 FLDs in Odisha. However, the variety NRCHB 101 in Jammu & Kashmir under irrigated condition recorded highest yield improvement of 66.1% with average seed yield of 1,709 kg/ha.

Under rainfed condition, the demonstrations with RGN 229 recorded a highest average seed yield of 2080 kg/ha with yield improvement of 12.4% in Rajasthan under rainfed situation. In Manipur, 123 demonstrations with DRMR 150-30 recorded lowest average seed yield of 994kg/ha with yield improvement of 27.3% over FP. However, the variety Shivani in Jharkhand under rainfed condition recorded highest yield improvement of

55.9% with average seed yield of 1,034 kg/ha.

Training programmes

Ten training programmes for extension workers of two days each were organized by ICAR-DRMR and AICRPRM centres for upgrading the knowledge and skills of grass root extension workers of States Department of Agriculture about research developments in the field of rapeseed-mustard.Two training programmes simultaneously by KVK(ICAR-DRMR), Bansur, Alwar (24-25 Feb. 2019 for 35 participants) and one each by Sriganganagar(27-28 Feb. 2019 for 20 participants)and Kota (12-13 Feb. 2019 for 20 participants)in Rajasthan;Ludhiana (11-12 March 2019 for 20 participants)in Punjab;Hisar (30-31 Jan 2019 for 20 participants)in Haryana;Chhata(27-28 Feb. 2019 for 18 participants) in Jammu & Kashmir;Kanpur (1-2 Feb. 2019 for 20 participants) in Uttar Pradesh;Morena (21-22 Feb. 2019 for 25 participants) in Madhya Pradesh and SK Nagar (17-18 Jan 2019 for 20 participants)in Gujaratwere organized during 2018-19. In these training programmes a total of 198 extension workers of respective districts/states participated and they were made aware of the new technologies advances in rapeseed-mustard cultivation so that they communicate the same to the farmers in the field.

DRMR-ATMA 1: Study the effect of different sources of sulphur on yield and oil content

Principal Investigator: Ashok Kumar Sharma, Pr. Scientist (Agriculture Extension)

Co-Principal Investigators: Anubhuti Sharma, Sr. Scientist (Biochemistry), M.D. Meena, Scientist (Soil Science), Har Vir Singh, Scientist (Agronomy), Udaibhan Singh, Professor & In charge, ARSS, Kumher; Balveer Singh, Deputy Director & In charge, ATC, Malikpur

A project entitled "Study the effect of different sources of sulphur on yield and oil content" was funded by ATMA, Bharatpur with total budget outlay of Rs. 5.0 lakh for 2018-19. The experiments under the aforesaid project were conducted at ICAR-DRMR and ATC, Malikpur under irrigated condition and ARSS, Kumher under rainfed condition during 2018-19. The experiment consisted of three treatments, viz. Control or recommended dose of N, P fertilizers (T1), Sulphur @40 kg/ ha through gypsum, (T2) and Sulphur 40 kg/ ha supplied through bentonite (T3). The experiments were conducted in randomized block design (RBD) with 7 replications. The plot size was 5x5 m^2. Yield and oil content was recorded.

The data revealed that sulphur significantly improved the seed yield of mustard. ICAR-DRMR recorded average seed yield of 2422 kg/ha with the treatment of bentonite and 2321 kg/ha with the treatment of gypsum along with yield improvement of 6.5% and 11.2%, respectively over control (2178 kg/ ha) under irrigated condition. ATC Malikpur recorded average seed yield of 2210 kg/ha with the treatment of bentonite and 2150 kg/ha with the treatment of gypsum along with yield improvement of 9.5% and 12.5%, respectively over control (1964 kg/ ha) under irrigated condition.

ARSS Kumher recorded average yield of 2426 kg/ha with the treatment of bentonite and 1960 kg/ha with the treatment of gypsum along with yield improvement of 1.8% and 26.0%, respectively over control (1925 kg/ ha) under rainfed condition.

The improvement of oil content ranged from 0.24 to 1.27% under irrigated condition and 0.32 to 0.47% under rainfed condition with gypsum and bentonite treatment, respectively.

Higher seed yield and oil content were recorded with 40 kg/ ha application of bentonite at all three locations.

Based on preliminary study, it showed that among two sources of sulphur, bentonite sulphur performed better in terms of mustard grain yield and oil contents. However, based on one year data, it is not appropriate to draw the final conclusion. The study needs to be continued further to draw the logical conclusion about the effect of different sources of sulphur on yield and oil content of mustard.

3 Transfer of Technology

Training programmes organized

ICAR-DRMR organized 13 trainings of 3-5 days duration for different stakeholders. These were organized during August 17-21, 2018 (33 participants) and September 15-19, 2018 (33 participants) on "Bee keeping and agriculture management" sponsored by PD ATMA, Tonk (Raj.); September 10-14, 2018 (20 participants) on "Production technology of mustard and other rabi crops", sponsored by PD ATMA, Gwalior (MP); September 24, 2018 (30 participants) and February 15-19, 2019 (30 participants) on "Scientific Production Technology of Mustard and Agriculture Management", sponsored by PD ATMA, Dholpur (Raj.). One training programme of 5 days duration during August 27-31, 2018 (34 participants) was organized on "Oilseed production Technology and its usefulness" for ATM/BTM/TA working of different districts of Uttar Pradesh sponsored by State Institute of Agriculture Management, Rehamankheda, Lucknow (UP). One training programme of 4 days duration during December 2-5, 2018 (35 participants) was organized on "Scientific Production Technology of Mustard" for tribal farmers of Lathehar district of Jharkhand, sponsored by ICAR- IIAB, Ranchi, Jharkhand. One training-cum-exposure programme of 3 days duration during February 24-26, 2019 (53 participants) was organized on "Scientific Production Technology of Mustard for Jharkhand" for tribal farmers of East Singhbhum and West Singhbhum districts of Jharkhand under STC programme of ICAR-DRMR. A total of 268 farmers and extension personnel from Rajasthan, Madhya Pradesh, Uttar Pradesh and Jharkhand were trained.

Besides, 20 trainings and one scientists-farmers gosthi of two days each under ATMA, Bharatpur were also organized during 2018-19, wherein farmers from Bharatpur district of Rajasthan participated.

Mera Gaon Mera Gaurav Programme

The "Mera Gaon Mera Gaurav" programme was actively taken up by ICAR-DRMR during 2018-19 to provide farmers with required information, knowledge and advisories on regular basis by adopting villages. Six Interdisciplinary groups of five members comprising of both scientific and technical staff was constituted for this purposes . Each group identified and adopted five villages in the vicinity of the institute and conducted meetings with farmers of respective villages before the start of mustard season. A total of 30 villages were adopted under MGMG programme by ICAR-DRMR. The group members visited their respective adopted villages during all stages of farming operations to give necessary instructions. Benchmark reports were made about the farming, climate and social and economic conditions of selected villages. Live telecast of honourable Prime Minister on Kisan Samman Nidhi Yojana on 24th February, 2019 was also organized for farmers.

Front line demonstrations (FLDs) on mustard conducted

A total 353 frontline demonstrations (FLDs) under whole package with five improved varieties Giriraj (266 FLDs), NRCHB 101 (39 FLDs), RH 725 (22 FLDs), PM 30 (16 FLDs) and DRMR 1165-40 (10 FLDs) were laid out in different villages of Bharatpur district of Rajasthan during the crop season 2018-19 to show the impact and production potential of these varieties on farmers' field. The average yield of demonstrated varieties viz., Giriraj, NRCHB 101, RH 725, PM 30 and DRMR 1165-40 was 2565, 2604,2531,2302 and 2650 kg/ha with yield improvement of 9.8, 7.38, 10.1, 7.6 and 13.7 % and additional net monetary return (ANMR) of Rs. 12096, 9657, 11360, 9716 and 15940, respectively over prevailing varieties. The average cost of cultivation under different varieties ranged Rs. 30000 to 32201 in IP, while it ranged Rs. 32500-34695 in farmers' plot. Out of these FLDs, 325 were laid out in 30 villages adopted under MGMG and rest of 28 were laid out

in other villages for wider dissemination of improved varieties. Technological interventions like Sulphur and Zinc application, seed treatment with Carbandazim to the farmers and extension workers. Regular visits to the adopted villages were organized for interaction meeting with farmers, monitoring of FLDs, providing first hand solution of the problems faced by the farmers, etc.

Sarson field day Organized

Seven Sarson Field days were organized in adopted villages namely; Nagla, Kalyan (25-1-2019), Ludhawai (2-3-2019), Visda (24-1-2019), ChakSitara (18-1-2019), Mudota (25-2-2019), Naswara,(7-3-2019), Lulahara (8-3-2019) of Bharatpur (Raj.) under MGMG programme, to show the performance and production potential of improved varieties of Indian mustard to the farmers and extension personnel at the farmers' field. About 900 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.



Literature Supported

Appropriate literature/ folders on scientific cultivation of mustard, potato, vegetables and other farming technologies were also distributed among farmers.

Sarson Farm School organized

ICAR-DRMR organized 10 Sarson Farm Schools in different villages namely, Notha, Chonkarwada, NaglaKalyan, Hantra, Kama, Awu, Unch, Babain, Ludhwai, Habibpur of Bharatpur district of Rajasthan during 2018-19 crop season sponsored by ATMA, Bharatpur, Department of Agriculture, Govt. of Rajasthan. To impart extensive and semi-formal training to mustard farmers. ICAR-DRMR reached at the farmers' door through this program for effective transfer of rapeseed-mustard technology and to provide the on spot solution of the problems faced by the farmers in adoption of scientific technology.



The Sarson Farm School brings the technology expertise of the scientists to the village in the form of formal and informal interactions. A technology demonstration on complete package of practices of mustard was laid out in one hectare area of an achiever farmer in each farm school to show the production potential of the scientific technology and serving as to the primary resource for learning to participating farmers. Each farm school provided comprehensive training on rapeseed-mustard cultivation and other related issues of crop production to 25-30 participants through demonstration, lectures, focused group discussion, agro-ecosystem analysis, etc.

"Sarson School on AIR" programme

To provide timely advice on various advanced production practices of rapeseed-mustard, enhance the knowledge and create confidence in adoption of improved technology among the farmers, Sarson School on AIR (Radio Krishi Shiksha Programme) was broadcasted in Rajasthan and Uttar Pradesh during 2018-19 through 6 All India Radio stations of Jaipur, Alwar and Kota of Rajasthan and Mathura, Varanasi and Agra of Uttar Pradesh. DRMR's scientists communicated the scientific technology to the

farmers and extension personnel of these states through 24 weekly episodes of radio talk during Sept., 2018 to Feb., 2019.

Visitors Advisory Services of ICAR-DRMR

Under Visitors Advisory Services, successfully organized/ coordinated interaction meetings and counselling sessions on rapeseed-mustard cultivation for 45 visiting groups of farmers and 8 groups of students from Rajasthan, Uttar Pradesh, Gujarat, Haryana, Himachal Pradesh and Madhya Pradesh consisting of 2316 stakeholders including 1430 farmers, 218 farm women, 310 extension personnel, 324 students and 34 teachers. The visiting groups were educated through lectures, visit to technology park, experimental fields, museum and also provided literature.



