ICAR-DRMR
ANNUAL REPORT
2019

ICAR-Directorate of Rapeseed-Mustard Research

(Indian Council of Agricultural Research)

Sewar, Bharatpur 321 303 (Rajasthan) India

(An ISO 9001:2008 Certified Organization)

ANNUAL REPORT
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Indian Council of Agricultural Research (ICAR) established ICAR-Directorate of Rapeseed-Mustard Research as a national repository for rapeseed-mustard genetic resources and also for undertaking basic, strategic and applied research to enhance the productivity and quality of oil and seed-meal. The Directorate is assigned the leadership role, not only for the ICAR institutes but also for the Central and State Agricultural Universities, in developing ecologically sound and economically viable agro-production and protection technologies for rapeseed-mustard based on location 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.

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

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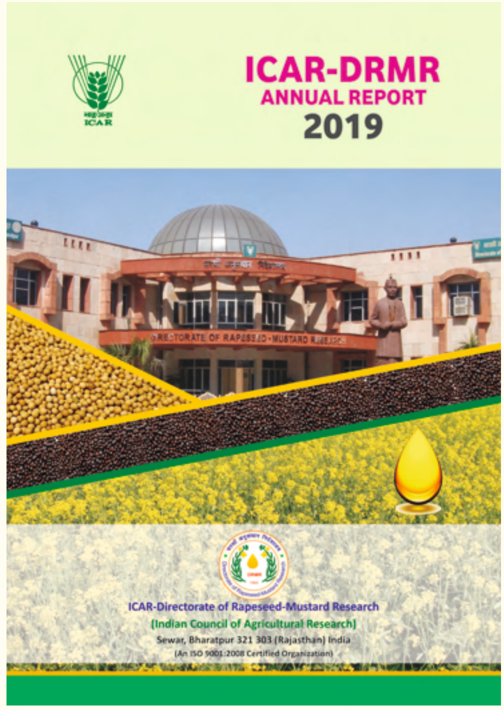

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VISION

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

I am pleased to place before you Annual report of ICAR-DRMR for the year 2019. Directorate is playing a pivotal role in overall development of rapeseed-mustard crops. During the year under report all time high crop productivity (1511 kg/h) and production (9.26 mt) was recorded. The highlights of the research programme and other activities at the Directorate were registration of four genetic stocks of Indian mustard viz., DRMR 10-40 (IC0632085, INGR 19085 for drought tolerance, DRMR 2059 (IC0520764, INGR19086) for heat tolerance at seedling and terminal stage, DRMR 4001 (IC0632086, INGR19087) for drought tolerance and DRMR 4005 (IC0632087, INGR19088) for thermos-tolerance at juvenile stage coupled with high seed and oil yield were registered by Plant Germplasm Registration Committee, ICAR, New Delhi. 26th AGM of AICRP-RM was held on August 3-5, 2019 at BAU, Ranchi. Two entries of Indian mustard, DRMR 2017-15 and DRMRIC 16-38 were promoted to AVT-II for zone II under late sown, irrigated conditions.

A Linkage map of *Brassica juncea* generated using 53 SSR markers in F_2 population (192 F_2) derived from NRCHB101 x BPR543-2. These 53 SSRs were mapped to 7 linkage groups (C1-C7) of *B. juncea* genome. In natural resource management experiments, significantly highest seed (2973 kg ha^{-1}) and stover (76.49 qha^{-1}) yield of mustard was observed under the treatment receiving micro and secondary nutrients at the rate of 5.0 kg Zn + 2 kg B+ 10 kg Fe +20 g S enriched FYM @ 500 kg ha^{-1}($Zn_2B_2Fe_2S_2$ En). Further, to conserve the soil moisture application of superabsorbent polymers (SAPs) significantly improved the seed yield with an average 13.7 and 15.5% over the controls under no-moisture stress and moisture stress conditions, respectively. Under conservation agriculture practices, mustard sowing on permanent beds of previous crop residues had significantly higher seed yield of mustard compared to conventional tillage however, it was at par with zero tillage.

ICAR-DRMR organized 373 FLDs of improved varieties in 335.4 hectares in Manipur region under NEH component and 300 FLDs in selected 30 villages of Bharatpur district of Rajasthan under MGMG. A total 16 research papers, 12 book chapters and 4 technical folders were published during the period. Directorate produced 895.95 q TL and 24.62 q breeder seeds of rapeseed-mustard varieties during year 2018-19. Rs. 59.81 lakh income was generated by various resources.

I extend my sincere thanks and gratitude to Dr. T. Mohapatra, Secretary DARE Govt. of India and Director General, ICAR, for his leadership and direction. I am also thankful to Dr. A.K. Singh, Deputy Director General (Crop Science), ICAR, Dr. P.K. Chakraborty, Assistant Director General (Oilseeds & Pulses), Dr. S.K. Jha (Acting) Assistant Director General (O&P) and esteemed member of RAC for guidance and help rendered to Directorate.

I acknowledge the efforts of the editors Drs. Pankaj Sharma, H.K. Sharma, M.D. Meena and Prashant Yadav who have done commendable job in compilation of this report. I thank and congratulate all the staff of ICAR-DRMR for their contribution in smooth functioning of the Directorate.

ICAR-DRMR, Bharatpur
June 30, 2020

(P. K. Rai)
Director (Acting)

Abbreviation

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	BirsaAgricultmal 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
FIG$_s$	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 Join 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 PhuleKrishi 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
SDA	State Department of Agriculture
SDAU	Sardar Dantiwada Agricultural University
SGM	Sesbania Green Manure
SIAM	State Institute of Agriculture Management
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SOC	Soil Organic Carbon
SPS	Single Plant Selection
SSG	Supporting Staff Grade
STMS	Sequence Tagged Microsatellites
TSP	Tribal Sub Plan
UAS	University of 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

- Four genetic stocks of Indian mustard viz., DRMR 10-40 (IC0632085, INGR 19085 for drought tolerance, DRMR 2059 (IC0520764, INGR19086) for heat tolerance at seedling and terminal stage, DRMR 4001 (IC0632086; INGR19087) for drought tolerance and DRMR 4005 (IC0632087; INGR19088) for thermo-tolerance at juvenile stage coupled with high seed and oil yield were registered by PGRC, New Delhi.
- Entry DRMR 2017-15 and DRMRIC 16-38 were promoted to AVT-II for zone II (late sown).
- A Linkage map of *Brassica juncea* generated using 53 SSR markers in F_2 population (192 F2) derived from NRCHB101 x BPR543-2 in Indian mustard. These 53 SSRs were mapped to 7 linkage groups (C1-C7) of *B. juncea* genome.
- Among different CA practices, mustard sowing on permanent beds of previous crop residues (anchored kharif crop stubbles) had significantly higher seed yield of mustard as compared to conventional tillage however, it was at par with zero tillage recorded in the third year of rotation (2018-19).
- Significantly highest seed (2973 kg ha^{-1}) and stover (76.49 qha^{-1}) yield of mustard was observed under the treatment receiving micro and secondary nutrient applied at the rate of 5.0 kg Zn + 2 kg B+ 10 Kg Fe +20 g S enriched FYM @ 500 kg ha^{-1}($Zn_2B_2Fe_2S_2En$).
- The seed yield of mustard significantly (*P=0.05*) influenced due to application of superabsorbent polymers (SAPs) under both the moisture regimes. Irrespective of type of SAPs, seed yield improved by on an average 13.7 and 15.5% over the controls under no-moisture stress and moisture stress conditions, respectively
- Soil treated with 25% recommended dose of chemical fertilizers (RDF) along with 1.5 t/ha of enriched composts had significantly higher Olsen-P (23.39 g/ha) as compared to alone use of chemical fertilizers and composts. Treatments receiving integrated use of chemical fertilizers along with nutrient enriched compost resulted in higher available nutrients and mustard yield over control.
- 373 FLDs were conducted on 335.4 hectares in Manipur region under NEH component and 300 FLDs of improved varieties were conducted in selected 30 villages of Bharatpur district of Rajasthan under MGMG.
- 24.62 q breeder seed of rapeseed-mustard varieties (DRMRIJ31, NRCDR02, NRCHB101, and NRCYS 05-02) was produced during 2018-19.
- A total 895.95 q TL seeds of improved varieties (DRMR IJ31, NRCHB101, RH-749 and NRCYS-05-02) were produced and sold during *Beej Pakhwada*.
- ICAR-DRMR organized 4 trainings and 3 exposure visit-cum-trainings programmes of 2 to 5 days each under ATMA/NGOs/KVKs/ APART/other schemes.
- A total of 110 on farm trials, 207 FLDs, 70 trainings, 10 field days, 08 Kisan gosthies 189 advisory services, 12 exhibitions, 37 diagnostic visits, 02 plant animal health camps, 10 method demonstrations, 03 kisan mela were organized and 1312 kg mustard seeds was sold by the KVK, Bansur.
- During the period 16 Research papers, 12 book chapters and 4 technical folders were published.
- 59.82 lakh 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 22 centers 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. ICAR also sanctioned a Krishi Vigyan Kendra for ICAR-DRMR on 28 March, 2012 which was established at Gunta-Bansur, Alwar (Rajasthan), 170 km from Bharatpur. 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.

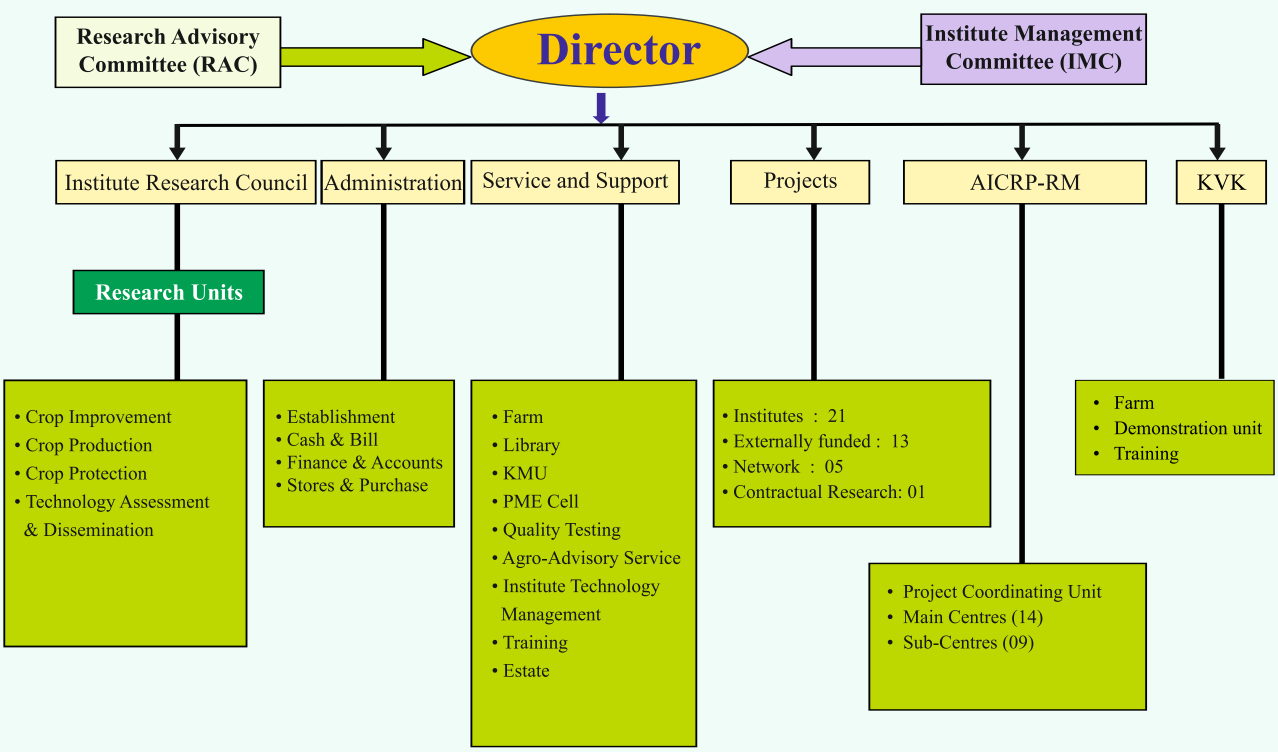
Objectives:

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

Functions

- The national repository of rapeseed-mustard genetic resources and information.
- Basic, strategic and applied research 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 trials

Entry DRMRCI 96 promoted to AVT-1 (Early mustard, Zone III) on the basis of 10.6% higher seed yield over the best check. Based on lower seedling mortality (<20%) and higher seedling dry matter (>40 mg/10 seedling), DRMR 2059 and DRMR 2300 were identified tolerant at seedling stage. DRMR 541-44 was found promising for low light stress. Genotypes DRMRCI 114 and DRMR 70 were found tolerant for drought stress. DRMR 2059 was also reported tolerant to terminal heat stress. Five promising entries viz; DRMRCI 116 (IVT, early sown), DRMRCI 117 (IVT, timely sown, irrigated), DRMRCI 118 (IVT, timely sown, rainfed) and, DRMRCI 115 (IVT, late sown) were contributed for multi-location testing in AICRP-RM trials during 2019-20. DRMRCI 96 and DRMRCI 98 were contributed for evaluation in state trial of UP and DRMRCI 70 and DRMR1153-12 in state trial of Jharkhand.