ICAR-DRMR on Print media

About 40 news items / stories/advice, etc. were published during the period in daily and weekly Hindi newspapers viz., Rajasthan Patrika, Dainik Bhaskar, Srusti Agro, Amar ujala, Dainik Navjoyati, Rastradoot, Punjab Kesari, Haldhar Times, Krishi Goldline etc. to educate and make farmers, farm women, extension personnel aware of scientific rapeseed-mustard cultivation technologies and programmes and activities of Directorate.

4 Training and Capacity Building

4.1 TRAININGS

4.1.1 Scientist

Topic	Venue	Period	Participants
Marker-assisted breeding in oilseed mustard (*Brassica juncea*)	CGMCP, University of Delhi South Campus, New Delhi	August 20-25, 2018	Bhagirath Ram, Ajay Kumar
Statistical analysis of data in agriculture	ICAR-NAARM, Hyderabad	September 6-11, 2018	Anubhuti Sharma
Training of trainers under Agriculture Skill Council of India	SKRAU, Bikaner	September 20 to 22, 2018	Bhagirath Ram
Advances in web and mobile applications development	ICAR-NAARM, Hyderabad	December 05-10, 2018	Vinod Kumar
21 days Training Program on "Advances in experimental designs and analysis" organized under the aegis of centre for advanced faculty training.	ICAR-IASRI, New Delhi	December06–26, 2018	RL Choudhary
LC/MS/MS basic triple quadrupole training program	SCIEX, Gurgaon	February 20-22, 2019	Anubhuti Sharma
Short training course "Non destructive high throughput phenotyping for gene discovery and development of climate resilient crops	ICAR-IARI, New Delhi.	March - 2019	Priyamedha

4.2 Participation in Seminars, Symposia, Conferences, Meetings

Event	Venue	Duration	Participant
National conference "Enhancing productivity of Oilseeds under changed climate scenario" (NOCS 2018)	ICAR-DGR, Junagarh	April 7-9, 2018	P.K. Rai, Pankaj Sharma
Review Meeting of FLDs	BHU, Varanasi	April 16, 2018	P.K. Rai
National Seminar on Road Map of vegetable oil production by 2022	ICAR-IIOR, Hyderabad	April 28-29, 2018	P.K. Rai, Pankaj Sharma
DAE-BRNS Life Sciences Symposium On "Frontiers in Sustainable Agriculture"	DAE Convention Centre, BARC, Mumbai	April 26-28, 2018	R.L. Choudhary
International Conference on "agriculture, Allied & Applied Sciences with Special Reference to Energy, Environment and Biotechnology Research	JNU, New Delhi	April 28-29, 2018	Anubhuti Sharma
Kisan Kalyan Karyashala Evam Kharif Krishak Goshti 2018	Panchayat Samiti Kumher, Bharatpur	May 02, 2018	K.H. Singh
Joint Annual Group Meeting of 33rd AGM of AICRP-NSP & 13th ARM of ICAR Seed Project on "Seed Production in Agricultural Crops	PAJANCOA & RI, Karaikal, Puducherry (UT)	May 9-11, 2018	Bhagirath Ram
Meeting regarding Quality Characteristics of Crops/Commodities and their availability for commercial scale processing and value addition in India.	NASC, New Delhi	May 15, 2018	P.K. Rai
XXXVIII Plant Germplasm Registration Committee	NBPGR, New Delhi	June 02, 2018	K.H. Singh, Arun Kumar
Review Meeting of CRP Molecular Breeding	IARI, New Delhi	June 09, 2018	V.V. Singh
Review Meeting of CRP on Hybrid Technology	IARI, New Delhi	June 09, 2018	K.H. Singh
Meeting on "Creation of seed hub for enhancing quality seeds availability of major oilseeds crops" under NFSM-Oilseeds approved by DAC & FW for 2018-18 to 2019-20.	ICAR-IIOR, Hyderabad	June 11, 2018	P.K. Rai
Review Meeting of IRA Project	NRRI, Cuttack	June 21, 2018	V.V. Singh
Solvent Extractors Association of India Rapeseed Mustard Conclave 2018	Jaipur	July 07- 08, 2018	P.K. Rai, K.H. Singh
Workshop on "Conservation Agriculture in India: Key Learnings, Research Gaps And Way Forward for Impact at Scale	NASC, Pusa, New Delhi	July 9-10, 2018	R.L. Choudhary
Formal Group Meeting of IRA Project	SS&T, New Delhi	July 11, 2018	V.V. Singh
24th AGM of AICRP-RM workers	BHU, Varanasi	August 4-6, 2018	P.K. Rai,V.V. Singh, K.H. Singh, P.D. Meena, A.K. Sharma, Pankaj Sharma, Bhagirath Ram, Arun Kumar, H.S. Meena, Anubhuti Sharma, I. Mowlong
International conference on "Agriculture and allied sciences: the productivity, food security and ecology"	BCKV, Mohanpur, Nadia, West Bengal	13-14 August, 2018	H.K. Sharma
Meeting of Varietal Identification Committee for Oilseed & Pulses crop.	Krishi Bhawan, New Delhi	August 16, 2018	P.K. Rai
The Rabi Zonal Research and Extension Advisory Committee (ZREAC).	Agricultural Research Station, Navgoan, Alwar	August 30-31, 2018	Arun Kumar
Meeting on Development of protocol for DNA Fingerprinting of crop varieties	NBPGR, New Delhi	September 07,2018	K.H. Singh
14th DUS Review Meeting at PPV&FRA	NASC, New Delhi	October 04, 2018	Priyamedha
Review Meeting of NASF Project	IASRI, New Delhi	October 08, 2018	K.H. Singh
World Food Day Function along with Agri-startup & Entrepreneurship Conclave	NASC, New Delhi	October 16, 2018	P.K. Rai
Review of Seed Hubs of pulses, oilseeds and nutri-cereals.	ICAR, New Delhi	October 22, 2018	P.K. Rai
Chaired meeting of stakeholder of STC Programme under implementation in Jharkhand state.	ATARI, Patna	October 23, 2018	P.K. Rai

Event	Venue	Duration	Participant
Chaired meeting of stakeholder of STC Programme under implementation in Jharkhand state	ATARI, Patna	October 23, 2018	P.K. Rai
XXI Biennial National Symposium on "Doubling Farmers' Income through Agronomic Interventions under Changing scenario"	RCA, MPUAT, Udaipur	October 24–26, 2018	RS Jat, RL Choudhary
International Conference on "Global Research Inititative for sustainable agriculture and allied science"	RARI, Durgapura, Jaipur	October 28-30, 2018	P.K. Rai, Pankaj Sharma, M.K. Meena, B.L. Meena
1st National Genetics Congress	IARI, New Delhi	December 14-16, 2018	K.H. Singh
PAC Meeting of ICAR Extramural projects	ICAR, Krishi Bhawan, New Delhi	December 19, 2018	K.H. Singh
International Conference on Food Security and Sustainable Agriculture (IFSA-2018), at, Pataya Bangkok, Thailand	Asian Institute of Technology, Bangkok, Thailand	December 21-24, 2018	Bhagirath Ram
XXXIX Meeting of Plant Germplasm Registration Committee.	ICAR-NBPGR, Pusa Campus, New Delhi.	January 28, 2019	P.K. Rai
VC-Director's Conference	NASC, New Delhi	January 31-February 01,2019	P.K. Rai
4th National Brassica Conference, organized by Society for Rapeseed-Mustard Resaerch, Bharatpur	CSAUA&T, Kanpur	February 1-3, 2019	K.H. Singh, P.D. Meena, Bhagirath Ram, Arun Kumar, H.S. Meena, B.L. Meena, I moulong, M.S. Sujith Kumar
Review Meeting of DBT-UDSC partnership centre on Genetic Manipulation of Brassicas'	Delhi University, South campus, New Delhi	February 02, 2018	P.K. Rai
XXV Meeting of ICAR Regional Committee (VI)	AAU, Anand, Gujarat	February 4-5, 2019	P.K. Rai
ICAR-CSSRI Golden jubilee international salinity conference on "resilient agriculture in saline environments under changing climate: challenges & opportunities"	ICAR- CSSRI, Karnal, India	February 7-9, 2019	R.L. Choudhary
13th International Conference on "Development of drylands converting dryland areas from grey to green"	ICAR-CAZRI, Jodhpur	February 11-14, 2019	H.K. Sharma, M.L. Dotaniya
International Conference on Trends in Plant Sciences and Agrobiotechnology-2019	Indian Institute of Technology, Guwahati	February 14-16, 2019	Arun Kumar, Ajay Kumar
14th Agricultural Science Congress	NASC, New Delhi	Feb 20, 2019	V.V. Singh
XIV Agricultural Science Congress	NASC, New Delhi	20-23 February, 2019	R.S. Jat, H.V. Singh, R.L. Chaudhary
SAC meeting of KVK	KVK, Bansur	March 1, 2019	P.K. Rai
National Conference on Advances in Chemistry, Food Technology & Environmental Sciences Towards Sustainable Development	R.B.S. Engineering Technical College, Bichpuri, Agra	March 8-9, 2019	Anubhuti Sharma
2nd meeting of proposed "National Mission on Vegetable Oils" (NMVO), 2019-20 to 2023-24.	Krishi Bhawan, New Delhi	March 13, 2019	P.K. Rai

5 Awards and Recognitions

Dr. P.K. Rai, Director, received Outstanding Achievement Award- in GRISAAS-2018 during October, 28-30, 2018 RARI, Durgapura, Jaipur. He also conferred with SEE Fellow Award for outstanding contribution in the field of extension education during 9th National Extension Congress 2018 at CAEPHT, Ranipool, Sikkim from Nov. 15-17, 2018. Furthermore, he was presented with Outstanding Brassica Researcher Award in recognition of significant contribution towards the advancement of Rapeseed and Mustard research and development by SRMR during February 1-3, 2019 at CSAUA&T, Kanpur.



Dr. K.H. Singh, Principal Scientist (Plant Breeding and Genetics), was elected Fellow of National Academy of Agricultural Sciences (NAAS) w.e.f. January 01, 2019. He also received "Dr P. R. Kumar Outstanding Oilseed Brassica Researcher" Award from Society for Rapeseed-Mustard Research (SRMR), on 1st February, 2019 during 4th National Brassica Conference, held at CSAUA & T Kanpur.



Dr. P. D. Meena, Principal Scientist (Plant Pathology), **Dr. Ashok Kumar Sharma,** Principal Scientist (Agri. Extension) and **Dr. Vinod Kumar,** Principal Scientist (Computer Application) received Gold Medal Award from Society for Rapeseed-Mustard Research (SRMR), in the 4th National Brassica Conference, held at CSAUA & T Kanpur.



Dr. Ashok Kumar Sharma, Principal Scientist (Agri. Extension) received Best Scientist Award of ICAR-DRMR 2018 on 25th Silver Jubilee Foundation day on Oct 20, 2018. He also received Gold Medal Award from Society for Rapeseed-Mustard Research (SRMR), in the 4th National Brassica Conference, held at CSAUA & T Kanpur.



Dr. Pankaj Sharma, Principal Scientist (Plant Pathology), Best Scientist Award of ICAR-DRMR 2018 on 25th Silver Jubilee Foundation day on Oct 20, 2018. Dr. Sharma also received Excellent in Research Award by Astha Foundation during International Conference (GRISAAS-2018), at RARI Jaipur from Oct 28-30, 2018



Dr. Bhagirath Ram, Principal Scientist (Plant Breeding and Genetics), was conferred Fellow Award of Society for Rapeseed-Mustard Research (SRMR) for significant contribution towards the advancement of Rapeseed-Mustard Research and development in the 4th National Brassica Conference. He also received Best worker Award for meritorious contributions and effective implementation of Swachh Bharat Mission at ICAR-DRMR during the year 2017-2018 on the occasion of Silver Jubilee Foundation Day of ICAR-DRMR on October 20, 2018. He received an excellence in Research Award for outstanding contribution in the field of Genetics & Plant Breeding on the occasion of International Conference on Food Security and Sustainable Agriculture held at Pattaya, Bangkok, Thailand during December 21-24, 2018.



Dr. Anubhuti Sharma, Senior Scientist (Plant Biochemistry), received Best paper award at International conference on "Agriculture, Allied & Applied Sciences with special reference to Energy, Environment and Biotechnology Research" organized by Biologix Research and Innovation Centre Pvt. Ltd. (INDIA) in association with Biotechnology Society of Nepal (NEPAL) from April 28-29, 2018 at Jawaharlal Nehru University (JNU) Convention Centre, New Delhi.

Dr. H. S. Meena, Senior Scientist (Plant Breeding and Genetics), was conferred Fellow Award by Society for Rapeseed-Mustard Research (SRMR), for significant contributions in advancement of rapeseed-mustard research and development in the 4th National Brassica Conference.



He also received Best Scientist Award by ICAR-Directorate of Rapeseed-Mustard Research for meritorious contributions and services towards research and development of ICAR-DRMR, on the Silver Jubilee Foundation Day of ICAR-DRMR.

Dr. Ajay Kumar, Senior Scientist (Biotechnology), received Best Poster Award in the 4th National Brassica Conference. He was elected as 'Member, Plant Tissue Culture Association of India (PTCAI)' during 'International Conference on Trends in Plant Sciences and Agrobiotechnology-2019 (ICTPA-2019) and 40th Meeting of PTCAI' during February 14-16, 2019 at IIT, Guwahati.

Dr. Priyamedha, Scientist (Plant Breeding and Genetics), received University Gold Medal for Ph.D. (Plant Breeding & Genetics) from Birsa Agricultural University, Ranchi, Jharkhand on 19 January, 2019.

Dr. B. L. Meena, Scientist (Plant Breeding and Genetics), received Young Scientist Award and best thesis Award in the International Conference on 'Global Research Initiative for sustainable agriculture and allied science (GRISAAS-2018), held at RARI, Durgapura, Jaipur during October 28-30, 2018.

Dr. M.D. Meena, and **Dr. M.K. Meena,** Scientists (Soil Science), received Best Thesis Award- 2018 in GRISAAS-2018.

Dr. R.L. Choudhary, Scientist (Agronomy), received the Best Poster Award in the ISMPP 39th Annual Conference & National symposium held at ICAR-Indian Institute of Pulses Research, Kanpur, during November 16-18, 2018.

Dr. Ibandalin Mawlong, Scientist (Plant Biochemistry) received Dr. P.R. Verma Young Scientist Award in the 4th National Brassica Conference. She was also presented with Best Worker Award–scientific category on the Silver Jubilee Foundation Day of ICAR-DRMR.

Dr. Reema Rani, Scientist (Biotechnology), received Best Poster award in the 4th International group meeting on "Wheat productivity enhancement through climate smart practices" held on Feb 14-16, 2019, CSK HPKV, Palampur.

Dr. Harvir Singh, Scientist (Agronomy), received Best Poster Presentation Award in the 4th National Brassica Conference. He was also awarded with Excellence in Research Award by Astha Foundation in the International Conference on 'Global Research Initiative for sustainable agriculture and allied science (GRISAAS-2018), held at RARI, Durgapura, Jaipur during October 28-30, 2018.

6 Linkages And Coordination

21 days skill development training programme organized under ASCI at ICAR-DRMR, Bharatpur

A 21 days skill development training programme for 200 hrs was organized for rural youth on quality seed grower-job role from January, 08-28, 2019 under Agriculture Skill Council of India by involving 20 participants from Bharatpur district. Skill development training programme included theory and practical sessions/exposures on introduction to Rapeseed-Mustard crops and seed production techniques, selection of suitable varieties of Rapeseed-mustard, seed law/seed law enforcement, seed classes, isolation distances, agronomic practices for seed production, role of



soil health and plant nutrition, role of conservation agriculture, mustard oil and its quality, important diseases and insect pest damages and its mitigation strategies, crop insurance process/advantages, climate change factors, role of honey bee in mustard production, formation of self-help groups of farmer's APOs (Agriculture Produce Organizations), role of information technology in quality seed production and e-marketing, rapeseed- mustard quality standards etc. Skill development training also included practical exposure visits to seed production plots/seed processing unit/improved agricultural implements and practical exposure visit to farmer's field and participatory seed production sites at DUVASU, Madhurikund Farm, Mathura. At the end of skill development training, an on-line assessment examination and personal interview was conducted by assessment agency of ASCI, New Delhi.

A two days farmer's training programme on "Rapeseed-Mustard Seed Production Technology" was organized at ICAR-DRMR, Bharatpur from February 28 to March 01, 2019 under ICAR seed project by involving 30 farmers.

The farmer's training programme included theory and practical sessions/exposures on introduction of Rapeseed-mustard crops and seed production



techniques, selection of suitable varieties, crop production, mustard oil and its quality, plant protection measures, crop insurance process and advantages. It also included practical exposure visit to seed production plots/seed processing unit/improved agricultural implements.

Awareness cum tribal farmer's training programme organized at KVK, Faloj, Dungarpur (Rajasthan)

One day awareness cum tribal farmer's training programme was organized on "Mustard seed production technology" at KVK, Dungarpur on 14.03.2019 under TSP of ICAR seed project. Twenty trainees from different villages of



Shimalwara Tehsil of Dungarpur District participated in the programme. Selection of farmers was made with help of Head, Krishi Vigyan Kendra, Dungarpur. Training programme included lectures on seed production techniques, selection of suitable varieties, important diseases of mustard and its management, insect pest and its management, seed storage, soil health and plant nutrition etc. Twenty seed storage bins were also distributed to tribal farmers for safe storage of mustard seeds.

7 All India Coordinated Research Project on Rapeseed-Mustard

25th Annual Group Meeting of AICRP on Rapeseed-Mustard was organized by ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur during August 4-6, 2018 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P.

Dr. A. Vaishampayan, Director, Institute of Agricultural Sciences, BHU presided over the inaugural session. Dr A.K. Singh, DDG (CS & Hort), ICAR, New Delhi was the Chief Guest of the function. Dr. A.P. Singh, Dean, Faculty of Agriculture and Dr. R.P. Singh, Head Genetics and Plant Breeding, BHU, Varanasi also graced the occasion. Dr. P.K. Rai, Director (Acting), ICAR-DRMR, Bharatpur, formally welcomed the dignitaries and participants. He presented Project Coordinator's report and research highlights, scenario of rapeseed-mustard production in different states of the country and global as well as ATR. He informed that the overall seasonal weather conditions during the crop season 2017-18 across the Rapeseed-Mustard production zones were quite normal and favorable for crop growth and development. He mentioned that 171 strains including 16 of toria, 7 of yellow sarson, 137 of Indian mustard, 7 of gobhi sarson and 4 of taramira were tested in twenty five performance evaluation trials at 47 locations across six agro-climatic zones of the country. Dr. Rai informed that 303.06 q breeder seed of 66 Rapeseed-Mustard varieties was produced, indicating a surplus availability of 227q. In agronomy trials, crop responded to 150% NPK in Zone I and balanced fertilizer application with supplementary application of fertilizers and manures in Zone II, III and V. He appraised the house that 2140 FLDs on Rapeseed-Mustard were conducted in 83 districts across 16 states. On this occasion Annual Progress Report - 2018 of AICRP-RM was released by the dignitaries.

Dr. R.P. Singh, Head, Deptt. of Plant Breeding and Genetics, IAS, BHU gave a brief account of alumni's who provided leadership in agricultural research across the country and globe.

Dr. A. Vaishampayan, Director, IAS, BHU said that looking to the importance of Rapeseed-Mustard in food, nutrition, medicinal, the per se productivity enhancement is need of the day. He pointed out some constraints such as changing climate, high temperature and biotic stresses. He said that varieties and technologies developed by this group should reach to the farmers.

Dr. A.K. Singh, DDG (Horticulture and Crop Science), ICAR, New Delhi raised his concern about increasing demand and import of edible oils in the country of about 75,000 crores annually. He emphasized needs of policy driven interventions/ options to reduce the imports. He said that about 2 million hectare area in rice-fallow can be tapped for horizontal expansion of the crop besides vertical expansion in irrigated areas (Zone II). He suggested approaching various stakeholders for enhancing productivity through intensive cultivation, seed replacement through new varieties, need based application of sulphur, gypsum and plant nutrients specially micronutrients. Weeds account for crop yield losses to an extent of over 20% in Rapeseed-Mustard. He also emphasized to manage different biotic and abiotic stresses. Systematic crop intensification in traditional and non-traditional areas and development of improved varieties besides their distribution to the farmers also needs to be addressed. Orobanche, a great problem need to be addressed through targeted efforts which should be cost effective and sustainable. He urged to develop and strengthen the international partnership for genetic materials with traits of interest. He urged that production technologies must reach to the farmers. Dr. Singh reviewed the achievement of one year and suggested to modify the programmes for targeted result or incorporate new programmes.

Eleven sessions, including presentation of reports, wherein all PIs presented the progress report of 2017-18 of their respective disciplines, technical programme formulation, technology dissemination and impact analyses, presentations

in key areas, breeder seed production and plenary session were held during the workshop. Technical programmes for the year 2018-19 were formulated for various disciplines. In brain storming session, three presentations were made and issues of conventional and molecular approaches of Brassica breeding, commercialization of bio-agents and vegetable oils vis-a-vis Rapeseed-Mustard in India were discussed. The session was chaired by Dr. Akshay Pradhan, University of Delhi, South Campus and Co-chaired by Dr. H.B. Singh, Ex. Prof. & Head, Mycology & Plant Pathology, BHU, Varanasi.

Prof. A.K. Pradhan, presented plan of hybrid development and quoted that first generation hybrids are being developed through marker assisted breeding, second generation hybrid will include quality improvement while third generation hybrid will include disease resistance. Similarly, fourth generation hybrids are proposed to be developed by use of QTLs. Dr. Pradhan further cited the role of genetics-genomics interface in breeding and informed about the development breeding chip which shall be useful in selection of desirable genotypes. Bi-parental mapping populations have been prepared for different traits. He also mentioned about the candidate genes responsible for GS biosynthesis in Indian and east European germplasm lines.

Prof. H.B. Singh, advocated the commercialization of bio-agents to place one of the best tools in disease management and to provide high quality biocontrol agents to end users.. Basic information is required on their protection and registration. He mentioned in detail the regulatory mechanism of biopesticides in India. Bioefficacy test of the product should be tested against target pathogen/pest at one of the laboratories of ICAR/SAUs/CSIR/ICMR system under laboratory and field conditions. He mentioned about the *Trichoderma harzianum* products developed and patented at BHU and asked the industry parterners to come forward for mass development of biopestides.