Evaluation of promising entries in station trials

Entry DRMRCI 117 recoded maximum yield (2745 kg/ha) in comparison to best check NRCDR 02 (2608 kg/ha) under irrigated timely sown trial. In station trials, under rainfed conditions, entry DRMRCI 118 gave highest yield (1498 kg/ha) followed by DRMRCI 119 (1312 kg/ha) in comparison to best check RH 406 (1190 kg/ha). In early trial, entry DRMRCI 116 recorded maximum yield (2260 kg/ha) followed by DRMRCI 115 with yield of 2118 kg/ha in comparison to best check NPJ 124 (1755 kg/ha).

Generation of breeding material

Following fresh crosses were attempted: RH 725 x DRMR 10-40, DRMR 10-40 x DRMR 541-44, DRMR 10-40 x RH 725, DRMR 541-44 X NPJ 112, NPJ 112 x DRMR 150-35, DRMR 150-35 x RGN 48, RGN 48 x RH 761, RGN 48 x DRMR 150-35, RH 761 x RH 555, RH 555 x Laxmi, Laxmi x RH 749, RH 749 x NRCDR 02, NRCDR 02 x NRCHB 101, NRCHB 101 x DRMRIJ 31, DRMRIJ 31 x NPJ 124, NPJ 124 x RH 406, RH 406 x Kranti, Kranti x RH 725. BPR 1860 (RH 749 x NPJ 112) x BPR 1869 (NRCHB 101 x RB 50), BPR 1861(NRCDR 02 x RH 406) x BPR 1860 (RH 749 x NPJ 112), BPR 1862 (DRMRIJ 31 x RB 50) x BPR 1861 (NRCDR 02 x RH 406), BPR 1863 (RH 555 x NPJ 112) x BPR 1862 (DRMRIJ 31 x RB 50), BPR 1864 (NRCDR 02 x DRMR 10-40) x BPR 1863 (RH 555 x NPJ 112), BPR 1865 (Kranti x NRCHB 101) x BPR 1864(NRCDR 02 x DRMR 10-40), BPR 1866 (RGN 48 x RH 406) x BPR 1865 (Kranti x NRCHB 101), BPR 1867 (RH 749 x DRMRIJ 31) x BPR 1866 (RGN 48 x RH 406), BPR 1868 (NRCHB 101 x DRMR 541-44) x BPR 1867 (RH 749 x DRMRIJ 31), BPR 1869 (NRCHB 101 x RB 50) x BPR 1868 (NRCHB 101 x DRMR 541-44), BPR 1870 (BPR 1826 x RLC 3) x BPR 1871(BPR 1826 x Heera) , BPR 1871 (BPR 1826 x Heera) x 1872 (BPR 1825 x PDZ 1), BPR 1872 (BPR 1825 x PDZ 1) x BPR 1873 (BPR 1824 x PDZ 1), BPR 1873 (BPR 1824 x PDZ 1) x BPR 1874 (BPR 1824 x Heera), BPR 1874 (BPR 1824 x Heera) x BPR 1875 (BPR 1827 x Heera), BPR 1875 (BPR 1827 x Heera) x BPR 1876 (BPR 1827 x RLC 3), BPR 1876 (BPR 1827x RLC 3) x BPR 1877 (BPR 1830x DRMR 1153-12), BPR 1877 (BPR 1830 x DRMR 1153-12)x BPR 1878 (BPR 1830 x DRMR 1165-40), BPR 1878 (BPR 1830 x DRMR 1165-40) x BPR 1879 (BPR 1831x DRMR 1153-12), BPR 1879 (BPR 1831x DRMR 1153-12) x BPR 1880 (BPR 1832 x DRMR 1165-40), BPR 1880 (BPR 1832 x DRMR 1165-40) x BPR 1881 (BPR 1833 x DRMR 1153-12), BPR 1881 (BPR 1833 x DRMR 1153-12) x BPR 1882 (BPR 1835x DRMR 1153-12), BPR 1882 (BPR 1835 x DRMR 1153-12) x BPR 1883 (BPR 1835 x DRMR 1165-40), BPR 1883 (BPR 1835 x

DRMR 1165-40) x BPR 1884 (BPR 1837 x RLC 3), BPR 1884 (BPR 1837 x RLC 3) x BPR 1885 (BPR 1837 x PDZ 1), BPR 1885 (BPR 1837 x PDZ 1) x BPR 1886 (BPR 1838 x RLC 3), BPR 1886 (BPR 1838 x RLC 3) x BPR 1887 (BPR 1839x Heera), BPR 1887 (BPR 1839 x Heera) x BPR 1870 (BPR 1826 x RLC 3)

Selection from segregating/non-segregating generations

The segregating and non-segregating generations [17 F_2 populations, $F_3$250 SPS (09 crosses), $F_4$127 SPS (03 crosses), F_5 107 (01 cross), observation nursery 149 (16 crosses)] were sown in augmented blocks with standard checks (RH 749, NRCDR-02, DRMRIJ 31, NRCHB 101) under irrigated conditions. From variable F_2 populations, 1200 SPS, 512 SPS in F_3, 275 SPS in F_4 and 241 SPS in F_5 selected for generation advancement. From observation nursery 75 bulks were selected.

Observation nursery

149 advanced progenies grown in observation nursery along with checks (NRCHB 101, DRMRIJ 31, RH 749 and NRCDR 2), on the basis of *per se* performance, progenies, DRMR 1729-2-25 (2990 kg/ha), DRMR 1729-64-128 (2908 kg/ha), DRMR 1743-78-131 (2695 kg/ha), DRMR 1688-54-117 (2683 kg/ha), DRMR 1743-82-133 (2659 kg/ha), DRMR 1724-72-114 (2636 kg/ha), DRMR 1758-26-109 (2612 kg/ha), DRMR 1758-13-119 (2576 kg/ha), DRMR 1733-45-33 (2565 kg/ha) were found superior in comparison to best check NRCHB 101 (2471 kg/ha).

Rainfed

Observation nursery

An assembly of 147 advanced breeding lines along with checks were sown on conserved moisture to evaluate and select promising lines for drought tolerance. Total 39.6 mm rains were received during the crop period. The top 10 lines DRMR 1758-13-107 (2056 kg/ha), DRMR 1758-8-105 (1962 kg/ha), DRMR 1758-11-106 (1950 kg/ha), DRMR1743-91-67 (1891 kg/ha), DRMR 1733-45-33 (1879 kg/ha), DRMR 1743-109-94 (1749 kg/ha), DRMR 1729-2-19 (1713 kg/ha), DRMR 1729-2-3 (1560 kg/ha) having higher yield against best check RH 406 (1040 kg/ha) were selected and characterized for yield contributing traits. Observations were recorded on number of primary branches/plant, number of secondary branches/plant, plant height (cm), silique/plant, fruiting zone length (cm), main shoot length (cm), number of seeds/siliquae, siliquae length (cm), biological yield/plant (g), seed yield/plant (g) , SPAD, water use efficiency (WUE), harvest index and test weight.

Genetic parameters

Maximum genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was reported for secondary branches/plant (39.9% and 48.07% respectively) followed by seed yield/plant (33.62 % and 38.28% respectively), biological yield /plant (24.34 % and 27.89% respectively) and water use efficiency (22.75% and 29.7% respectively). Estimates of heritability were maximum for seed yield /plant (77.11%) followed by plant height (76.86%) and biological yield /plant (76.15%). It indicates that ample genetic variation is available for seed yield in the material which can be exploited for genetic enhancement of drought tolerance. Drought susceptibility index (DSI) was calculated for each line and based on DSI values, DRMR-1733-45-1-72-2, DRMR-1743-100-2-98-1, DRMR-1686-34-11, DRMR-1758-12-56, DRMR-1733-45-1-71-1, DRMR-1758-7-49, DRMR-1758-30-64, DRMR-1743-94-2-92-1, DRMR-1733-45-1-38-1, DRMR-1758-11-52 were identified.

Selections from segregating generations

Under rainfed conditions, [9 F2 populations, F_3 121 SPS (5 crosses), F_4 127 SPS (7 rosses), F_5 107, observation nursery (149 bulk from 16 crosses), were grown along with checks (RB 50, RH 406, RGN 48, Kranti) for selection and evaluation. Individual plant (400 SPS in F_2, 242 SPS in F_3, 200 SPS in F_4, 252 SPS in F_5 and 50 bulks in observation nursery) as well as promising lines were selected. Advance lines of karan rai were evaluated and 40 bulks and 200 SPS were selected.

Germplasm registration

Two genetic stocks viz., DRMR 10-40 (IC0632085, INGR 19085 for drought tolerance and DRMR 2059 (IC0520764, INGR19086) for heat tolerance (seedling and terminal stage) were registered by PGRC, New Delhi.

DRMR CI-12: Widening of gene pool in

Brassieas through inter-specific and inter-generic hybridization.

Principal Investigator: Arun Kumar, Pr. Scientist (Genetics and cytogenetics)

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

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

From the F_4 progenies of inter-specific hybrids between *B. juncea* cv. Rohini, Laxmi & Varuna x *B. fruticulosa* (Colchi-tetraploid), screening and scoring for mustard aphid infestation, selection of single plant progenies was done. Screening for the mustard aphid infestation in the field conditions was performed against check BSH 1and JMM 927 at DRMR experimental field. 25 lines of F_4 progenies, including parents, were shared with Scientist (Entomology), AICRP-RM, PAU, Ludhiana for screening for aphid tolerance, during the rabi season 2018-19. Three progenies of *B. juncea* (cv. Laxmi) × *B. fruticulosa* (2n = 4x =32) cross, six progenies of *B. juncea* (cv.Rohini) × *B. fruticulosa* (2n=4x=32) cross and one progenies of *B. juncea* (cv. Varuna) × *B. fruticulosa* (2n = 4x =32) showed tolerance against mustard aphid infestation under field conditions (Table 1).

Table 1. Mustard aphid infestation under natural conditions at PAU, Ludhiana during 2018-19 crop season

Progenies/parent	AII	Progenies/parent	AII
DRMR-IC-A-18-01	1.4	DRMR-IC-A-18-15	0.5
DRMR-IC-A-18-02	1.4	DRMR-IC-A-18-15	1.2
DRMR-IC-A-18-03	0.8	Rohni	2.5
DRMR-IC-A-18-04	0.7*	DRMR-IC-A-18-17	3
DRMR-IC-A-18-05	0.9	DRMR-IC-A-18-18	1.0 *
DRMR-IC-A-18-06	1.3	DRMR-IC-A-18-19	1.8
DRMR-IC-A-18-07	1.3	DRMR-IC-A-18-20	2.4
DRMR-IC-A-18-08	1.1	DRMR-IC-A-18-21	1.6
Laxmi (Parent)	1.9	DRMR-IC-A-18-22	1.8
DRMR-IC-A-18-09	1.6	DRMR-IC-A-18-23	1.4
DRMR-IC-A-18-10	0.6	DRMR-IC-A-18-24	1.6
DRMR-IC-A-18-11	0.8*	DRMR-IC-A-18-25	1.8
DRMR-IC-A-18-12	1.1	Varuna (Parent)	1.6
DRMR-IC-A-18-13	0.7	BSH 1((Sus. check)	1.6
DRMR-IC-A-18-14	0.7	*B. fruticulosa*	0.4

*F_4progenies showing tolerance against mustard aphid under field conditions at DRMR

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

Two advance lines (DRMR-YS-17-01 and DRMR-YS-17-02), renamed as (DRMR-BS-17-01 and DRMR-BS-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. As compared to parent (NRCYS 05-02) leaf colour of both the selected lines were light green to medium green (Fig.1). Comparison of agro-morphological characters of these lines such as tetra and bi-locular pods plant types of F_6 progenies are presented in Table 2.

Fig.1: Brown seeded *B. rapa* along with its parents

Table 2. Comparison of agro-morphological characters of parent *B. rapa* (c.v. NRCYS 05-02) and DRMR- BS-17-01 (tetra-locular pod type) and DRMR- BS-17-02 (bi-locular pod type)

Charact-eristics	*B. rapa* (c.v NRCYS 05-02)		DRMR- BS-17-01 (tetra-locular pods type)		DRMR- BS-17-02 (bi-locular pods type)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Days to maturity	119	122	119	120	119	123
Plant height (cm)	135	137	136	125	150	130
Primary branches	7	7.2	5	6.2	5.2	6.8
Secondary branches	4.3	6.4	8.2	14.2	8	11.4
Main shoot length(cm)	52	54	62	69	62	60
No. of siliqua on main shoot	39	53.4	56	64	44	46
1000 seed weight (g)	3.5	4	3.7	4.1	3.1	3.2
Oil content (%)	42	42	42.15	42.6	39.8	41.5

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)

Performance of early maturing and high oil content breeding line

Indian mustard advanced breeding line DRMRHT-13-13-5-4 was developed and contributed for initial varietal trial testing under AICRP-RM 2018-19. Tested entry recorded consistently higher seed yield (2031 kg/ha), high oil content and high oil yield (831 kg/ha) over the check PM-25 at four locations in zone-II. It also recorded the consistently higher seed yield (1951 kg/ha) over the check PM-25 at six locations in zone-III.