Dr. Anupam Barik, Additional Commissioner, DAC, Ministry of Agriculture & farmers Welfare made a presentation on vegetable oils vis-a vis Rapeseed-Mustard in India. He presented the demand and supply status of vegetable oil in the country and informed that huge amount of vegetable oil is being imported to meet the demand. Dr. Barik also presented the projection of Demand and Supply by 2022-23 and strategy to enhance the availability of vegetable oil from domestic sources. He stressed upon strategies for enhancing vegetable oil production by area expansion of oilseed crops, area expansion of oil palm & coconut, productivity enhancement through seed production & distribution, establishing seed hubs, promotion of new varieties through minikits, providing protective irrigation, improved management practices etc., pricing, procurement and duty structure, enhanced capacity utilization of oil industry, encouraging oil extraction and value chain through establishing of small extraction units. Dr. Barik mentioned that establishment of 8 seed hubs for rapeseed-mustard with allocation of Rs. 12.0 crore will produce 3800 qtls of seed in 2018-19. He also emphasized upon the introduction of intercropping rapeseed-mustard crop with sugarcane in UP & Bihar, potato in western UP, cheakpea & lentil in Rajasthan, UP. Policy on blended oil and pure oil will be implemented soon by the Government.

Dr. Bhagirath Ram, Principal Scientist from ICAR-DRMR presented the status report of breeder seed production. Session on technology dissemination, management and impact analysis was chaired by Prof. O.P. Mishra, Head, Deptt. Of Agricultural Extension, IASc, BHU, Varanasi and Co-chaired by Dr. S.K. Jha, Principal Scientist, ICAR headquarter. Dr. A.K. Sharma, Principal Scientist, ICAR-DRMR presented the results of 2140 Frontline demonstrations (FLDs) on rapeseed-mustard conducted in 83 districts across 17 states during 2017-18. All the demonstrations were conducted under whole package demonstrations in two different situations viz., irrigated (1459) and rainfed (681). Under irrigated conditions, maximum average yield of 27.7q/ha from the IP under irrigated conditions

was in Haryana followed by 23.5 q/ha in Rajasthan; 21.4 q/ha in Punjab; 20.7 q/ha in Uttar Pradesh and 18.8 q/ha in Madhya Pradesh.

The maximum yield gap of 57.6% was recorded in Jammu and Kashmir followed by 55.6% in Tripura; 48.8% in Jharkhand; 29.2% in Maharashtra; 28.4% in West Bengal and 18.2% in Gujarat. Under rainfed whole package, maximum average yield of 24.2 q/ha from the WP under rainfed conditions was in Haryana followed by 15.2 q/ha in Tripura and 14.9 q/ha in Rajasthan; The maximum yield gap of 147.8% was recorded in Tripura followed by 53.6% in Assam, 45.5% in Himachal Pradesh; 25.1% in Manipur and 21.4% in Arunchal Pradesh..

More than 125 scientists/personnel from both public and private sector associated with rapeseed-mustard research and development in the country participated in this event. The workshop was successfully concluded on 6th August, 2018 with the plenary session chaired by, Dr. A. Vaishampayan, Director, IAS, BHU.

The following action points were suggested for implementation:

- Looking the availability of early maturing hybrids, a separate trial IHT (Early maturing hybrids) shall be constituted for evaluation of these hybrids in Zone II, III and V.
- In case of promotion on the basis of white rust resistance, strains shall be compared with resistant check for disease score, which should be at par with resistant check, similarly, seed yield should be at par with best check to qualify for the promotion.
- Cut-off date for all mustard trials being conducted in Zone V shall be 30 November.
- AVT I+II late sown mustard trial in Zone V shall be concluded during 2018-19 and shall not be repeated further.
- It was also decided to conduct hybrid trial in Zone IV from this year (2018-19).
- In AVT I quality mustard trial Zone II, two strains; RLC 3, LES 54 shall be repeated.
- It was also decided to conduct salinity and taramira trials in alternate years, after consulting concerned Scientists

Recommendations

- Seed treatment (ST) carbendazim 50 WP 2g/kg seed+ no irrigation during 25th Dec to 15th Jan+ foliar spray (carbendazim 50WP @ 0.2%) at 45-50 and 65-70 DAS for effective management of Sclerotinia stem rot.
- Yield losses with different incidence level of Sclerotinia rot disease were resulted in increased yield loss (13.3% at 1, 24.4% at 2, 48.4% at 3 and maximum 64.7% at score 4).





8 Publications

Research Papers

1. Bhagirath Ram, Priyamedha, Meena HS, Kumar A, Singh BK, Rani R, Kumar A, Singh KH, Rai PK. (2018). Studies on combining ability and gene action for heat stress tolerance traits in Indian mustard (*Brassica juncea* L.). J Oilseed Brassica. 9 (2): 139-145.
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9 Research Programmes and Projects

9.1 Institute Research Project

Name of Programme	Project code	Leader/PI
Programme 1. Genetic enhancement for stress tolerance in Indian Mustard		**V.V. Singh**
Breeding for high yield and oil content under normal and moisture stress condition	DRMR CI-10	V.V. Singh
Widening of gene pool in Brassicas through inter-specific and inter-generic hybridization	DRMR CI-12	Arun Kumar
Breeding for earliness and high temperature tolerance in Indian mustard	DRMR CI-14	Bhagirath Ram
Re-synthesis of Indian mustard (*Brassica juncea* L. Czern & Coss) through inter-specific hybridization	DRMR CI-15	H.S. Meena
Breeding for white rust and stem rot resistance/tolerance in Indian mustard	DRMR CI-16	B.L. Meena
Programme 2. Designer Brassica for oil quality		**V.V. Singh**
Genetic enhancement for quality traits in Indian mustard (*Brassica juncea* L.)	DRMR CI-13	Priyamedha
Proteomics studies in oilseed Brassica	DRMR B-07	Ibandalin Mawlong
Screening of oilseed Brassica germplasm for value addition	DRMR B-08	M.S. Sujith Kumar
Quantitative and qualitative estimation of glucosinolates and fatty acids in oilseed Brassica	DRMR B-09	Anubhuti Sharma
Programme 3. Breeding for yield and quality enhancement in rapeseed-mustard		**K.H. Singh**
Development of hybrids in Indian mustard (*Brassica juncea*)	DRMR CI-05	K.H. Singh
Programme 4. Oilseed *Brassica* genetic resource management		**H.K. Sharma**
Collection, evaluation, characterization and conservation of rapeseed-mustard germplasm	DRMR CI-06	H.K. Sharma
Programme 5. Biotechnological interventions to improve rapeseed-mustard productivity		**Ajay Kumar**
Biotechnological interventions for development of Orobanche tolerance in Indian mustard (*Brassica juncea* L.)	DRMR BT-05	Reema Rani
Enhancing the repertoire of microsatellite markers for genomics interventions in Indian mustard (*Brassica juncea* L. Czern. & Coss) crop improvement	DRMR BT-07	Ajay Kumar
Programme 6. Enhancing resource use efficiency and abiotic stress managements for resilient rapeseed-mustard production system		**O.P. Premi**
Enhancing soil resilience under mustard based systems through integrated crop management	DRMR CP-06	O.P. Premi
Sustainable intensification of Brassica production system (SIBPS)	DRMR CP-16	R.S. Jat

Role of micro and secondary nutrients and their fortification on rapeseed-mustard productivity and quality	DRMR CP-17	M.K. Meena
Nutrient transformation in soil as influenced by enriched composts and their effect on yield and quality of mustard	DRMR CP-19	M.D. Meena
Management of poor quality water for sustainable mustard production	DRMR CP-20	M.L. Dotaniya
Yield maximization through best crop management strategies in mustard based cropping systems	DRMR CP-21	Harvir Singh
Climate smart agro-techniques for enhancing water productivity of mustard based cropping systems under moisture stress	DRMR CP-22	R.L. Choudhary
Programme 7. Management of biotic stresses in India mustard		**P.K. Rai**
Managements of sclerotinia rot in rapeseed-mustard	DRMR PP-01	Pankaj Sharma
Epidemiology and managements of White rust	DRMR PP-05	P.K. Rai
Management of collar rot caused by Sclerotium rolfsis rapeseed-mustard crops	DRMR PP-06	P.D. Meena
Programmed 8. Technology assessment and dissemination		**A.K. Sharma**
Participatory extension for dissemination of rapeseed-mustard technology	DRMR TAD-04	A.K. Sharma
Development of application software for rapeseed-mustard information management	DRMR CA-01	Vinod Kumar

9.2 Externally Funded Projects

Name of project	Project code	PI/Nodal Officer
Characterization of rapeseed-mustard varieties for distinctness uniformity and stability (DUS) testing	DRMR EA-2	Priyamedha
ICAR seed project on seed production in agricultural crop	DRMR EA-4	Bhagirath Ram
CRP on hybrid technology for higher productivity in selected field and horticultural crops (component Indian mustard)	DRMR EA-11	K.H. Singh
Pre-breeding for genetic enhancement of Ethiopian (*Brassica carinata*) and Indian mustard (*B. juncea*) gene pool	DRMR EA-12	K.H. Singh
Incentivizing research in agriculture-Indian mustard	DRMR EA-14	V.V. Singh
CRP on molecular breeding for improvement of tolerance to biotic (white trust/stem rust) and quality traits (low erucic acid and glucosinolate) in mustard	DRMR EA-15	V.V. Singh
Creating a fully characterized genetic resource pipeline for mustard improvement programme in India	DRMR EA-16	K.H. Singh
Creation of seed-hubs for enhancing quality seed availability of major oilseed crops-Rapeseed-mustard funded by DAC & FW, GOI	DRMR EA-17	P.K. Rai
Genome wide association mapping for yield contributing traits in Indian mustard (*Brassica juncea* L. Czern. & Coss)	SR/WOS-A/LS-484/2017	N. Parmar

Garmin Krishi Mausam Sewa	DRMR EA-8	O.P. Premi
Induced mutagenesis for isolation of Alternaria blight resistant mutant in *Brassica juncea*	DRMR EA-9	P.D. Meena
Development of low glucosinolates and low phytic acid mutations for improving nutritional value of low erucic acid genotypes in Indian mustard	DERMR EA-10	Anubhuti Sharma
XII plan scheme national agriculture innovation fund/intellectual property management and technology transfer commercialization of agriculture technology	DRMR EA-13	Vinod Kumar
Frontline demonstration and other related activities of oilseeds	DRMR NMOOP-1	A.K. Sharma
Study the effect of different sources of sulphur on yield and oil content	DRMR-ATMA-1	A.K. Sharma
NEH component, Enhancement of rapeseed-mustard production in Tripura and Imphal	DRMR EA-18	P.K. Rai
Newton Bhabha Fund UK- India Pulses and Oilseed Research Initiative (PORI). Funded by BBSRC, Govt. of United Kingdom and DBT, MoST, GoI	DRMR EA-19	P.K. Rai

10 IRC, RAC and IMC

Institute Research Council Meeting

28th Institute Research Council (IRC) meeting of ICAR-DRMR was held during October 3-5, 2018 and on October 10, 2018 under the Chairmanship of Director. The individual scientist presented progress of their project work done during year 2017-18 and proposed technical program for the year 2018-19.