Relative performance of advanced early maturing breeding lines under heat stress

A total of ten early maturing thermo-tolerant lines,including two checks *i.e.* NPJ 112 and BPR 543-2, were evaluated during *rabi* 2018-19 in RCBD in five rows of five metre length for their *per se* performance with respect to their high temperature tolerance at seedling stage. Estimation of mean and range for all the characters exhibited wide range of variation (Table 3). 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 (%). Characters 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 1208.87 (NPJ-112) to 3109.30 (DRMRHT-13-22-10). Thousand seed weight ranged from 3.95 (BPR 543-2) to 5.85 g (DRMRHT-13-28-8) (Table 3). Significant estimates for days to maturity were observed among the different lines. The minimum days to maturity was recorded in DRMRHT-13-13-5-4 (116) whereas it was maximum for BPR-543-2 (132). Data for days to 50% flowering ranged from 37 (DRMRHT-13-13-5-4) to 50 (BPR-543-2). Similarly, physiological traits *i.e.* membrane stability index (%), excised leaf water loss (%), relative water content (%) and water retention capacity of leaves (%) of different advanced breeding lines also exhibited wide variation. Membrane stability index ranged from 8.43 (DRMRHT-13-13-22-9) to 23.51 (DRMRHT-13-13-5-4). RWC ranged from 76.54 (NPJ-112) to 85.50 (DRMRHT-13-13-5-4) while ELWL ranged from 20.57 (DRMRHT-13-13-5-4) to 36.53 (DRMRHT-13-22-9). Water retention capacity of leaves ranged from 54.79 (DRMRHT-13-22-9) to 69.09 (DRMRHT-13-28-8).DRMRHT-13-13-5-4 recorded earliness (116) alongwith, MSI (25.34%), minimum ELWL (21.47%), and seed yield 2580.41 (kg/ha) among all the selected early maturing lines. Similarly, DRMRHT-13-13-5-6 also recorded early maturity (119 days) alongwith and seed yield 2421.30 kg/ha among all the selected early maturing lines. On the basis of physiological parameters and yield potential, DRMRHT-13-13-5-4 and DRMRHT-13-13-5-6 were promising. Rigorous selections were made for making a pool of early maturing advanced breeding lines and advanced to F_7 stage.

Variability and association studies under heat stress in early maturing lines

Amongst the selected lines, DRMRHT-13-13-5-4, DRMRHT-13-22-10, DRMRHT-13-28-8 and DRMRHT-13-13-5-6 were found highly promising in terms of earliness and thermo-insensitivity. Analysis of variance for selected lines indicated significant differences for morphological and physiological traits, indicating sufficient variability for effective selection. High heritability estimates (broad sense) were observed for relative water content (98.02%), water retention capacity of leaves (96.00 %) and membrane stability index (93.60%). Genetic advance ranged from 1.06% for 1000 seed weight (g) to 47.17% for oil yield (kg/ha) (Table 4).A positive and significant correlation was obtained between water retention capacity of leaves (%) and membrane stability index (%), indicating the possibility of increasing water retention capacity of leaves and membrane stability index by enhancing the level of thermo-insensitivity. In addition, association studies revealed that seed yield (kg/ha) and RWC (%) are highly positive correlated (r=0.805**) (Table 5).

Table 3. Morpho-physiological characterization of advanced early and heat stress tolerant breeding lines of Indian mustard during *rabi* 2018-2019.

Genotype	Days to 50% flowering	Days to maturity	1000-seed weight (g)	Membrane Stability Index (%)	Excised leaf-water loss (%)	Relative water content (RWC %)	Water retention capacity of leaves (%)	Oil content (%)	Oil yield (kg/ha)	Seed yield (kg/ha)
DRMRHT-13-13-6-5	40	118	4.33	13.38	25.78	82.63	54.79	41.27	905.72	2194.64
DRMRHT-13-13-5-6	39	119	4.69	15.12	25.71	81.87	55.29	41.44	1003.38	2421.3
DRMRHT-13-13-5-4	37	116	4.7	25.34	21.47	85.5	68.24	41.6	1073.45	2580.41
DRMRHT-13-13-5-5	42	118	4.15	15.54	29.79	81.28	57.58	41.45	992.2	2393.75
DRMRHT-13-22-9	46	120	4.26	8.43	36.53	80.51	54.71	40.87	956.88	2341.3
DRMRHT-13-22-10	47	122	5.43	23.02	20.87	83.75	67.87	41.59	1293.15	3109.3
DRMRHT-13-28-8	47	121	5.85	24.31	21.62	83.22	69.09	41.87	1196.53	2857.74
DRMRHT-13-28-16	48	122	4.95	12.62	30.62	79.69	58.85	40.87	1222.09	2990.19
NPJ-112 (C)	44	122	4.16	16.06	20.57	76.54	59.08	40.5	489.59	1208.87
BPR 543-2 (C)	50	132	3.95	13.01	29.65	79.72	57.38	41.59	952.3	2951.08
Mean	44	121	4.65	16.68	26.26	81.47	60.29	41.31	1008.53	2504.86
Range	37-50	116-132	3.95-5.85	8.43-25.34	20.57-36.53	76.54-85.50	54.79-69.09	40.50-41.87	489.59-1293.15	1208.87-3109.30

Table 4. Descriptive statistics and genetic parameters for morpho-physiological traits in Indian mustard during *rabi* 2018-2019.

Characters	Environment	Mean ± SEm	CV (%)	Range	PCV (%)	GCV (%)	Heritability h^2 (%)	Genetic advance as % of Mean
Days to 50% flowering	2018-19	44.50± 1.45	5.67	37-50	10.87	9.26	72.7	9.28
Days to maturity	2018-19	120.93 ± 0.66	2.98	116-132	3.89	3.78	94.1	11.7
1000- seed weight (g)	2018-19	4.64 ± 0.286	5.65	3.95-5.85	15.81	11.68	54.6	1.06
Membrane Stability Index (%)	2018-19	16.65 ± 0.842	8.76	8.43-25.34	34.63	33.51	93.6	14.25
Excised leaf- water loss (%)	2018-19	26.29 ± 0.49	12.29	20.57-36.53	20.22	19.96	97.4	13.67
Relative water content (%)	2018-19	81.41 ± 0.11	4.25	76.54-85.50	3.03	3.01	98.02	6.45
Water retention capacity of leaves (%)	2018-19	60.28 ± 0.09	3.11	54.79-69.09	9.64	9.63	96	15.33
Oil content (%)	2018-19	41.30± 0.78	3.31	40.50-41.87	2.15	0.84	15.5	3.64
Oil yield (kg/ha)	2018-19	1008.98 ± 74.08	12.71	489.59-1293.15	24.35	20.76	72.7	47.17
Seed yield (kg/ha)	2018-19	2439.11± 202.11	14.39	1208.87-3109.30	24.8	20.2	66.3	10.59

Table 5. Genotypic correlation coefficients between different morphological and physiological traits under heat stress in Indian mustard during rabi 2018-2019.

Characters	Days to maturity	1000- seed weight	Membrane Stability Index	Excised leaf- water loss	Water retention capacity of leaves	Oil content	Oil yield	Seed yield
Days to 50% flowering	0.871**	0.269	-0.361	0.342	-0.639*	0.189	0.045	-0.031
Days to maturity	1.000	0.102	0.109	0.181	-0.305	0.402	0.158	0.098
1000- seed weight		1.000	0.091	0.301	-0.502	0.279	0.416	0.336
Membrane Stability Index			1.000	-0.188	0.911**	0.594*	0.378	0.098
Excised leaf- water loss				1.000	-0.891**	-0246.	0.647*	0.981**
Relative water content					0.698*	-0.152	-0.125	0.805**
Water retention capacity of leaf					1.000	0.188	0.101	0.781*
Oil content						1.000	0.145	0.601*
Oil yield							000	-0.178

* and ** Significant at 5 and 1 per cent level of significance, respectively. E : Year 2018-19

Evaluation of promising interspecific crosses for high temperature tolerance

A total of 62 F_1 crosses including 21 parents were evaluated in RCBD with two replicationsin two rows of five metre length for their *per se* performance under high temperature stress at seedling stage. Counted seeds of 62 crosses including 21 parents were sown in the field under heat stress (28th September) condition during *rabi* 2018-19. The crosses differed significantly for growth and productivity parameters under heat stress namely; seed yield per plant (g), days to maturity, 1000-seed weight (g) and oil content (%). Based on growth and productivity parameters, 8 best crosses *i.e.* DRMRIJ31xDRMR2191, NPJ-112xPusa Agrani, NPJ-112x*S. Alba*, Pusa Agrani x DRMR2191, NRCDR02 xDRMR2205, NRCDR02 x *S. Alba*, Pusa Agrani x *S. alba*, Urvashi x *S. alba*, were identified as heat tolerant. These crosses will be grown in next *rabi* season for single plant selections.

Evaluation of advanced late maturing breeding lines under heat stress

A total of 34 advanced breeding lines (F_6/F_7) including two checks *i.e.* NRCHB-101 and NRCDR02 were evaluated in RCBD with two replications in three rows of five meter length for high temperature tolerance at seedling stage. Two hundred fifty seeds of 34 genotypes were sown in the field under heat stress (28th September) condition during *rabi* 2018-19. Growth and 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, seed yield per plant, oil content (%), seed yield (kg/ha) were recorded. The days to 50% flowering under early heat stress condition ranged from 43.5 to 50.5. 1000-seed weight (g) from 4.63 g to 7.05 g. oil content from 41.06 to 43.96% and seed yield (kg/ha) from 905.18 to 2839.99 kg/ha. DRMRHT-13-28-3 recorded maximum seed yield 2839.99 (kg/ha) followed by DRMRHT-13-28-15 (2618.51 kg/ha), DRMRHT-13-28-2 (2605.18 kg/ha), DRMRHT-13-28-1 (2365.17 kg/ha) and DRMRHT-13-28-18 (2354.07 kg/ha). Selections were made for making a pool of earliness and late/medium maturity group and advanced to F_7 stage.

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

Progeny row yield trial of six selected crosses DRMRHT-17-1 to DRMRHT-17-24 (DRMRIJ-31 x Urvashi); DRMRHT-17-27 to DRMRHT-17-45 (Urvashi x BPR-549-9); DRMRHT-17-46 to DRMRHT-17-66 (RH-119 x Urvashi);

DRMRHT-17-67 to DRMRHT-17-86 (DRMRIJ-31 x BPR 549-9); DRMRHT-17-87 to DRMRHT-17-110 (NRCDR-02 x BPR 549-9)); DRMRHT-17-111 to DRMRHT-17-131 (RH-406 x Urvashi) was conducted separately under early sown conditions. Two hundred counted seeds of each line were sown in two rows of 5 m length. Urvashi was used as check.

Generation of breeding material

Interspecific crossing was under taken by involving registered lines/varieties/germplasm including different wild species *i.e.Brassica tournefortii* (DRMR-2191, DRMR2205, DRMR 2206), *Brassica carinata*-Karan rai (Pusa aditya, Kiran, DSLC-1, PC-5-17) and *Brassica juncea* (DRMRIJ-31, NRCHB-101, NPJ-112, NRCDR-02, Urvashi and BPR-543-2 during *rabi* 2018-19 in order to develop germplasm for earliness and heat stress tolerance. F_1 crosses were harvested.

Mapping population for heat stress tolerance

A mapping population was developed from a cross of NRCHB-101/BPR-549-9 following single seed descent method. From each F_2 plant a single siliqua was advanced to F_3 generation as progeny row. In F_3 and subsequent generations, a single siliqua was taken randomly from each progeny row for advancement to next generation. A set of mapping population comprising of 176 recombinant inbred lines derived from cross was advanced from F_6 to F_7 stage through selfing during *rabi* 2018-19.

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-Investigators: 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 2017-21 (early mustard), DRMR 2018-25 (timely sown irrigated), DRMRSJ 47 (timely sown rainfed) and DRMR 2017-26 (late sown irrigated) were inducted for multilocation testing under AICRP-RM trials during 2019-20.

Entry DRMR 2017-15 has been promoted to AVT-II for zone II (late sown). Entry DRMR 2017-16 has been promoted to AVT-I in zone I for timely sown irrigated conditions. Genotypes DRMR 2018-37, DRMR 2018-41, DRMRSJ-1, DRMRSJ-18, DRMRSJ-21, DRMRSJ-22, DRMRSJ-25, DRMRSJ-26, DRMRSJ-31 (18-1-1), DRMRSJ-34 & DRMR 5206 were identified as white rust resistant under AICRP-RM pathological (NDN/UDN) trials during 2018-19. DRMRSJ-21 was identified as powdery mildew tolerant. Genotypes DRMRSJ-22, DRMR 5206 and DRMR 2017-15 were identified as *Sclerotinia* rot tolerant. Genotypes DRMR 2017-15 and DRMR 2017-26 were identified as tolerant against mustard aphid with AAII $\leqslant$ 2.0 under entomological trials during 2018-19. Further, 5 entries were inducted in physiological trials for evaluation of heat and drought tolerance and 26 entries in pathological trials for evaluation of disease reaction under NDN/UDN during 2019-20.