The chairman suggested to prioritize experiments in light of available resources and give proper justification of Co-PIs in all the projects. Scientists should use the labour judiciously for maximum output. He said that crop production unit should address the emerging problems like water salinity, climate changes, low nutrient efficiency, weed management, etc. He emphasized that lab facility should be shared among scientists. He said that priority of biochemistry should be decided and all equipments should be repaired on priority basis.

The chairman suggested that extensive review of



existing work should be done before proposing new project. The Chairman also suggested that each scientist must comply with the recommendations of the RAC/QRT/Council and design the experiments accordingly.

The IRC expressed satisfaction on the progress made under various projects during 2017-18 and approved the technical program for 2018-19 with given modifications/observation.

Research Advisory Committee Meeting

21st Research Advisory Committee (RAC) meeting of ICAR-DRMR was held during 6-7 February, 2019 under the Chairmanship of Dr. J. B. Chowdhury. Following members were present:

Dr. J. B. Choudhary	Ex Vice Chancellor, CCS HAU Hisar and GBPUAT Pantnagar	Chairman
Dr. P. K. Chakrabarty	Assistant Director General (PP & OP), ICAR, New Delhi	Member
Dr. K. P. Singh	Ex Professor and Head, Mycology and Plant Pathology, BHU Varanasi	Member
Dr. R. P. Singh Ratan	Ex Director Extension Education, BAU Ranchi	Member
Sri Banke Lal Lodha	Farmers' Representative	Member
Dr. P. K. Rai	Director, ICAR-DRMR, Bharatpur	Member
Dr. K. H. Singh	Principal Scientist, ICAR-DRMR, Bharatpur	Member-Secretary

Four members; Dr. B. S. Mahapatra, Professor (Agronomy), GBPUA&T, Pantnagar, Dr. S. R. Bhat, Emeritus Scientist, NRCPB New Delhi, Dr. V. K. Yadav, Director Research, SKNAU Jobner and farmers' representative Sri Bhanu Pratap Singh could not attend the meeting.

At the outset, Dr. K. H. Singh, Member-Secretary, RAC extended warm welcome to Chairman, members and all participants of RAC meeting. Session started with introductory remarks by the Chairman. He emphasized importance of rapeseed-mustard as an oilseed crop and cited that this crop has very high potential for yield enhancement as well as for horizontal expansion. He also mentioned about GM technology being developed in this crop. Dr. P. K. Chakrabarty, ADG (OP) in his remarks appreciated the overall ambience, cleanliness of this institute. He mentioned about scenario of oilseed production in country. He also cited the losses being caused by different biotic stresses . Dr. K.H Singh, Member-

Secretary RAC presented Action Taken Report on recommendations of 20th RAC meeting which was confirmed by the RAC with conditions that further action is needed on two recommendations; use of weedicide/ herbicide should be brought in form of a technical bulletin for farmers and *Orobanche* management strategies should be strengthened involving DWR, Jabalpur and CCS HAU Hisar.

Director, ICAR-DRMR Bharatpur presented the achievements and development of Directorate. He apprised about establishment of oil expeller unit and Seed Hubs at different locations. One publication on rapeseed-mustard varieties was released by the Chairman. Later, presentations were made by PIs of different disciplines. Dr. V. V. Singh, Dr. O.P. Premi, Dr. Pankaj Sharma, Dr. Ashok Kumar Sharma, Dr. Sushil Kumar Sharma (I/C, KVK Bansur), Dr. Ajay Kumar and Dr Anubhuti Sharma presented the annual report and technical programmes of Crop Improvement, Agronomy, Plant Protection, Technology Assessment & Dissemination, Krishi Vigyan Kendra, Biotechnology and Biochemistry, respectively. During the discussion, Chairman raised apprehension about availability of FYM in large quantity and advised to consider the ground realties before making any recommendation. Scientists were advised to work in collaboration and in multidisciplinary mode. Dr. P. K. Chakrabarty, ADG (O&P), suggested for developing strategies for enhancement of organic content in soil. He also pointed out the role of microbes in bioremediation and in biocontrol. Dr. K. P. Singh elaborated the integrated and multidisciplinary approach for management of biotic stresses. Dr. R. P. S. Ratan suggested to have at least three treatments in On Farm Testing (OFT). Issues like use of labeled claim pesticides, formulation of biotechnology /biochemistry projects with applied outcome, Orobanche management strategies, formulation of strategies/ recommendation to enhance productivity in UP, were also discussed.

RAC visited field experiments at research farm and interacted with concerned scientists at field itself.

Following recommendations were made by RAC after in depth and detailed deliberations:

1. As per previous RAC recommendation, Orobanche management strategies should be strengthened involving DWR, Jabalpur and CCS HAU Hisar.(Crop Production).
2. Efforts should be strengthened to facilitate labeling of herbicide and technical bulletin should be brought up on recommendation of weedicide/herbicide in rapeseed-mustard. (Crop Production).
3. Considering the scarcity of FYM, appropriate microbial formulations should be identified for nutrient management, biocomposting and for waste water treatment with the help of NBAIM Mau, Arka Microbial Consortium Bengaluru and National Environmental Engineering Research Institute, Nagpur.
4. Looking to the importance of Alternaria blight in many regions including, Uttarakhand, eastern UP, Bihar and eastern India, research on management of alternaria blight in rapeseed-mustard should continued.
5. A survey should be conducted to find out impact, in monetary terms, of research outcome on rapeseed-mustard growers. Possibility for outsourcing such study may be explored.



20th Institute Management Committee

20th Institute Management Committee meeting was held on 07th July, 2018 under the chairmanship of Dr. P.K. Rai, Director at ICAR-DRMR, Bharatpur. Other IMC Members, Dr. S.J. Singh, Director RARI, Durgapura, Dr. R.C.

Bhattacharya, Pr. Scientist, ICAR-NRCPB, New Delhi, Sh. S.K. Sharma, FAO, ICAR-NRCPB, New Delhi, P.K. Tiwari, FAO, ICAR-DRMR, Bharatpur and Sh. R.C. Meena, SAO, ICAR-DRMR, Bharatpur were present.

The Member Secretary presented the status of the proceedings and action taken report of the XIX IMC meeting held on 21-03-2018. The IMC expressed satisfaction and confirmed the same. The Women Complaint Committee was constituted. Member Secretary placed a list of other items of SFC for appraisal of IMC, list of items to write-off the losses incurred during the cyclone on 02-05-2018 was also presentedfor approved of IMC. The IMC also approved the proposal of Write-off of completely collapsed rainout shelter installed to conduct physiological experiments at this Directorate costing Rs.8.82 lakhs. The proposal of Changing of water pipe line from over head water tank was also approved



by IMC. The meeting was ended with vote of thanks to the chair.

11 Scheduled Tribe Component and Scheduled Caste Sub-Plan

ICAR-DRMR, Bharatpur implemented Scheduled Tribe Component (erstwhile TSP) during 2018-19 in collaboration with ICAR-ATARI, Patna in Jharkhand through KVKs, Ranchi, Gumla, East Singhbhum and West Singhbhum in selected tribal dominated villages/block of jurisdiction area of respective KVKs for the sustainable livelihood security of tribal farmers. Under STC programme, 407 Front line demonstrations were conducted on mustard (407 farmers), organized 7 Institutional Trainings (309 farmers), 20 Awareness camp/ Field Days/ Kisan Diwas / Gosthi / On farm trainings/ scientists-farmers interaction (764 farmers), 2 Exposure visits (52 farmers), 3 Farmers' fairs (7700), distributed 325 Storage bins, sprayers, small farm implements and 30 relevant literature by all four KVKs in their respective districts. 4 Mini oil expellers, one at each KVK were also installed for the completion of mustard value chain and for the benefit of the local community. A total 69787 tribal farmers benefitted under the programme.



TSP activities conducted during 2018-19 by KVK, East Singhbhum

During the period, the programme was implemented in 13 villages of three blocks namely Dhalbhumgarh, Jamshedpur and Baharagora of East Singhbhum district of Jharkhand. 100 Front line demonstrations on mustard were conducted in 40 ha area. Two institutional training of 2 days duration each were organized on scientific production technology of rapeseed-mustard that benefitted 83 tribal farmers. Besides, two awareness camp/ Field Days/ On farm training/ Scientists-farmers interaction/ kisan gosthies and one farmers' fair was also organized that benefitted 83 and 200 tribal farmers, respectively. The 100 storage bins/ small farm implements were also distributed to selected tribal farmers. An exposure-cum-training to ICAR-DRMR for 29 tribal farmers from East Singhbhum to ICAR-DRMR was organized during 24-26 February, 2019.

TSP activities conducted during 2018-19 by KVK, West Singhbhum

During the period, the programme was implemented in 13 villages of four blocks namely Noamundai, Jagannathpur Hatgamhira, and Manjhgaon of West Singhbhum district of Jharkhand. 100 Front line demonstrations on mustard were conducted in 40 ha area. Three institutional training of 2 days duration each were organized on scientific production technology of rapeseed-mustard that benefitted 189 tribal farmers. Besides, three awareness camp/ Field Days/ On farm training/ Scientists-farmers interaction/ Kisan gosthies were also organized that benefitted 44 tribal farmers of the district. The 100 storage bins/ small farm implements were also distributed to selected tribal farmers of the district. An exposure-cum-training of 23 tribal farmers from East Singhbhum to ICAR-DRMR for was organized during 24-26 February, 2019.

TSP activities conducted during 2018-19 by KVK, Ranchi

During the period, the programme was implemented in one village of one block namely Angara of Ranchi district of Jharkhand. 100 Front line demonstrations on mustard were conducted in 40 ha area.



Two institutional training of 2 days duration each were organized on scientific production technology of rapeseed-mustard that benefitted 60 tribal farmers. Besides, four awareness camp/ Field Days/ On farm training/ Scientists-farmers interaction/ kisan gosthies and one farmers' fair was also organized that benefitted 336 and 2500 tribal farmers, respectively. The 100 storage bins/ small farm implements were also distributed to selected tribal farmers of the district.

TSP activities conducted during 2018-19 by KVK, Gumla

During the period, the programme was implemented in 21 villages of four blocks namely Bishunpur, Ghaghra, Sisai, Bharno & Palkotof Gumla district of Jharkhand. 107 Front line demonstrations on mustard were conducted in 40 ha. area. Two institutional training of 2 days duration each were organized on "Scientific production technology of rapeseed-mustard" and "Post-harvest management of rai/mustard crop" that benefitted 60 tribal farmers. Besides, 11 awareness camp/ Field Days/ On farm training/ kisan gosthies/ scientist-farmers interaction and one farmers' fair was also organized that benefitted 301 and 5000 tribal farmers, respectively. The 25 storage bins/ sprayers were also distributed to 30 selected tribal farmers of the district.

SCSP activities conducted by ICAR-DRMR

Under SCSP, ICAR-DRMR, Bharatpur organized four one day training at KVK, Bansur, two at ICAR-DRMR, Bharatpur, one at KVK, Kumher on climate change, water and nutrient use efficiency, mustard crop yield, soil health management, sustainable agriculture etc. In these training programmes sickle, sprayer, training kit and literature were distributed and more than 204 farmers were benefited.