Germplasm registration

Germplasm DRMR 4001 (IC0632086; INGR19087) for drought tolerance and DRMR 4005 (IC0632087; INGR19088) for thermo tolerance at juvenile stage coupled with high seed and oil yield of Indian mustard (*Brassica juncea* L.) were registered by Plant Germplasm Registration Committee of ICAR-NBPGR, New Delhi.

Re-synthesized *B. juncea* progenies

During *rabi* 2018-19, re-synthesized *B. juncea* progenies *viz*., 269 S_5, 24 S_6 and 48 advance progenies were planted in the field for evaluation, selections and stabilization along with check NRCHB 101, DRMRIJ-31, Kranti, NPJ 112, RH 406 and RH 749.Considerable amount of genetic variability was observed for component traits (Table 6). Desirable progenies / lines were marked, selected for specific traits and single plant selections were made from different progenies for further advancement and selection. Oil content in S_5 (307 SPS) progenies range 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 S_6 progenies. In advanced re-synthesized lines, the seed yield /ha varied from 1325 - 3920 kg, OC (%) 36.07-43.15 and 1000-SW from 3.28 - 6.07 %.

Table 6: Genetic variability for important traits in S_5 and S_6 re-synthesized *B. juncea* progenies (2018-19).

Trait Entry	PH (cm)	PB	SB	MSL (cm)	SMS	SL (cm)	S/S	OC (%)	1000-SW (g)	DF	DM
S_5 progenies	112.0-309.0	4.0-19.0	11.0-53.0	38.0-129.0	33.0-114.0	2.1- 7.5	8.0-22.0	37.40-43.50	2.07-7.32	28.0-69.0	110.0-164.0
S_6 progenies	178.0-243.0	5.0-13.0	15.0-38.0	56.0-108.0	44.0-96.0	2.6-6.1	12.0-20.0	38.61-42.05	3.18-6.47	37.0-55.0	124.0-152.0
NRCHB 101	196	7.2	19.6	79.4	64	5.3	15.4	41.08	5.52	36	133
NPJ 112	169.2	5.6	16.8	68.3	54.6	4.1	14.7	41.43	4.93	31	124
DRMRIJ-31	207	6.4	17.4	83.2	58.8	5.1	16.1	42.09	5.7	42	139
RH 749	228.4	7	21.4	72.6	61.4	5.6	15.6	39.04	5.88	53	147

Performance of entries in station trials

During 2018-19 twenty five advance lines along with 5 check genotypes were evaluated in replicated trials and the entries over yielded best check by 10% seed yield are given in the table below. Early maturing entries DRMR 2017-21 and DRMR 2018-27 out yielded early check NPJ 112 by 10% seed yield (Table 7).

Table 7: Performance of entries in station trials during 2018-19.

Entry	Seed yield (kg /ha)	OC (%)	1000-SW (g)
DRMR 2017-	3520	41.77	6.18
DRMR 2017-	3324	42.21	5.00
DRMR 2017-	3213	41.30	5.31
DRMRSJ-47	3212	42.28	6.64
DRMR 2018-	3071	41.56	5.45
DRMR 2017-	2982	41.45	4.51
RH 749 (check)	2704	39.24	5.50
Early maturing entries			
DRMR 2017-	2942	41.83	4.98
DRMR 2018-	2893	41.62	6.23
NPJ 112	2353	41.25	5.17
CV (%)	11.90		

Observation nursery

Sixty seven advanced progenies / lines were evaluated in observation nursery during rabi 2018-19 along with 5 checks. Four entries revealed better performance over best check DRMRIJ 31 and six entries exhibited higher seed and oil yield over early maturing check NPJ 112 with maturity period of 119 to 128 days (Table 8).

Table 8: Performance of entries in observation nursery during rabi 2018-19.

Entry	Seed yield (kg /ha)	Oil yield (kg /ha)	OC (%)	1000-SW (g)
DRMR 2018-24	4025	1653	41.07	6.56
DRMR 2018-1	3547	1412	39.82	6.11
DRMR 2018-2	3137	1360	43.35	6.16
DRMR 2018-4	3025	1237	40.88	6.40
DRMRIJ 31	2812	1159	41.23	5.56
DRMR 2018-17	2684	1124	41.87	6.60
DRMR 2018-28	2666	1130	42.40	5.86
DRMR 2018-15	2628	1080	41.11	5.82
DRMR 2018-18	2464	1045	42.40	4.89
DRMR 2018-23	2416	1037	42.92	5.36
DRMR 2018-19	2391	1014	42.42	6.91
NPJ 112 (check)	2157	882	40.89	4.92

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

During *kharif* 2019, 52 entries along with resistant (RC) and susceptible checks (SC) were screened for white rust resistance at 'IARI, regional station Wellington in offseason (June to September 2019) nursery. Fourteen entries exhibited complete resistance to WR (score=0) against susceptible checks (score=9) (Table 9). Selfed seeds were harvested from a total of 39 individual resistant plants.

Table 9: Resistance against white rust at IARI-RS, Wellington (offseason, 2019)

Genotype	Score	Reaction for WR
DRMR 2019 (RC), DRMR 2035(RC), Heera (RC)	0.0	R
PHR 2(RC), Bio-YSR (RC)	3.0	R
Rohini (SC), Varuna (SC), Kranti (SC)	9.0	S
DRMRSJ-1, DRMRSJ-4, DRMRSJ-7, DRMRSJ-9, DRMRSJ-16, DRMRSJ-18, DRMRSJ-20, DRMR 5206, DRMRSJ-25, DRMRSJ-26, DRMR2018-37, DRMRDJ-1, DRMRDJ-2, DRMRDJ-3	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 A.K.Thakur, Sr. Scientist (Biotechnology)

Generation of breeding material

43 fresh crosses were generated using white rust and stem rot resistant/tolerant parents with high yielding genotypes. DRMRSJ 1 x Donskaja; BIO-YSR X Heera; DRMRSJ 18 x Donskaja; BIO-YSR x DRMR 2035; DRMRSJ 31 x Donskaja; BIO-YSR x DRMR 2019; DRMRSJ 31 x Heera; Heera x BIO-YSR; Varuna x Donskaja; Heera x DRMR 2035; DRMR 2035 x Donskaja; Heera x DRMR 2019; DRMR 2035 x Heera; DRMR 2019 x DRMR 2035; DRMRSJ 19 x Donskaja; DRMR 2019 x Heera; DRMRSJ 19 x Heera; DRMR 2019 x BIO-YSR; Rohini x Donskaja; DRMR 2035 x DRMR 2019; Varuna x DRMRSJ 1; DRMR 2035 x BIO-YSR; Varuna x DRMRSJ 18; DRMR 2035 x Heera; RH 749 x DRMRSJ 1; NRCHB 101 x DRMR 18-25; RH 749 x DRMRSJ 18; NRCDR 2 x DRMR 18-17; DRMRIJ 31 x DRMRSJ 1; DRMRIJ 31 x DRMRSJ 206; DRMRIJ 31 x DRMRSJ 18;DRMRIJ 31 x DRMR 18-23; Pusa Bold x DRMRSJ 159; Pusa bold x DRMRSJ 312; Pusa bold x DRMRSJ 271; DRMR 2017-15 x DRMR 2018-25; DRMRIJ 31 x DRMRSJ 302; DRMR 2017-15 x DRMR 2018-23; NRCDR 2 x DRMR 18-1;DRMR 2017-15 x DRMR 2018-26; NRCDR 2 x DRMR 18-24; DRMR 2017-15 x DRMR 2018-19; NRCHB 101 x DRMR 18-24.

Generation advancement and selection from segregating generations

14 F_2 populations of DRMRIJ 31 x DRMR 1493, NRCDR 2 x EC399301, Pusa Bold x DRMR 1542, PUSA BOLD x PHR 2, NRCDR 2 x DRMR 2019, NRCDR 2 x BIO-YSR, RH 749 x DRMR 1542, Kranti x DRMR 1493, DRMRIJ 31 x EC399301, NRCHB 101 x DRMR 1222-28, NRCHB 101 x EC597328, NRCHB 101 xPusa Bold, NRCDR 2 x DRMR 2035 and Basanti x DRMR 2035 crosses were planted in 22 rows of 5 m length each to select desirable plants for white rust resistance and yield related traits. Sixty four F_3 and 47 F_4 single plant progenies were planted in 2 row of 5 m length each to select desirable plants for white rust resistance and yield related traits and screening for white rust and stem rot along with parents (13 parents) using augmented design along with 4 row of 5 meter length.

64 F_1 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. Eight back crosses were generated using F_1 with their parents P_1 and P_2 (RH 1222-28, RH 1034, DRMR 1542, DRMR1493 and DRMRIJ31) to derive genotypestolerantto Sclerotinia rot. Resistant donors and high yielding genotypes were planted to screen for white rust and stem rot.

Table 10: Performance of F_1crosses

Crosses	PHT	PR	SEC	FZ	SMS	MSL	SL	SP	SW	DF	DM
DRMRIJ 31 x DRMR 1493	217.8	6.2	21	80	54.2	71.4	4.52	70.6	4.29	93	142
NRCDR 2 x BIOYSR	224.4	10.4	23.8	74.6	43	59	3.96	63.2	5.4	93	143
RH 749 x DRMR 1542	243.6	9	26	110.2	60.6	85	4.26	64.8	5.33	95	141
Pusa bold x EC399299	219.4	10.6	21.2	74.8	74.2	82	4.5	78.4	4.71	83	137
Pusa bold x PHR 2	242.6	6	11	74.6	48.6	60.4	3.72	59.8	4.83	91	138
NRCDR 2 x EC399301	197.8	7.8	16.6	70	47.2	59.4	3.92	64.2	4.9	86	138
Pusa boldx DRMR 1542	201	6.6	14.6	105	48.6	70	4.64	64.8	4.53	81	136
DRMRIJ 31 x EC399301	208.8	7.4	17.6	96	66.2	77.8	3.58	59.4	6.34	91	139
Kranti x DRMR 1493	243.4	8.4	17.6	107.2	61.6	85.2	4.28	59.2	3.96	81	139
NRCDR 2 x DRMR 2019	223.8	6.6	14.2	106.4	42.2	64.4	4.24	55.6	5.69	80	136

Screening for white rust in off season nursery at wellington

47 F_3 along with their parents and checks were planted at offseason nursery, Wellington for screening against white rust and generation advancement. Out of 47 crosses, 11 crosses showed resistant reaction (score 0.0) 16 showed mixed reaction. Resistant plants were selfed and seeds were collected at maturity for further advancement and screening during *rabi* season at Bharatpur.

Screening for Sclerotinia stem rot

36 F_1, resistant and susceptible checks were artificially inoculated withSclerotinia stem rotpathogen and data was recorded on % disease incidence, lesion size and stem diameter.

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-Investigators: Bhagirath Ram, Pr. Scientist (Genetics and Plant Breeding), H.K. Sharma, Sr. Scientist (Plant Breeding)

Performanceof entry in AICRP-RM trials

Two double low entries DRMRQ1-16-27 and DRMRQ 4-7-23 were contributed for IVT trial under AICRP-RM, 2018-19. Entry DRMRQ1-16-27 showed maximum amount of total phenol content (5.16%), maximum tocopherol content (196.93 mg/100g), maximum oil content (40.88%) along with good quantity of beta-carotene (3.49ppm) in 5 AICRP-RM centres in comparison to other entries and checks in biochemistry experiments. Further, these two entries were evaluated for biochemical traits at DRMR, Bharatpur (Table 11).

Table 11. Biochemical nature of promising double low lines in comparison to checks assessed during 2019-20.

Genotypes/ Traits	Erucic Acid (%)	Glucosinolate (µmoles/g of defatted seed meal)	Beta carotene (ppm)	Antioxident (mg/g AAE)	Total phenol (%)	Tocopherol (mg/100g)	Phytic acid (%)
DRMRQ1-16-27	1.9	19.3	3.98	38.85	6.58	197.52	1.62
DRMRQ 4-7-23	1.5	15.9	2.74	35.35	5.48	182.5	2.16
PDZ1 (Double low quality check)	1.65	22.6	2.77	29.35	4.45	162.98	2.85
NRCHB 101 (Non quality check)	39.38	136.7	3.26	47.35	3.59	147.58	3.36

Table 12. Range of nutritional parameters of LERs and checks

Nutritional parameters	Beta Carotene (ppm)	Total Flavenoid (QEmg/g	Antioxidents (AAEmg/g)	Saturated Fatty Acid (%)	Oleic Acid (%)	Linoleic Acid (%)	Linolenic Acid (%)	Erucic Acid (%)	Glucosinolate (µmole/g)	Oil Content (%)
Maximum	5.34 (DRMR 32-6)	3.41 (DRMR 5-2)	50.35(DRMR 204)	4.8(DRMR 204)	43.09(DRMR 5-5-1-15)	42.92 (DRMR 21)	18.14(DRMR 18-3)	6.08(DRMR 16)	92.33 (DRMR 14-1)	41.13 (DRMR 18-3)
Minimum	0.44 (DRMR 5-2)	0.18 (DRMR 18-3)	11.35 (DRMR 15)	3.7 (DRMR 5-5-1-15)	30.45(DRMR 16)	30.58 (DRMR 32-6)	10.21(DRMR 21)	0.87 (DRMR 5-1)	14.59(DRMR 204)	39.47(DRMR 21)
RH 749 (Non-quality)	3.65	1.24	25.85	3.8	11.4	19.2	16	39.4	137.8	39.32
PM29 (Low erucic)	4.37	1.24	19.35	4.5	36.2	17.5	24	2.5	79.3	40.12
RGN73 (Non-quality)	0.59	1.47	26.35	3.2	13.5	17.8	19	41.3	125.8	39.67

Generation advancement and selection

A total of 54 advanced low erucic lines (F_6) of two crosses (NRCHB101 x LES-1-27; NRCHB101 x LET-17) were grown and evaluated for oil quality. Fatty acid profiling of oil for these advanced low erucic lines recorded 2.86-5.78% (saturated fatty acid), 26.68-41.2 % (oleic acid), 32.77-42.14% (linoleic acid), 12-25.46% (linolenic acid), 0.9-5.64% (erucic acid) with oil content ranged from 38.44-43.47%. A total of 834 SPS from F_5 generation of the cross (NRCHB101 x PM-21) were screened for low erucic acid content in oil and test weight, out of which 188 were found to have erucic acid content <1-5% with test weight 4.00 to 5.95g. Ninety four single plant progeny lines in F_3 generation of the cross NRCHB101 and PM-21 as parents were advanced and 315 single plants have been selected for further biochemical analysis for quality traits.Further, 1200 SPS from 9 F_2 population of crosses involving advanced double low lines and PDZ1 as parents were selected in field and evaluated for glucosinolate content. F_2 population of 3 crosses involving non quality (NRCHB101, RH749, DRMRIJ31) and quality lines (PDZ1, RLC3) were advanced by single seed descent method to develop RIL population for quality trait.

Generation of breeding material

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 (DRMRIJ 31/PM 24, DRMRIJ31/PM 30, NRCHB 101/ PM24, NRCHB 101/ PM30, 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 and DRMR Q1-10-33) and respective parents. Single crosses have been 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 and DRMRIJ31) as parents. Following crosses were generated to transfer low erucic acid trait generation of 6 BC2-BC1F1 (DRMRIJ 31, NRCHB101, RH 749 /PM 24, PM30) with non-quality parents to transfer high oleic acid trait in advanced double low lines: generation of 2 BC1F1 - F1 (DRMRQ1-11-32, DRMRQ1-10-33 x GSC 5) with DRMRQ1-11-32, DRMRQ1-10-33 to transfer white rust resistance with double low trait: generation of 2 F_1 - (DRMRIJ 31, NRCHB101) x DRMR1-5 (White rust resistant double low registered line).

DRMR B 7: Proteomic studies in oilseed Brassica

Principal Investigator: Ibandalin Mawlong, Scientist (Plant Biochemistry)

Co-investigators: M.S. Sujith Kumar, Scientist (Biochemistry), O.P. Premi, Pr. Scientist (Agronomy), Reema Rani, Scientist (Biotechnology)

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

Oil bodies are structural entities that store triacylglycerols (TAG) in oilseeds. Each oil body contains a matrix of triacylglycerol (TAG) surrounded by a layer of phospholipids and its associated oil body proteins. Description of oil body and its associated proteins has not been well documented in *B. juncea* unlike Arabidopsis which is a related species. 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 (cv. Maya) to 1.05 (cv. 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 8: Screening of Oilseed Brassica germplasm for value addition

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

Co-investigators: Ibandalin Mawlong, Scientist (Biochemistry), Prashant Yadav, Scientist (Biotechnology), Hariom Kumar Sharma, Sr. 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 (Fig. 2). 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. 3).

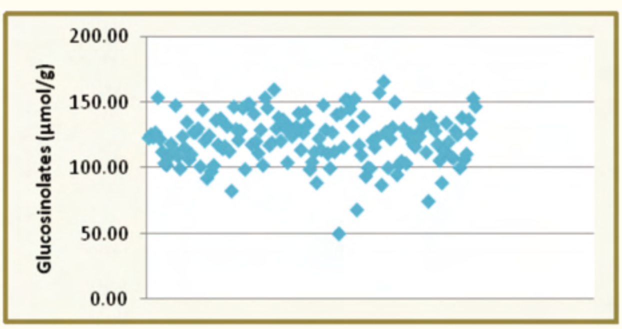


Fig. 2: Glucosinotes content in 147 accessions

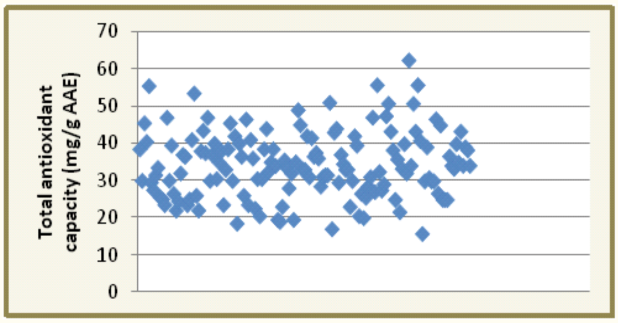


Fig. 3: Total antioxidant capacity in 147 accessions

α and δ Tocopherol content in 17 accessions that had total antioxidant capacity > 45 mg/g AAE was done (Fig. 3, 4). 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 (Fig. 5).

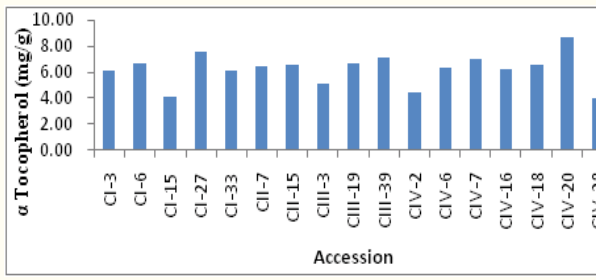


Fig. 4: α Tocopherol content in 17 accessions

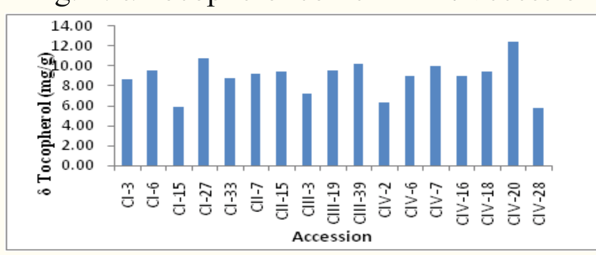


Fig. 5: δ Tocopherol content in 17 accessions

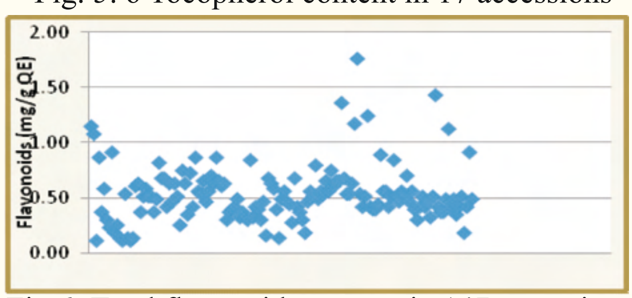


Fig.6 :Total flavonoids content in 147 accessions

DRMR B 9: Quantitative & qualitative estimation of glucosinolates and fatty acids in oilseed Brassica

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

Co-Investigator: Arun Kumar, Pr. Scientist (Cytogenetic)

Aliphatic glucosinolate was characterized in two selected varieties i.e. Giriraj and PDZ4. Using thin layer chromatography (TLC), different secondary metabolites i.e. cinnamic, ferulic, vanillic, p-coumaric, glucosinolates were identified. HPLC techniques confirmed the presence of different types of glucosinolates 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 (Fig. 7; Table 13). 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 acid, linolenic acid, oleic acid etc) was found in hexane and methanol treated extracts.

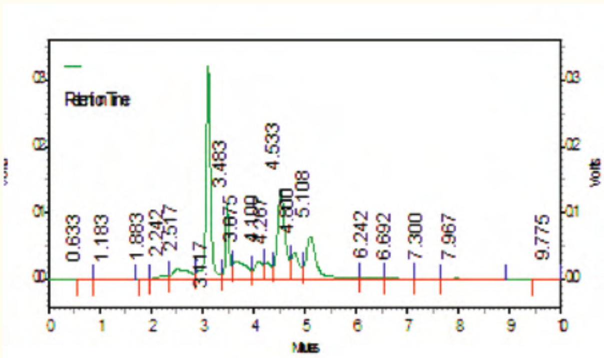


Fig. 7: HPLC analysis of crude glucosinolate

Table 13: Identification of Bioactive compounds using HPLC

Peak no.	Retention time	Integration area	Tentative identification	Concentration ($\mu g\ gfw^{-1}$)
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	4.57	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 (Genetics and Plant Breeding),

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

Evaluation of hybrids

Initial hybrid trial (IHT) under AICRP-RM was conducted to evaluate the performance of 12 experimental hybrids alongwith four check cultivars; DMH 1, NRCHB 506, Kranti and RGN 73. Performance of 35 experimental hybrids were tested in three station trials. Similarly 14 inbred lines were evaluated for their yield performance in 4 station trial alongwith 2 check cultivars; Giriraj and Pusa Mustard 25. All four station trials have been conducted in randomized block design with 3 replications keeping plot size of 5 rows of 5 m length (2.25 x 5 m). In addition 171 inbred lines and 234 F_1 crosses were evaluated for yield and other agronomic traits in three different experiments conducted in augmented block design. 32 progeny rows of *B. juncea* were raised in paired row. Observations on days to flower initiation, days to flower senescence, days to maturity, fertility status and reaction to white rust were recorded.

Maintenance of inbreds/ maintainer lines

217 lines including 171 inbreds, 46 maintainer lines were selfed for maintenance.

Conversion of A and R lines

Forty nine lines, including 35 CMS lines and 14 restorer lines,were back crossed to advance the generation under conversion programme.

Generation of breeding material

A total of 177crosses in *B. juncea* and 15 in *B. carinata*were attempted.

Multiplication of the seed of parental (A, B and R) lines

Seed of 45 experimental hybrids was produced in seven isolated plots. Seed of 15 CMS lines and six inbred lines is being multiplied under nets.

Selection from segregating generations

Segregating populations of *B. juncea*: F_2 =06 (MJB 11/Heera, HB 9925/IJ 17-40, MJB 9/RGN 73, OA 630/NAJR 30, OJA 3/NAJR 30, F2 12 1S-IJ 31/PRT 17-108); Others = 05 (13x3x7, F2 4, OJR 1, F2 2-1, F3 1-8)

Segregating generation of *B. carinata*: Pusa Swarnim / F2 6-1, PC6 / F2 11-2, K5 / F2 11-2, Kiran / F2 6-1, K 16/ F2 6-1, IPS 23/ F2 6-1, Pusa Swarnim / Kiran, Kiran / MCB 1-2-3-5

2.4 Oilseed *Brassica* genetic resource management

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

Principal Investigator: Hariom Kumar Sharma, Sr. Scientist, (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)

Regeneration, maintenance and conservation

Regenerated 541 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.

Evaluation for heat tolerance in Indian mustard

128 lines of Indian mustard were selected from 604 lines based on screening in 2017. These 128 lines were evaluated in ABD with seven checks (Kranti, NRCHB 101, CS 56, PM25, Pusa Bold, BPR541-1, NPJ112) for terminal heat tolerance in rabi, 2018-19. Sowing for terminal heat tolerance was done on 19 November, 2018. Based on the pooled data of two years (2017, 2018) 66 lines were selected on the basis of yield stability index (>0.8), HSI (<0.6), % yield reduction (<20%). These accessions were grown in replicated trials during 2019-20 in late sown condtions for evaluation. A fresh set of 190 exotic lines of Indian mustard were also evaluated for terminal heat tolerance in 2018-19 for first year. From this set, 102 accessions were selected on the basis of yield stability index (>0.8), HSI (<0.6), % yield reduction (<20%) for second year testing in replicated trials

Evaluation and characterization of yellow sarson germplasm

A total of 41 accessions of yellow sarson were evaluated for different agro-morphological traits with four checks (YSH401, Pitambari, NRCYS 05-02, Benoy) in Randomized block design. Two lines DRMR 2694 (24.8g), DRMR 638 (23.6) were found significantly superior for SPY over best check [NRCYS5-2 (14.20g)]and two lines DRMR 2185 (279), DRMR 2381 (274), were found significantly superior over best check for SPP [Benoy (207)]. Another set of 318 accessions of yellow sarson obtained from NBPGR, New Delhi were evaluated in ABD along with four checks (NRCYS-02-04, Pitambari, Benoy, YSH401). From which 08 accessions with single plant yield of more than 30g, 11 accessions with 1000 seed weight ofmore than 5g, and 10 accessions with oil content of more than 45% and 19 accessions with more than 320 siliqua per plantwere identified. These identified accessions were grown in RBD during *rabi*, 2019 for yield evaluation.