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On Farm Trials: Seven technologies were assessed through 80 trials at different locations on different problems such as integrated nutrient management in mustard, popularization of newly released high yielding wheat variety (HD-3086), integrated wilt complex management in chickpea, assessment of boron on growth and yield of bottle gourd, assessment of plant spacing on growth and yield of cauliflower, Assessment of effect of probiotic on milk production and effect of *Azolla* on milk production in goat.

Front Line Demonstrations (FLDs)

Total 282 FLDs were conducted at farmer's fields covering 130.5 hectare area in different villages of Bansur Tehsil of Alwar District. During Kharif season, 5 FLDs were conducted for varietal evaluation, integrated disease management and intercropping in 32.5 hectare areas in 4 villages on Mungbean, Cotton and Pomegranate crop while in Rabi season, 7 FLDs in 98 hectare areas were conducted for varietal evaluation of GNG-1581, seed treatment and sulphur application in mustard, molya disease management by neem oil in wheat, intercropping of methi with pomegranate, management of blossom end rot in tomato and optimum use of fertilizers in cauliflower crop.

Trainings

Krishi Vigyan Kendra conducted 85 trainings on different need based subjects in all discipline including 69 On-campus and Off-campus trainings, 04 extension functionaries trainings, 11 sponsored training and 01 vocational training, which benefited 2429 farmers and farm women, 287 rural youths, 105 extension functionaries and 282 sponsored farmers.

Extension activities

To popularize the technologies among farmers in the areas, 05 field days on different crops in different villages were organized for 177 farmers, farm women, extension functionaries and rural youths. 05 Kisan Gosthies on different topics for 169 farmers, 07 exhibitions were displayed in different event for farmers, 59 scientist visits to farmers fields, 1276 Farmers visit to KVK, 386 advisory services to 919 farmers, farm women and rural youths, 56 film shows were organised to benefit 1680 farmers, 04 Group discussions to 62 progressive farmers, farm women, rural youths and 09 important days celebration were organized by the KVK.

Kisan Samman Nidhi Programme

Krishi Vigyan Kendra organized Kisan Sammelan and agriculture exhibition on the occasion of "Pradhan Mantri Kisan Samman Nidhi" on 24th February, 2019. Chief guest of the function was Smt. Shankutala Rawat, MLA, Bansur and Special guest was Shri Deena Nath Babbal, SDM, Bansur. Smt. Shankutala Rawat, advised the farmers to take the benefit of KVK and adopt improved technology for higher production of crops, fruits and vegetables in the area. She emphasized on the better linkage among farmer, extension worker and scientists. She also advised the farmers for use of internet facility and connects with e-mandis. On this occasion, live telecast of Hon'ble Prime minister Sh. Narendra Modi was organized Kisan gosthi and Scientist-farmers interaction was also organized. More than 600 farmers, farm women from different villages of Alwar district of Rajasthan participated in the Mela. During Rabi -2018-19, 826 Kg Mustard seeds of DRMR was distributed to the farmers in KVK jurisdictions.



Kisan Diwas or National Farmers Day

To celebrate the birthday of late Chaudhary Charan Singh, Ex-Prime Minister of India, National Farmers Day was celebrated by the Krishi Vigyan Kendra on 23rd December, 2018. On this occasion, an awareness programme was organised for farmers by the KVK, where in 30 farmers from the different Tehsils taken part to

share their views and to know the importance of this day for farm community.



International Women Day

International Women Day was celebrated on 8th March, 2019 at KVK.



Gram Swaraj Abhiyan programme

Krishi Vigyan Kendra, organised Kisan Kalyan Diwas on 2nd May 2018 in Bansur, Behror, Kisangarhbas, Kotkasim, Tizara and Neemrana Tehsils under the Gram Swaraj Abhiyan programme. In this programme, workshops were organised for doubling farmers income at Tehsil headquarters where experts from KVK and line Departments delivered lectures on different farmers welfare schemes.

Parthenium awareness week

Parthenium awareness week, a national programme, for mass awareness, was organized during 16-22 August 2018 by KVK. In this programme, KVK experts created awareness among the farm community on detrimental effects of Parthenium grass on human being, animals, agricultural production and environment.

Swachh Bharat Abhiyan

As a part of Swachh Bharat Abhiyan 'Swachhata Pakhwada' was observed during December 16-31 , 2018. During this period, all the staff of KVK participated in the cleaning of the KVK premises. During the cleaning process polythene waste, noxious weeds like Parthenium and waste scraps were collected and disposed in the dogged pit to make KVK premises plastic waste and Parthenium free.



World Honey Bee Day World Honey Bee Day was celebrated by Krishi Vigyan Kendra on 20th May 2018 in Harsora village of Bansur Tehsil. In this event 30 farmers, farm women and rural youths benefited through the expert's lectures.

World Soil Day

World Soil day was celebrated on 5th December, 2018. The programme was successfully organized to create awareness about the



importance of soil health for sustaining agriculture production and our lives. The main objective of this programme was to make aware the farmers about the importance of healthy soil and eco-friendly methods of soil management.

Direct interaction Programme with Hon'ble Prime Minister

Direct interaction programme with Hon'ble Prime Minister Sh. Narendra Modi was organised by Krishi Vigyan Kendra on 12th July, 2018 at 9.30 AM. In this programme farm women (Trainees), particularly SHGs members, were invited at KVK to interact directly with the Hon'ble Prime Minister through webcast.



60 farm women from different SHGs participated in this programme and interacted directly with Hon'ble Prime Minister Sh. Narendra Modi.

Animal Health Camp

One Animal Health Camp was organized in the village Nangal Bhau Singh with the help of Veterinary Officer on infertility, prolapse, diarrhea, worm infestation etc. The livestock farmers were also made aware about the importance of timely vaccination, deworming and balance feeding for maximum milk production.

M-Kisan Advisory

11 advisory services through m-Kisan Portal were send to 192798 farmers in the areas. 08 radio talks, 16 TV talks on different subjects were given by the KVK experts for mass communication.

Publications and HRD

16 popular articles, 10 workshops, 04 conferences, 03 meetings, 12 folders, 01 training manual, 01 extension literature were published KVK officials were attended 05 trainings during 2018-19.

13 Distinguished Visitors

Name	Designation and Affiliation	Date
Shri Chhabilendra Roul	Special Secretary DARE, Secretary ICAR, New Delhi	December 12, 2018
Sh. Rajan Agrawal	Director (International Cooperation), DARE and CVO, ICAR, Ministry of Agriculture, GoI	December 31, 2018
Dr. N.K. Jain	Pr. Scientist(HRM), ICAR, New Delhi	March 15, 2019
Dr. Arvind Kumar	Vice Chancellor, RLBCAU, Jhanshi	October 20, 2018
Dr. A.K. Singh	DDG (CS), ICAR, New Delhi	October 20, 2018
Dr. A.K. Chakrabarty	ADG (OP), ICAR, New Delhi	February 06, 2019





14 Personnel

Personal

Director's office

1. Dr. P. K. Rai, Director (Acting)*
2. Smt. Veena Sharma, Personal Assistant
3. Sh. Lala Ram, Supporting staff (SSS)

Scientific Staff

Crop Improvement

1. Dr. V.V. Singh, Principal Scientist (Genetics & Plant Breeding)
2. Dr. Bhagirath Ram, Principal Scientist (Genetics & Plant Breeding)
3. Dr. Arun Kumar, Principal Scientist (Cytogenetics)
4. Dr. H.S. Meena, Senior Scientist (Genetics & Plant Breeding)
5. Dr. Hariom Kumar Sharma, Scientist, SS (Genetics & Plant Breeding)
6. Dr. B. L. Meena, Scientist, SS (Genetics & Plant Breeding)
7. Dr. Priyamedha, Scientist, SS (Genetics & Plant Breeding)

AICRP-RM Unit

1. Dr. K.H. Singh, Principal Scientist (Genetics & Plant Breeding)

Natural Resource Management (NRM)

1. Dr. O.P. Premi, Principal Scientist (Agronomy)
2. Dr. R.S. Jat, Principal Scientist (Agronomy)
3. Dr. M.L. Dotaniya, Scientist, SS (Soil Science)#
4. Dr. M.D. Meena, Scientist, SS (Soil Science)
5. Dr. R.L. Choudhary, Scientist, SS (Soil Science)##
6. Dr. M.K. Meena, Scientist (Soil Science)
7. Sh. Harvir Singh, Scientist (Agronomy)

Plant Protection

1. Dr. P. D. Meena, Principal Scientist (Plant Pathology)
2. Dr. Pankaj Sharma, Principal Scientist (Plant Pathology)

Plant Biotechnology

1. Dr. Ajay Kumar, Senior Scientist (Plant Biotechnology)
2. Ms. Reema Rani, Scientist (Plant Biotechnology)
3. Sh. Prashant Yadav, Scientist (Plant Biotechnology)**

Plant Biochemistry

1. Dr. Anubhuti Sharma, Senior Scientist (Plant Biochemistry)
2. Dr. Ibandalin Mawlong, Scientist (Plant Biochemistry)

3. Dr. M.S. Sujith Kumar, Scientist (Plant Biochemistry)

Technology Assessment & Dissemination

1. Dr. Ashok Kumar Sharma, Principal Scientist (Agricultural Extension)

Agriculture Knowledge Management Unit

1. Dr. Vinod Kumar, Principal Scientist (Computer Application in Agriculture)

Technical Staff

1. Dr. R.C. Sachan, Chief Technical Officer (CTO)
2. Sh. M.L. Meena, Assistant Chief Technical Officer (ACTO)
3. Sh. H.P. Meena, Assistant Chief Technical Officer (ACTO)
4. Sh. Ram Narayan, Assistant Chief Technical Officer (ACTO)
5. Sh. Karnal Singh, Assistant Chief Technical Officer (ACTO)
6. Dr. Kailash Narayan Meena, Senior Technical Officer (STO)
7. Sh. Sanjay Kumar Sharma, Senior Technical Officer (STO)
8. Sh. Govind Prasad, Technical Officer (Driver)
9. Sh. R.C. Meena, Technical Officer (TO)
10. Sh. Ram Singh, Senior Technical Assistant (STA)
11. Sh. Rakesh Goyal, Senior Technical Assistant (STA)
12. Sh. Bachu Singh, Senior Technical Assistant (STA)
13. Sh. Radha Charan Rajpoot, Technical Assistant (TA)

Administration

1. Sh. R.C. Meena, Senior Administrative Officer (SAO)
2. Sh. Ram Sahay Meena, Assistant Administrative Officer (AAO)
3. Sh. Mukesh Kumar, Assistant
4. Sh. Anurag Bharat, Assitant
5. Sh. G.L. Meena, Senior Clerk
6. Sh. Pankaj Pathak, Senior Clerk
7. Ms. Vimla Meena, LDC$
8. Sh. Srikant Kumar Singh, LDC$$

Audit and Accounts Unit

1. Sh. P.K. Tiwari, Finance& Account Officer (FAO) ^
2. Sh. Ajay Tandon, Junior Account Officer (JAO) ^^

Supporting

1. Sh. Tara Singh, Skilled Supporting Staff
2. Sh. Kamal Singh, Skilled Supporting Staff
3. Sh. Sheetal Kumar Sharma, Skilled Supporting Staff