Screening for stem rot tolerance

300 indigenous germplasm accessions of Indian mustard were sown for screening for resistance to stem rot disease through artificial stem inoculation technique.

Germplasm distribution

Distributed 496 accessions of rapeseed-mustard to different indenters.

Raising of F_{1s}

30 F_1 crosses of yellow sarson and 15 F_1 crosses of Indian mustard were raised and selfed to get F_2 seeds.

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 Thakur, Senior Scientist (Biotechnology)

Co-investigator: K.H. Singh, Principal Scientist (Genetics & Plant Breeding)

Sub-Project 1A: Genome-wide spanning of microsatellite markers in Indian mustard covering all the linkage groups and evaluating their polymorphic potential

Primer sequences were designed for 360 SSR markers (20 SSRs/linkage group) of *B. juncea*. These primer pairs were evaluated for their polymorphic potential across a genetically diverse panel of 16 genotypes of Indian mustard comprising of varieties and germplasm lines. Out of 360 SSR markers, 112 were found polymorphic, while 188 resulted into monomorphic amplicons.

Sub-Project 1B: 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_5 population) were sown in field following standard package of practicesand advanced to F_6 generation using SSD method. Further, initiated SSR genotyping of both the parents of this cross to find out polymorphic SSR markers for future genotyping of the RIL population.A total of 49 SSRs exhibit parental polymorphism between both the parents.

Sub-Project 1C: Candidate gene-based marker-assisted breeding for improvement of white rust resistance

In the crop season 2019-20, F1 seeds of the cross Giriraj x DRMRMJB 35 were sown in the field to raise F_2 population. Hybridity confirmation of F1 plants were carried out using SSR markers (Fig. 8). The confirmed F_1 plants exhibited the presence of both the white rust resistance loci in a single background as confirmed by foreground markers. Further, in the parental polymorphism survey between both the parents, 43 polymorphic SSRs were obtained, which will be used for recurrent parent genome selection in the forthcoming back-cross populations. Confirmed F1 plants were crossed with the recurrent parent, Giriraj and BC_1 seeds will be harvested.

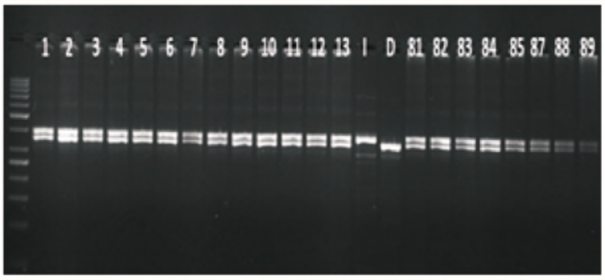


Fig. 8: Hybridity confirmation of F1s using SA0306 marker 1-13 & 81-89: F1 plants; I: Indian mustard variety Giriraj; D: DRMRMJB 35

DRMR BT05: Biotechnological interventions for development of *Orobanche* tolerance in Indian Mustard (*Brassica juncea L.*)

Principal Investigator: Reema Rani, Scientist (Biotechnology)

Co-investigators: O.P. Premi, Pr. Scientist (Agronomy), Mrs. Ibandalin Mawlong Scientist (Biochemistry), Hariom Kumar Sharma, Sr. Scientist (Genetics and Plant Breeding)

Screening of germplasm lines for the Glyphosate tolerance

During Rabi 2019-20, 60 herbicide tolerant germplasm lines of Indian mustard were sown in the fields of ICAR-DRMR. Glyphosate was sprayed 40 DAS to validate the tolerance of herbicide by plants.

Identifying potential *Orobanche* gene targets: Isolation and characterization of the genes of Strigolactone pathway in Mustard

Strigolactones (SLs) are a novel class of plant

Fig. 9: Symptoms of glyphosate spray on the germplasm lines of Indian mustard

hormones and acts as germination signal for *Orobanche* seeds and helps in the attachment to the host plants through haustorium. Genes involved in strigolactone pathway are: Strigolactone (SL) biosynthesis (*D27, CCD7, CCD8* and *MAX1*), perception (*MAX2* and *D14*) or transport (*PDR1/PDR12*). The manipulation of SL biosynthesis pathway may reduce production of SLs in plants and root exudates which could further compromise the germination of parasitic plant seeds, and thus reduce mustard crop losses.Gene specific primers were designed using PRIMER3 software. Genomic DNA was isolated from the 7 days old seedlings of DRMRIJ31 and RH749. PCR amplification reaction was carried out to test the functionality of designed primers. Amplified bands of the genes were excised and gel purified. Total RNA was also isolated using Monarch Plant RNA isolation kit. cDNA synthesis was performed using primescript cDNA synthesis kit. Bands amplified using qPCR were excised and purified. Sequencing of PCR products will be carried out for further confirmation of genes.

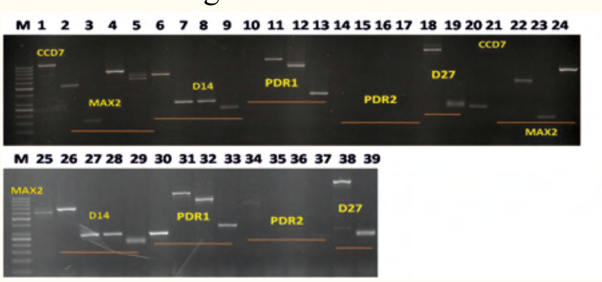


Fig. 10: Agarose gel electrophoresis showing PCR amplification of primers specific for strigolactone pathway

DRMR BT08: Development of Orobanche tolerance in Indian mustard

Principal Investigator: Prashant Yadav, Scientist (Biotechnology)

Co-investigators: Arun Kumar, Principal Scientist (Cyto-genetics), R.L. Choudhary, Scientist (Agronomy)

An EMS-based mutagenic population of Indian mustard (var. DRMRIJ-31) is being developed to search for the management of Orobanche. EMS treated seeds of mustard (var. DRMRIJ-31) were sown in November in the experimental field of ICAR-DRMR, Bharatpur. Line to line distance was 45cm and the length of each line was 5 meter. The crop was raised with standard agronomic practices. The EMS-treated plants showed delayed germination, abnormal growth, asymmetric leaf blades and chimeric plants (Fig. 11). A total of 82 M0 lines were raised with 25-35 plants in each line. Each plant was selfed by bagging for M1 generation advancement (Fig.12).

Fig. 11: Chimera plants with asymmetric leaves were observed in M0 generation

Fig. 12: Selfing of the M0 generation plants to develop M1 generation of Indian mustard (DRMRIJ-31)

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

DRMR CP-6: Enhancing soil resilience under mustard based systems through integrated crop management practices

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

Economic feasibility and sustainability of Indian mustard (*Brassica juncea*) productivity through organics under semi - arid region of Rajasthan

The long term replicated experiment under fallow-mustard (*B. juncea*) system has been in progress since 2005-06 at DRMR, keeping conventional practices (CP), *Sesbania* Green Manuring (SGM) and 2.5 t/ha mustard straw recycle + SGM (MSGM) in main plot and eight combinations of NPK fertilizers in subplot. The fourteenth harvest of mustard crop indicated that green manuring with sesbania significantly increased mustard seed yield by 31.7% over control. Supplementary incorporation of MSI @ 2.5t/ha further augmented the seed yield by 18.4% over SGM alone and by 55.9% over control (Table 14). Application of balance fertilizer (F_8) increased the seed yield atleast by 17.1% over suboptimal doses F_1, F_2, F_3 and F_4. Adoption of MSI + SGM system further augmented the seed yield at F_8 atleast by 22.9% over suboptimal 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% higher over SGM and CP, respectively.

Table 14. 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	1648	1694	1793	1932	2170	2401	2265	2491	2049
Sesbania (SGM)	2284	2549	2796	2599	2685	2861	2775	3139	2698
Mustard straw @ 2.5 t/ha + *Sesbania* (MSGM)	2904	3055	3025	3061	3250	3506	3376	3361	3195
Mean	2279	2433	2512	2530	2701	2923	2805	2997	-
CD (P=0.05)	CS: 360, Fertility level: 257								

*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)

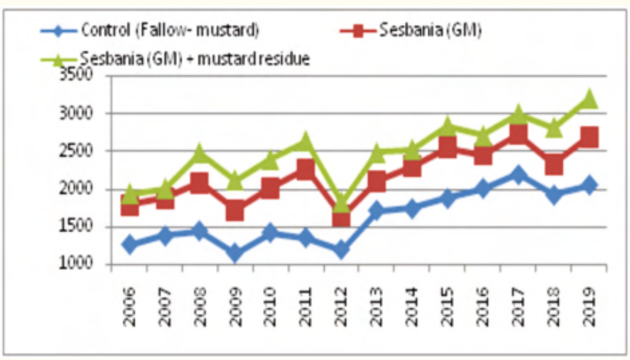


Fig. 13: Temporal effect of various mustard production systems

Evaluation of nutrient management strategies for sustainable mustard production

A dynamic mustard production system of higher resilience to biotic stress and changing climate is most important for sustainable productivity. A long term field experiment was initiated in 2005-06 to evaluate the resilience capacity of four oilseed *Brassica* (OSB) production systems. However, the experiment was refined during 2011-12, keeping three 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 vermin compost) in sub plot. The trial is being conducted in AxB+2 control randomized design keeping absolute control and conventional control (100% RDF) as checks.

Recommended fertility recorded significantly higher seed yield (2767 kg/ha) than moderate and subsistence fertility management practices. Overall, the use of organic source increased the seed yield by 41.8% over conventional control. The mustard productivity declined by 229% in absolute control over conventional control. Supplementing organic source with chemical fertilizers further augmented the seed yield of OSB by 16.8% due to MFM (Table 15). Among the organic sources, MSI + SGM produced significantly higher seed yield than rest of the organic sources. It was followed by SGM and VC. The use of mustard straw mulch gave lowest seed yield of mustard.

Table 15: 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)	2915	2358	3426	2312	2716	2877	2767
MFM: Moderate (50% RDF)	2416	2202	3319	1685	2199	2274	2349
SFM: Subsistence (no fertilizer)	2176	1760	2115	1668	2150	2196	2011
Mean	2502	2106	2953	1888	2355	2449	-
AC: Absolute control- 508 CC: Conventional control (100%RDF)- 1674		CD 5%: FMS 341, OS:: 270					

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 IARI.

Table 16: Effect of microbes and irrigation level on mustard productivity (kg/ha)

Irrigation level	Culture				Mean
	No Inoculation	NSRSSS 1	MRD 17	MKS 6	
Rainfed	1444	1422	1552	1824	1560
One irrigation	1791	2124	2357	2046	2080
Two irrigation	1855	1938	2477	2119	2097
Mean	1697	1828	2129	1996	-
CD 5%:Irrigation. Level:116, Culture: 201, Interaction:S					

The irrigation scheduling and microbial cultures had shown significant effect on mustard seed yield. However, interaction had no significant influence on the seed yield. Significantly highest seed yield (2097 kg/ha) was recorded with two irrigations but was at par with one irrigation (2080 kg/ha).Among the microbial cultures seed dressing with MRD 17 recorded significantly higher seed yield of mustard over NSRSSS 1 and without inoculation but was at par with MKS 6. The mustard productivity increased by 25.4%, 17.6% and 7.7% with MRD 7, MKS 6 and NSRSSS 1 over no inoculation, respectively. The other parameters such as relative water content, membrane stability index and chlorophyll content were also higher in these treatments.

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

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

Co-Investigators: Mukesh 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 (CA) 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 atpar with zero tillage,recorded significantly higher seed yield of mustard cv. RH 749 (3256 kg/ha) compared to conventional tillage (2861 kg/ha) in the third year of rotation (2018-19) (Table 17). The plant height, branches/plant and harvest index of mustard were also recorded higher under permanent beds with residue. Cropping systems significantly affected the plant height, branches/plant and seed yield of mustard. The maize- mustard cropping system was found superior to enhance the mustard growth and yield attributes and recorded highest seed yield of mustard (3455 kg/ha).

Table 17. Growth and yield parameters of mustard (2018-19) influenced with CA practices.

Cropping system	Plant height (cm)	Primary branches/plant	Secondary branches/plant	Seed yield (kg/ha)	HI (%)
CA practices					
Permanent bed+residue	232	8.8	21.1	3256	28.2
Zero tillage+residue	224	8.4	17.6	3152	26.8
Conventional tillage-residue	211	7.9	17.4	2861	26.7
C.D.at 5%	16	0.6	1.8	288	1.25
C.V. (%)	8	7.4	10.7	10	6.0
Mustard based cropping systems					
Fallow-Mustard	222	8.2	18.4	3031	26.5
Cluster bean-Mustard	223	8.3	18.6	3096	27.0
Green gram-Mustard	225	8.6	19.2	3346	27.1
Maize-Mustard	232	9.0	20.4	3455	28.6
Pearl millet-Mustard	221	8.1	18.2	2865	27.3
Sesame-Mustard	211	8.1	17.3	2747	26.6
C.D.at 5%	12	0.6	1.8	286	NS
C.V. (%)	6	7.2	10.1	10	6.5

*Kharif*crops were sown under the CA with residues and conventional tillage without residues of previous mustard crop in 2019. The kharif crops sown different response to CA practices and recoded higher seed yield of maize and pearl millet under zero tillage with residues compared to bed planting and conventional tillage. However, the higher seed yield of cluster bean, green gram and sesame were recorded under bed planting with residue compared to zero tillage and conventional tillage.

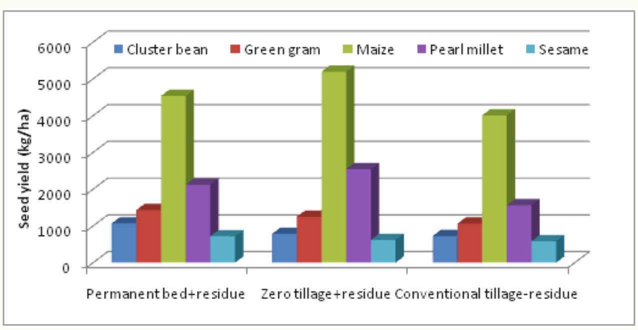


Fig. 14. Seed yield of kharif crops influenced with CA practices (2019).

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), M.L. Dotaniya, Scientist (Soil Science), Harvir Singh, Scientist (Agronomy), Ibandalin Mawlong, Scientist (Plant Biochemistry)

Application of micronutrient enriched farm yard manures (FYM) improve the availability and their uptake to mustard results in higher productivity and quality of crop in calcareous 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}). Significantly highest seed (2973 kg ha^{-1}) andstover (76.49 qha^{-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 the effect of M_4 treatment was found atpar. Half dose (@5 t ha^{-1}) of FYM is sufficient to obtain significantly highest seed yield of mustard when FYM enriched with micro and secondary nutrient. Fortification of micro and secondary nutrients has increased their availability in soil solution. Availability of S, Zn Fe and boron has increased by 17.74, 127.68, 43.41 and 52.76 percent under the treatment in which these nutrients are 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) over control($Zn_2B_2Fe_2S_2$) respectively. The treatment in which 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) increased the seed yield by 29.48 and 3.51 percent 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.S. Sujith Kumar, Scientist (Plant Biochemistry), R.S. Jat, Pr. Scientist (Agronomy), M.L. Dotaniya, Scientist (Soil Science)

Composting of low grade waste mica and rock phosphate as low cost source of nutrients with mustard stover is getting importance as an organic fertilizer for enhancing mustard productivity as well as soil fertility. Soil treated with 25% recommended dose of chemical fertilizers (RDF) along with 1.5 t/ha enriched composts had significantly higher Olsen-P (23.39 g/ha) as compared to use of chemical fertilizers and compostsalone. Treatments receiving integrated use of chemical fertilizers along with nutrient enriched compost resulted higher available nitrogen (N) over control. Significantly higher available N (326.3 kg/ha) was reported with 25% RDF along with 1.5 t/ha enriched composts in comparison to use of compostsalone. Soil organic carbon (SOC) was more influenced with organically treated soil than chemical fertilizers. Highest SOC had reported with treatments receiving nutrient enriched compost in comparison to 100% RDF. The magnitude of changes in soil pH and EC was at par in all treatments.However, slightly lower values of pH and EC was registered with organically treated soil in comparison to chemical fertilizers. Mustard grain yield was significantly higher with 100% RDF than control. Integrated use of composts @1.5 t/ha +25% RDF improved soil fertility in terms of available nutrients as compared to use of compost and chemical fertilizersalone.

DRMR CP-20: Yield maximization through best crop management strategies in mustar 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)

A field experiment was conducted to maximize the yield of mustard through best management strategies. The experiment was laid down in split plot design comprising 5 main plots and 03 sub plots with 03 replications. The main plots included five 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 include; RDN 100% (N_1), RDN 125% (N_2), RDN 150% (N_3). Recommended fertilizer dose (N:P:K:S) 80:40:40:40 were 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 days after sowing. Other package of practices, including insect and pests, weeds control were followed according to proper agronomic practices. Pre and post harvest observations in the field were recorded. Pre-harvest observations were plant height at different dates, chlorophyll content at 60 and 90 days after sowing. Post harvest observations like 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 were recorded.Result showed that treatment T_4 and T_5 performed atpar and using RDF+ FYM+ Biofertilizer + Mustard Straw, it gives around 20 % more yield compare to RDF. Increased N level increased crop yield, if we are applying 150 % RDN it gives 7.7 % more yield compare to RDN (Table 18). Interaction between N levels and organic sources was found non-significant.

Table 18. Effect of various nutrient sources on yield and glucosinolates content

Treatments		
Sources of Nutrient	Yield (q/ha)	Glucosinolates content (µmol/g)
T_1- RDF	29.00	135.01
T_2 – RDF + FYM	31.01	129.00
T_3 – T_2 + Biofertilizers	32.00	132.00
T_4 – T_3 + Mustard straw	34.83	124.38
T_5 – T_4 + Jivamrat	34.68	117.62
SEm±	0.48	3.94
C.D.(P=0.05)	1.57	NS
N levels		
N_1 – RDN 100 %	31.10	129.95
N_2 – RDN 125 %	32.47	124.28
N_3 – RDN 150 %	33.48	128.68
SEm±	0.24	3.19
C.D.(P=0.05)	0.72	NS
Interaction	Main × Sub	Main × Sub
C.D.(P=0.05)	NS	NS

Another experiment was conducted to evaluate best nitrogen and sulphur levels for obtaining high yield and quality in mustard. The experiment was conducted in split plot design with three replications. There were five N levels and four S levels in this experiment. 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). Data were recorded on different parameters. Pre-harvest observations were plant height at different dates, chlorophyll content at 60 and 90 days after sowing. Post harvest observations like 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 were recorded. Oil content was also recorded for quality purpose.In N levels, 120 kg N/ha gives significantly higher yield compared to rest of the treatments.In S levels, 60 kg S/ha gives 10% more yield compare to control treatment (Table 19).

Table 19. Effect of various N & S levels on available N status in soil and yield of mustard

Treatments	Available N at harvest	Yield (q/ha)
N levels		
N_0- Control	132.00	19.00
N_1 – 60 Kg/ha	143.20	26.01
N_2 – 80 Kg/ha	155.05	27.00
N_3 – 100 Kg/ha	164.50	28.88
N_4 – 120 Kg/ha	179.83	30.57
SEm±	1.34	0.15
C.D.(P=0.05)	4.38	0.50
S levels		
S_0 – Control	148.47	24.88
S_1 – 20 Kg/ha	153.40	25.75
S_2 – 40 Kg/ha	156.27	26.67
S_3 – 60 Kg/ha	161.07	27.61
SEm±	1.08	0.23
C.D.(P=0.05)	3.11	0.65
Interaction	Main × Sub	Main × Sub
C.D.(P=0.05)	NS	NS

DRMR CP-21: 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 moisture stress in mustard (*var.* DRMR IJ 31), two field experiments were conducted. First experiment was laid down in factorial-RBD with twelve treatment combinations of plant bio-regulators (PBRs; salicylic acid, SA; thiourea, TU; potassium nitrate, PN) and superabsorbent polymer-*Pusa hydrogel* (SAP) under no moisture stress and moisture stress conditions with three replications. The values of growth and yield parameters were reduced due to moisture stress but these were improved with the use of SAP either alone or in combinations with PBRs. Seed yield was significantly (*P=0.05*)decreased by 11% due to moisture stress over no moisture stress condition. However, the maximum values of the seed, stover and biological yields and harvest index of the mustard were recorded with SAP+SA followed by SAP+TU, SAP+PN and SAP whereas the lowest values of these parameters were recorded with control (without SAP and PBRs). Seed and biological yields with SAP+SA were found atpar with other PBRs but significantly improved by 9 and 5 % over SAP alone and by 25 and 18 % over the control, respectively. Similarly, moisture stress at reproductive stage has resulted in significantly lower oil yield than the no moisture stress condition. However, oil yield with the use of SAP along with PBRs was significantly improved yield by 20–30 % over the control (Fig. 15).

Another field experiment was conducted to assess

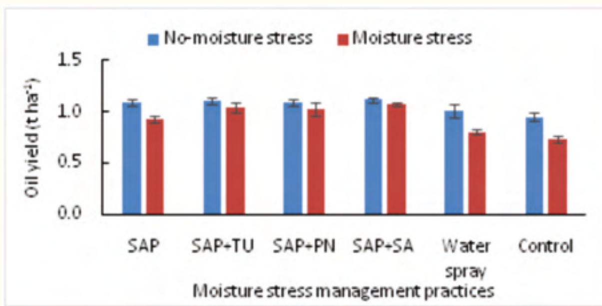


Fig. 15. Effect of different moisture stress management practices on oil yield of mustard under different moisture regimes

the effect of three superabsorbent polymers (SAPs) *i.e.* P-gel, V-gel and B-gel and their application rates i.e. 1.5, 2.5 and 5.0 kg/ha on the performance of mustard under moisture stress and no-moisture stress conditions. SAP materials *i.e.* P-gel, V-gel and B-gel were provided by the ICAR-IARI, New Delhi. The seed yield of mustard significantly (*P=0.05*)influenced due to application of SAPs under both the moisture regimes. Irrespective of type of SAPs, seed yield improved by on an average 13.7 and 15.5% over the controls under no-moisture stress and moisture stress conditions, respectively (Fig. 16). However, seed yield was similar under all the SAPs. Though, there was significant difference observed between different levels of SAPs. The maximum seed yield was recorded with 5.0 kg/ha which was significantly higher than 1.5 and 2.5 kg/ha under moisture stress condition but remained atpar with 2.5 kg/ha under no moisture stress condition. Seed yield with 5.0 kg/ha SAP improved by 18.4,10.3 and 2.6 % over control, 1.5 and 2.5 kg /ha SAP, respectively under no moisture stress condition. Whereas, under moisture stress condition, seed yield improved by 26.3, 19.5 and 11.4 % with the same SAP rate i.e. 5.0 kg/ha over control, 1.5 and 2.5 kg/ha, respectively. Seed yield was also significantly higher at 2.5 kg/ha over 1.5 kg/ha under no moisture stress condition but the difference between 1.5 and 2.5 kg/ha was not significant under moisture stress conditions.

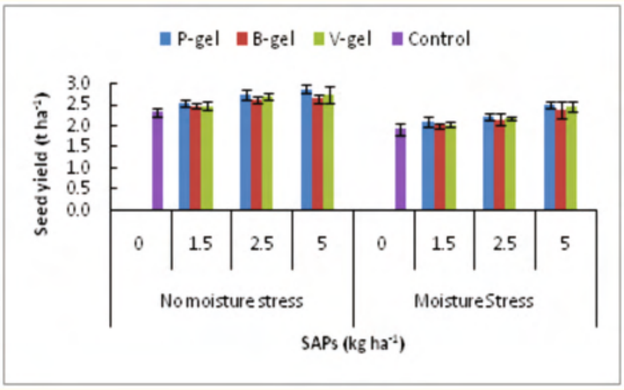


Fig. 16. Effect of different super absorbent polymers (SAP) and their application rates on seed yield of mustard under different moisture regimes

DRMR CP-22: Management of poor quality water for sustainable mustard production

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

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

Soil physico-chemical properties are greatly mediated with the application of organic matter. Most of the mustard growing areas of Rajasthan having lower amount of SOC and low to medium status of other plant nutrients. Other than this, soil salinity is also a yield deciding factor across the region. Addition of organic matter in soil through FYM and pressmud may enhance soil fertility and reduce the salinity. Geo-referenced soil and water samples were collected from the region to delineatesoil fertility and water quality parameters. The collected soil samples showed low to medium range (0.39-0.63) of Walkley and Black carbon, low to medium (171-306 kg/ha) Alkaline KMNO4-N, medium range of Olsen's phosphorus (11.8-28.4 kg/ha) and available potassium (126-213 kg/ha). Soil available sulfur ranged 12.3 to 24.4 kg/ha (low to medium). Also analyzed the water samples and found high pH & EC. These results are helping to decide the application rate of FYM and press mud for enhancing soil fertility status for sustainable mustard yield.