Krishi Vigyan Kendra, Gunta-Bansur

1. Dr. Bhagwant Singh Rathore, Senior Scientist & Head^^^
2. Dr S.K. Sharma, Senior Scientist & Head###
3. Dr. Rupendra Kaur, T-6
4. Sh. Sandeep Rastogi, T-6
5. Sh. Sunil Kumar, T-6
6. Sh. Prem Chand Garhwal, T-6
7. Dr. Arvind Kumar Verma, T-6

* Since January01, 2017

** On study leave

Transferred from ICAR-IISS, Bhopal and Joined DRMR on June 28, 2018

Transferred from ICAR- NIASM, Baramati and joined DRMR on June 30, 2018

Transferred from KVK, ICAR-CAZRI, Jodhpur and joined KVK, Bansur on December 24, 2018

^ Transferred to ICAR, Krishi Bhawan, New Delhi, relieved on January 14, 2019

^^ Transferred to ICAR-IARI, New Delhi, relieved on August 28, 2018

^^^Transferred to KVK, ICAR-CAZRI, Jodhpur, relieved on December 20, 2018

$Fresh joining at ICAR-DRMR on November 11, 2018

$$Fresh joining at ICAR-DRMR on November 20, 2018

Institute Committees

Committee	Members
Priority Setting, Monitoring and Evaluation (PME Cell)	Dr. Pankaj Sharma, Pr. Scientist (In-charge), Drs. Vinod Kumar, , Ajay Thakur, Hariom Kumar Sharma, M.L. Dotaniya, M.D. Meena, Sh. Sanjay Sharma, Mrs. Veena Sharma (Members)
Results- Framework Document (RFD)	Dr. Vinod Kumar, Pr. Scientist
Institute Technology management Unit (ITMU)	Dr. P.K. Rai (Ex-office Chairman), Dr. Vinod Kumar (Member secretary) and Dr. Ajay Kumar
Institute Purchase committee (IPC)	Dr. Pankaj Sharma (In-charge), Drs. R.S. Jat, H.S. Meena, SAO (Member secretary), F&AO
Institute Joint Staff Council (IJSC)	Dr. P.K. Rai (Ex-office Chairman), Drs. Pankaj Sharma, Bhagirath Ram (Member secretary), Priyamedha, Harvir Singh, SAO, F&AO
Institute Research Council (IRC)	Dr. P.K. Rai (Chairman), Dr. Ashok Kumar Sharma (Member secretary)
Research Advisory Committee (RAC)	Dr. J.B. Chaudhary, (Chairman) Ex-Vice Chancellor (GBPUA&T, Pantnagar); Director, ICAR-DRMR, Dr. S.R. Bhatt, Ex- Pr. Scientist, ICAR-NRCPB, New Delhi; Dr. B.S. Mahapatra, Professor Agronomy, GBPUA&T, Pantnagar; Dr. K.P. Singh, Ex- Professor Mycology and Plant Pathology, BHU, Varanasi; Dr. V.K. Yadav, Director Research, SKNAU, Jobner; Dr. R.P. Singh Ratan, Director Extension Education, BAU, Ranchi; Assistant Dierctor General (O&P) ICAR, New Delhi and Dr. K.H. Singh, Pr. Scientist ICAR-DRMR, Bharatpur (Member Secretary)
Institute Management Committee (IMC)	Dr. P.K. Rai (Ex-office Chairman), Joint Director of Agriculutre, Deptt. Of Agri. Govt. of Raj, Bharatpur; Joint Director of Agriculutre (Oilseed), Deptt. of Agri. Govt. of MP,Bhopal, Dr. S.J. Singh, Director, RARI, Durgapura, Jaipur; Dr. Rajbir Yadav, Pr. Scientist, ICAR-IARI, New Delhi; Dr. R.K. Tyagi, Head Germplasm Conservation, ICAR-NBPGR, New Delhi; Dr. B.D. Sharma, Pr. Scientist, ICAR-CIAH, Beechwal, Bikaner; Dr. R.C. Bhattacharya, Pr. Scientist, ICAR-NRCPB, New Delhi; Assistant Dierctor General (O&P) ICAR, New Delhi, F&AO, ICAR-NRCPB, New Delhi; SAO, ICAR-DRMR, Bharaptur; F&AO, ICAR-DRMR, Bharatpur
Institute Germplasm Identification Committee (IGIC)	Dr. P.K. Rai (Ex-office Chairman), Drs. K.H. Singh, (Member secretary), Pankaj Sharma, R.S. Jat, Arun Kumar, Priyamedha
Women Complaint Committee (WCC)	Drs. Anubhuti Sharma, Sr. Scientist (Chair person), Priyamedha, Scientist , Ibandalin Mowlong, Ms. Veena Sharma
Human Resource Development (HRD)	Dr. Pankaj Sharma, Pr. Scientist (Nodal Officer), Dr. R.S. Jat (Co-Nodal Officer)
Institute Foreign Deputation Committee (IFD)	Drs. Pankaj Sharma, Bhagirath Ram, Arun Kumar, Shri R.C. Meena (SAO)

15 Panorama

International Day of Yoga

ICAR-DRMR celebrated 4th anniversary of "International day of Yoga" on 21st June 2018 as per common yoga protocol issued by Ministry of Ayush, Govt of India and ICAR. On this occasion discussions on various topics including Yoga and consciousness were held. The yoga asanas were conducted under the supervision of trained yoga instructor who, apart from conducting the yoga exercises, elaborated the benefits of each asana. The instructor educated the participants about the importance of yoga for stress free healthy living and healthy mind. Scientists, Technical, Administrative and Skilled supporting staff of ICAR-DRMR enthusiastically participated in the programme. The function ended with the promise to do yoga regularly to live healthy life and contribute more in the progress of the nation.



Independence Day Celebration

ICAR-DRMR celebrated the 72nd Independence Day on 15th August 2018 with pride and honour the great sacrifices made by patriots and freedom fighters. Dr P. K. Rai, Director of the institute hoisted the tricolour flag and addressed the staff. He remembered the great sacrifices made by the great leaders and freedom fighters for getting the Independence and highlighted that it is the duty of every Indian citizen to protect the same and to strive hard for sustainable growth and prosperity of the country. While addressing the staff, he emphasized the importance of team work, and holistic approach to make novel strides in the research front of the directorate because the country looking towards us for break through in oilseed research specially in rapeseed-mustard to meet out the ever growing demand of edible oil.



Parthenium Awareness Week

13th Parthenium Awareness Week was observed during August 16-22, 2018 at ICAR-DRMR. During Awareness week Parthenium in the DRMR campus was uprooted. Scientist and technical staff shared their knowledge and experience on this notorious weed which causes many diseases like skin allergy, hay fever, breathing problems in human beings and animals.

21st Beej Pakhwada

ICAR-DRMR organised 21st Beej Pakhwada (Seed Fortnight) during Sept. 15–Oct 05, 2018 for sell of TL seeds of improved varieties of Rapeseed-mustard to farmers. A total of 335.85 q TL seeds of seven improved varieties of rapeseed-mustard viz. DRMRIJ 31, NRCHB 101, NRCDR 02, RH 749, RH 406, NRCHB 506 (hybrid) of Indian mustard and NRCYS 05-02 of yellow sarson was sold. A sum of Rs. 57.36 lakh was generated from sell of seeds during seed fortnight. The seeds were sold to the farmers on first-come-first basis. The farmers were also provided counselling for situation specific varietal selection along with advice on scientific cultivation of rapeseed-mustard during seed fortnight.



Organized a poetry lessons for giving tribute to Late Shri. Atal Bihari Vajpayee

Samaj Sadan, a recreation club of the ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, organized poetry lessons 16-9-2018 for giving fitting tribute on first monthly death anniversary of Bharat Ratna late Sh. Atal Bihari Vajpayee, the former Prime Minister of India. The programme was started by observing a two-minute silence for the peace of the departed soul followed by reading the introduction of Vajpayee's life, he his achievements of political carrier, devotion to country and sensitiveness to the society.



In the poetry annotation, the famous poets of Bharatpur, Shri Som Dutt Vyas, Shri Ram Babu Bidhohi and Shri Purnan Sharma, through their poems, explained the Bajpayee's personality. The popular poems composed by Sh. Vajpayee ji such as "हार नही मानूंगा, रार नही ठानूंगा..", "काल के कपाल पर लिखता ही जाता हूँ", etc. were discussed. On this occasion poets read several poems on patriotism. DRMR staff and farmers participated in the programme. Dr. Vinod Kumar recorded hearty thanks to the poets and all participants.

Swachh Bharat Abhiyan

The Swachchh Bharat Mission provides opportunity to staff members for healthy interaction and awareness regarding cleanliness. Cleanliness drives were conducted successfully on every month from April 2018 to March 2019 in the ICAR-DRMR office premises, staff quarters, glass houses complex, basic science complex, farm areas and outside office premises. All staff members including scientists, technicals and office staff, rendered their services in the cleanliness drives. A drawing competition was





organized by involving primary class students from nearby schools on Swachh Bharat Abhiyan on 02.05.2018. An awareness programme about cleanliness drive was also organized for students. ICAR-DRMR celebrated the 150th birth anniversary of Shri Mahatma Gandhi on 02.10.2018. A seminar was organized on this occasion in basic science complex of ICAR-DRMR. Dr. Bhagirath Ram, Nodal Officer, SBA

apprised the whole year activities of Swachh Bharat Mission at the Directorate. Dr P K Rai, Director, ICAR-DRMR apprised the principles of Mahatma Gandhi on cleaniness. ICAR-DRMR, observed "Swachhta Hi Seva Campaign" from 15.09.2018 to 24.09.2018. During the programme, all the employees of this Directorate carried out cleaning drives at Bharatpur-Sewar Main Road in front of Office building of ICAR-DRMR. Swachhta Pakhwara was also observed during 16.12.2018 to 31.12.2018 in order to spread the message of cleanliness, not only among staff but also in surrounding villages.

ICAR-DRMR, Bharatpur Celebrated its Silver Jubilee Foundation Day

ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur celebrated its Silver Jubilee Foundation day on October 20, 2018. Dr. A. K. Singh, Deputy Director General (Horticulture & Crop Science), ICAR, New Delhi graced the occasion as Chief guest and delivered foundation day lecture. Dr. Arvind Kumar, Vice Chancellor, Rani Lakshmi Bai Central Agricultural University, Jhansi, UP was Guest of Honour on this occasion.



Dr. A. K. Singh appreciated the work done by the Directorate over the last 25 years. On this occasion, he emphasised that, to meet the increasing demand of edible oil and minimize the import bill on edible oil, rapeseed-mustard can play an important role. He further emphasized that there is an urgent need to develop farmer friendly technologies to minimize losses caused by biotic and abiotic stresses.He urged to explore the possibilities to use newer technologies such as gene editing in rapeseed-mustard improvement programme. Dr. Arvind Kumar said that, after its inception, the Directorate played a significant role in development of new high yielding varieties as well as production and protection technologies which increased rapeseed-mustard productivity in the country.

Dr. P.K. Rai, ICAR-DRMR welcomed all the guests and apprised about the work done by the Directortae. He said that in order to increase the productivity and production of oilseed crops, a better coordination among research institutes, Department of Agriculture, KrishiVigyan Kendra, SAUs, Seed Corporations has been established by the Directorate.



On this occasion, former Directors of the ICAR-DRMR, Dr. Bhori Singh and Dr. Y. P. Singh were honoured. Dr. Pankaj Sharma, Dr. Ashok Sharma, Dr. Bhagirath Ram, Dr. H. S. Meena, Dr. Ibadalin Mawlong were awarded with best worker award, in the scientific category; Mrs.Veena Sharma, Mr. Mukesh Kumar, Mr. Pankaj Pathak, Mr. Lalaram and Mr. P.K. Tiwari in the administrative and financial category; Sh. Sanjay Sharma and Sh. Ram Narayan in the technical category were

honoured with certificate and memento for their significant contributions made during 2017-18.

On this occasion, DDG inaugurated 150 KWP roof-top solar power system and laid the foundation stone of community centre. He also unfolded Silver Jubilee stone at the campus. Three publication were also released on the occasion.

Vigilance Awareness Week

ICAR-DRMR observed Vigilance Awareness Week-2018 from October 29 to November 3, 2018, with the theme of "Eradicate corruption-build a new India". Director, ICAR-DRMR administered the pledge to all the staff members and explained the importance of the event.



World Soil Day

World Soil Day was celebrated on 5th December, 2018. On this occasion an awareness cum training programme was organized on Soil Health Management for Sustainable Crop Production. More than 72 farmers/faculty members participated and were made aware how to reduce chemical use in crop production and to apply recommended dose of fertilizer to maintain the soil health. They were also sensitized about practical utility of Soil health card.



Celebrated 70th Republic Day

ICAR-DRMR celebrated 70th Republic Day on 26 January 2019 at its colorful illumination premise wherein all the staff including scientific, technical, administrative were present. On this occasion, Director, ICAR-DRMR hoisted the national flag and addressed to the staff. At the outset, he conveyed his warm wishes to all the staff and family of ICAR-DRMR on the occasion of 70th Republic day. He highlighted the key achievements of the directorate and complimented the staff members who brought success by winning awards and recognitions in various fora. He called upon all the members of ICAR-DRMR family to strive hard to take forward the momentum so as to realize the vision of the directorate.



25th Sarson Vigyan Mela organized

ICAR-DRMR organized its 25th Sarson Vigyan Mela on February 7, 2019. The mela was inaugurated by honourable member of Research Advisory Committee of ICAR-DRMR, Dr. K.P. Singh. Addressing the farmers, he said that a number of improved varieties and scientific technologies have been developed by research institutes in the country, not only in rapeseed-mustard but also in all crops. Now farmers should come forward to adopt the scientific technology to increase the production and productivity of the crops. Development in the rural areas of the country can only be accelerate enhancing of the farmers' income. In order to double the income of

the farmers in accordance with the wishes of the Honorable Prime Minister, farmers should be made aware and trained about advanced techniques. The Guest of Honour, Dr. S.K. Dalal, National Consultant, oilseed division, DAC&FW, MoA&FW, Govt. of India highlighted the situation of oilseeds production, area and productivity in the world and in India and said that to meet the demand of edible oil, increasing production is the first priority. To meet the demand of edible oil, the production of mustard should be increased. Mustard crop is important and its production capacity is huge. In view of which, all the stakeholders, scientists, agricultural officers, farmers, etc. should make concerted efforts so that advanced technologies developed by the research organizations should reach the farmers faster and increase the contribution of mustard in oil basket. On this occasion, the Guest of Honour, Dr. R.P. Singh Ratan, former Extension Director, BAU, Ranchi said that technology development has contributed a lot in increasing the income of farmers. Farmers and scientists should decide the course of research. Technology dissemination from farmers to farmers is more important than extension personnel to farmers. He said that the farmers should come forward for new techniques and participate in the training and demonstrations. He emphasized the need to work through farmers' organizations.



Director, ICAR-DRMR, Dr. P.K. Rai said that rapeseed-mustard crop has special place in Indian economy. It is possible to achieve self-sufficiency in oilseeds by adopting advanced varieties and techniques developed by the scientists in the country. For this, scientists, extension officers and farmers will have to work together. Farmers have to get information about advanced techniques and adopt them. By their hard work, the production of oilseeds will increase and the country will get self-reliance in oilseed and import bill of edible oil could be minimized. This directorate has always been ready to help farmers. The information about advanced technologies of rapeseed--mustard is being provided by the scientists to the farmers through the FLDs, farmer-scientist interaction, exhibitions, fairs, radio programmes etc.

On this occasion, Shri Desharaj Singh, Joint Director, Department of Agriculture, Bharatpur; Dr. Amar Singh, Dean, CoA, Kumher; Sh. Yogesh Sharma, P.D. ATMA; Dr. Uday Bhan Singh, In charge, ARSS, Kumher also expressed their views. The five technical folder/bulletins were released on this occassion. Several exhibitions by different institutions were organized to provide advanced information on the agriculture and allied sectors along with farmers welfare schemes of GOI. The progressive farmers were honoured on this occasion.



Webcast of PM-Kisan Samman Nidhi Scheme

The Webcast of "PM-Kisan Samman Nidhi Scheme" was arranged at ICAR-DRMR, Bharatpur on February 24, 2019. On this occasion, Director, ICAR-DRMR briefed about the different farmer's welfare schemes of GOI including 'PM-Kisan Samman Nidhi Scheme'. About 650 farmers and farm women, staff of ICAR-DRMR, 10 Public Representatives

including Sh. Bahadur Singh Koli, Member of Parliament, Bharatpur, Dr. Jitendra Singh, President BJP, Bharatpur, 35 State Government Officials viewed the programme. On this occasion, Sh. Bhadur Singh Koli and Director ICAR-DRMR honored 11 beneficiaries of PM-Kisan Samman Nidhi Scheme.



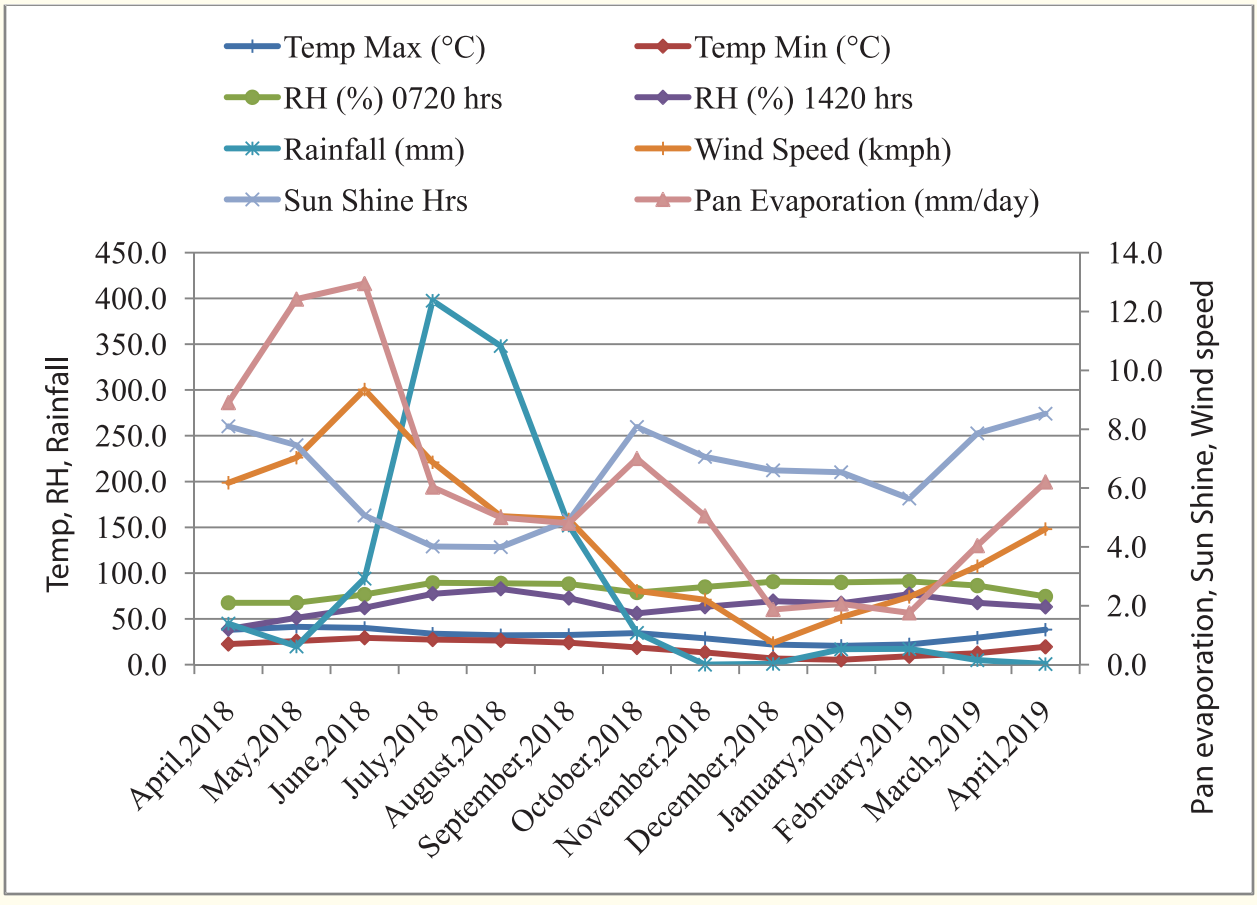
International Women's Day

International Women's Day was observed in ICAR- Directorate of Rapeseed-Mustard Research, Bharatpur on March 8, 2019. On this occasion Director Dr. P.K. Rai addressed the employee of the Directorate. He elaborated the theme for IWD- 2019 "Think Equal, Build Smart, Innovate for Change" and shared his valuable thoughts. He wished all the women employee of the Directorate and motivated them. ICAR-DRMR webcasted address of Hon'ble PM on International Women's Day. It was viewed by all the staff members of the Directorate along with Professors and students from Amity University, Noida and Rajasthan University, Jaipur.



16 Meteorological Data

This year maximum temperature was recorded 41.3ºC in the month of May and minimum in the month of January, 2019 (20.5 ºC). Relative humidity was ranged 67.6 to 90.9% and 38.9 to 82.8% at 0720 hrs and 1420 hrs, respectively. Maximum rainfall received in three months (July - September) and rest of the months received small amount of precipitations except November, 2018. The wind speed varied from 0.7 kmph in December, 2019 and 9.4 kmph in June, 2019. Highest sunshine (hour) was recorded in April and October, 2018 whereas, lowest in August, 2018.



17 Budget and Resource Generation

Budget (Rs. in Lakhs)

Head	Sanctioned	Utilized
ICAR-DRMR	1130.0	1130.08
AICRP-RM	1139.5	1139.50

Resource Generation (Rs.)

Account head	Amount	Account head	Amount
Sale of farm produce	47,85,045	Training	87,375
Sale of tender form	47,500	Guest House	3,50,000
License fee	291841	Transport charges	1,40,000
Analytical testing fee	40450	DRMR	6,87,718
Total Income generated			**64,29,929**

Notes

Notes