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*

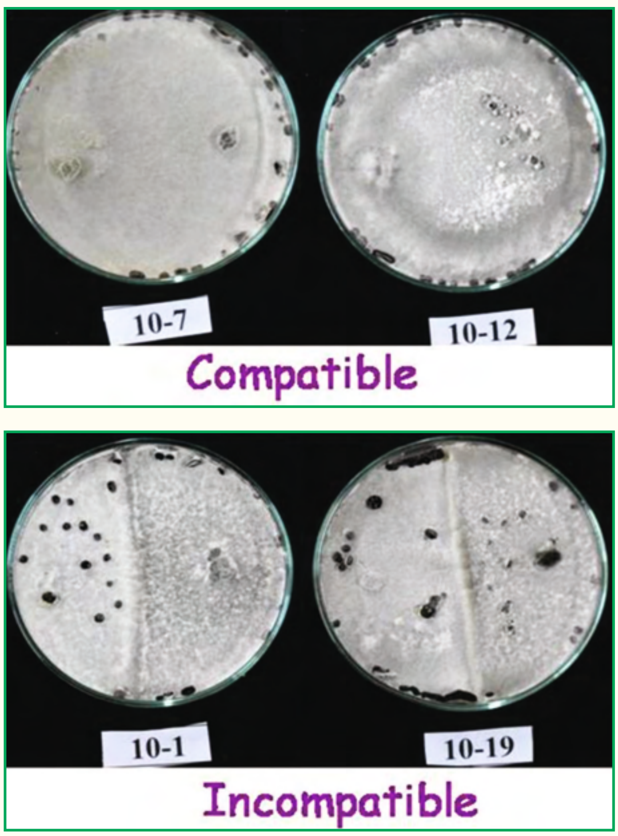


Fig. 17: Compatible reaction in different isolates of *S. sclerotiorum*

75 geographical isolates of *Sclerotinia sclerotiorum,* collected from different geographical regions of oilseed Brassica growing areas in the country, were maintained for further study.

Mycelial Compatibility Group (MCG)

Mycelial compatibility is the ability of two strains of filamentous fungi to anastomose and form one continuous colony. All possible combinations of mycelial compatibility and incompatibility from 75 *S. sclerotiorum* isolates are in progress and ESR 1 to ESR 20 were completed. The combinations with antagonistic reactions with each other formed a thin band of live or dead mycelia. The full mycelial compatibility reactions are probably due to the vegetative compatibility. Mycelial compatibility group (MCG) is a phenotypic marker system that is controlled by multiple loci.

There were 1500 pairings of 20 isolates, of these 167 combinations showed compatible reaction (11.1% of all combinations), where mycelia of the two isolates intermingled at the interaction zone (Fig. 17). The isolates, ESR-1, ESR-2, ESR-3 and ESR- 10 were most compatible with other isolates. The compatibility and incompatibility between different geographical isolates were considered as 0 and 1 and data recorded will be used for cluster analysis.

Screening of *Brassica* germplasm for stem rot tolerance

635 oilseed Brassicagermplasmsscreened during 2019-20 crop season. Germplasm were sown on 24 Oct 2019 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design with two replications. Pathogen inoculum was mass multiplied on autoclaved sorghum grain and mixed with soil prior to sowing to create epiphytotic conditions. Further, the plants were stem inoculated with the mycelial bit of pathogen.

Epidemiology

Epidemiological studies were done using seven dates of sowing starting on October 8, 2019 at weekly intervals with three replications in plot size of 4.5x5 m using cultivar DRMRIJ-31 of Indian mustard. Data for soil moisture at weekly intervals, and disease incidence will be recorded apart from petal infection and weather data to identify the suitable 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 farmof ICAR-DRMR. The var. DRMRIJ-31 was sown on October24,2019 with plot size 15 x 7m. The module was having 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 December 25 to January 15and control was maintained with farmer practices.

Development of RILs

Three crosses involving RH 749 x RH 1222-28, RH 749 x EC 597328 and RH 406 x RH 1222-28 were attempted during 2016-17. 153, 283 and 122, F3 population of respective crosses sown under sick plot condition on October 24, 2019.

Mustard residue management with *Trichoderma*

An experiment was laid out on plot having mustard straw (2.5 t/ha) of DRMRIJ 31, sown on October 24, 2019 with plot size 9x5m; 45x20cm (RxP) in three replication. After first irrigation (35DAS), straw was inoculated with *Trichoderma* sp. (TS 2) multiplied on sorghum grains. Control was maintained with farmer practice.

Effect of *Panchgavya* on mustard diseases

An experiment was laid out to investigate effect of Panchgavya (PG) on different diseases of mustard. Indian mustard var.DRMRIJ 31, was sown on October 24, 2019 with plot size 13.5

x5m; 45x20cm (RxP) in three replication and control was maintained without foliar spray of PG. First foliar application of PG done at 65 DAS and another will be done 95 DAS.

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

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

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

Pathogenicity Test

Ten-seeds in each pots (30x30x25cm) were sown on November 05, 2018 using cultivar NRCHB 101 to test the percent disease incidence in different inoculation methods. Different inoculation methods including seed inoculation, soil inoculation, stem inoculation, seed + soil inoculation and un-inoculated check were taken to confirm the pathogenicity of *Sclerotium rolfsii* on *B. juncea* cultivar NRCHB 101. Accordingly, maximum 40% infection was observed in seed+soil inoculation method followed by stem inoculation method (28.8%), seed inoculation method (21.9%) and soil inoculation method (19.6%) in comparison with un-inoculated check (3.1%).

Survey of the disease in mustard growing areas

Survey on appearance of disease was undertaken at different centre's of AICRP-RM all over the country. Negative response on *Sclerotium rolfsii* occurrence received from Pantnagar, Morena, Dholi, Guwahati and other locations. There was only report from Pahadi Tehsil of Bharatpur.

Re-identification of the fungus

The pathogen collected from diseased samples was isolated, purified and sent to Agarkar Research Institute, Pune, India for identification. Analysis of the sequences of different fragments of the ribosomal genes demonstrated that isolated pathogen belongs to the Nectriaceae family and was genetically different from other morphologically similar species of *Fusarium*. This new species is unique in having colonies on PDA at 25°C$\pm$ 2°C, fast growing, rosy pink to vanacous, reverse pell leuteus to light ochraceous. Based on our studies the fungus was morphologically identified as *Fusarium equiseti* (Corda) Sacc.(NFCCI 4564). As per the micromorphology, hyphae were hyaline, smooth, pigmented and 2.75-4.77µm wide. Singlespore pure culture produced were intercalary, fusoid, hyaline and smooth walledchlamydospores. Although, fusoid, smooth walled, hyaline, foot cell present and sickle shaped, 2-septate 14.59-45.48 x 2.88-4.10µm in sized macroconidia were abundantly produced. Microconidia were fusoid, 1-septate and 2.5-2.67 x 2.67-13.7 µm in size.

Molecular identification of isolated pathogen

Genomic DNA was isolated in pure form from the culture of isolated pathogen. The ITS-rDNA partial gene was successfully amplified using primers ITS4 & ITS5. The sequencing PCR was set up with ABI-BigDye® Terminator v3.1 Cycle Sequencing Kit. The raw sequence obtained from ABI 3100 automated DNA sequencer was manually edited for inconsistency. The sequence data was aligned with publicly available sequences and analyzed to reach identity. The tested fungal strain showed 100% sequence similarity with *Fusarium equiseti.* Sequnce analysis with NCBI accession number EU326202.1, *Fusarium equiseti isolate* XSD-80 resulted in following alignment statistics.

DRMR-PP-7: Morphological, biochemical and molecular basis of host resistance in Brassica – Alternaria interaction

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

Co- Investigators: M.S. Sujith Kumar (Scientist, Biochemistry); H.S. Meena, Senior Scientist (Plant Breeding); Prashant Yadav, Scientist (Plant Biotechnology)

Morphological and biochemical basis of tolerance to AB

Estimation and evaluation of biochemical compounds (Phenols, Sugars, chlorophyll, Anti-oxidants, and carotenoid) responsible for Alternaria blight resistance in thirty *Brassica juncea* breeding lines/ genotypes (R&S) was done. Brassica genotypes characterized for smooth or hairy surface, number of stomata, for further confirmation. Characterization of genotypes expressing field tolerance to Alternaria blight was done.

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

Study of the cost of cultivation of mustard and returns thereof and identification of major constraints faced by farmers in production of mustard crop

A survey was carried out in Bharatpur district of Rajasthan to study the cost of cultivation of mustard and returns thereof, and constraints in production of mustard crop. For the purpose of the study, 5 villages namelyLudhawai, NaglaKalyan, Notha, HabibpurandChonkarwara of Bharatpur district of Rajasthan, adopted under MeraGaonMeraGourav (MGMG) programme of ICAR-DRMR during 2018-19, were selected. Finally, a sample of 250 mustard growing farmers was selected randomly from selected villages taking equal representation i.e. 50 respondents from each of the selected village.

The study was based on the primary as well as secondary data. The field data on input and output along with other required information were collected through pre-structured schedules and questionnaires by personal interview group discussion and triangulation methods and with the help of participatory rural appraisal. The secondary data on prices, wages, land use, etc. were collected from records and reports of different departments and KrishiMandies. Findings are based on the verbal expression and responses of the farmer respondents. Due to limitation of time and resources, elaborative and micro level studies could not be taken up.

Cost of cultivation of mustard and returns thereof

The cost of cultivation incurred in the cultivation of mustard crop starts from land preparation and ends to harvesting/threshing. It includes the variable cost as well as fixed cost. The variable cost includes cost of seed and manure and fertilizer, human labour, bullock labour and irrigation etc. The fixed cost includesdoes depreciation, repair and interest on implements and machines, farm building and land revenue etc. The study was undertaken to work out the cost of cultivation of mustard and returns from the resulted production of the crop. The study only included variable cost which incurred by the farmers in cultivation of the crop. The study did not include fixed cost keeping in mind its constant nature whether cropped or received fallow.

Cost of cultivation of mustard per hectare

Overall average cost per hectare in mustard was found to Rs. 31694 in the study area (Table 20). The cost incurred includes the items like ploughing, planking, sowing of seed, cost of seed and fertilizers, application of fertilizers, intercultural operations, irrigation harvesting, threshing and miscellaneous. The study reported that maximum per cent of cost i.e. 32.53% was incurred in ploughing which, on an average, was Rs 10312 per ha. It was observed that majority of farmers were practicing fallow mustard cropping system in the study area and to conserve the soil moisture and proper land preparation for sowing, 8-12 ploughing and 2-4 planking were done which costed Rs. 11719/ha (about 36.96% of the total cost) . The study reported that irrigation was the second most important component which costed Rs. 5000/ha for one life saving irrigation that shares 15.77 % of the total cost. In many areas, depending on soil type, preceding rains, moisture content, farmers are bound for two irrigations that also add substantial share of irrigation to the total cost. The data in table also show that majority of respondent farmers in the study area were using about 250-300 kg SSP +90-100 kg Urea /ha at sowing and 90-120 kg Urea /ha at first irrigation, which costed Rs. 3350/ha and shares 10.56% of the total cost. A few farmers were also using 100-125 kg DAP & 60-70 kg Urea/ha at sowing time which resulted in an additional cost of Rs. 750/ha on account of fertilizers in comparison to SSP and Urea combination.

The table further reveals that 15-17 labourers per hectare were required for harvesting of which costed on an average of Rs. 4000/ha in the study area that accounted about 12% of the total cost of cultivation of mustard. This is important to note that about R. 2325 was incurred on purchase and sowing of seeds which were 7.32% of the total cost.

The threshing of harvested crop by the tractor amounted Rs. 2800/ha, which was 8.83% of the total cost. It was also reported that miscellaneous items/operations (Labour for different operations/ fertilizer applications/ pesticides/ packing/ carrying, etc.) costed Rs 2500 per hectare.

Table 20: Item-wise average cost of cultivation of mustard per hectare

Items	Activities	Av. CoC (Rs./ha)	Per cent
Ploughing	8-12 Ploughing by tractor	10312	32.53
Planking	2-4 Planking by tractor	1407	4.43
Sowing of seed	By tractor	1125	3.54
Seed	5-6 kg/ha	1200	3.78
Fertilizers	(250-300 kg SSP +90-100 kg Urea /ha at sowing)	2750	8.67
	(100-125 kg DAP & 60-70 kg Urea / ha at sowing)	3500	
Top dressing of Fertilizers	90-120 kg Urea /ha at first irrigation	600	1.89
Irrigation	One irrigation	5000	15.77
Harvesting	15-17 men/ha. (Rs. 250/labourer)	4000	12.00
Threshing	By tractor and labourer	2800	8.83
Miscellaneous (Labour for different operations/ fertilizer applications/ pesticides/ packing/ carrying, etc.)	-	2500	7.88
	Total	31694	100

Returns and income against the cost incurred in mustardproduction

Table 21 shows the gross income, total cost of cultivation, average yield, net income and input: output ratio per hectare in mustard crop. The study reported that farmers madean average expenditure of Rs. 31694 per hectare for the production of mustard crop. The data of production of mustard and selling price of produce were also collected from the selected respondents. An average yield of mustard per hectare was reported 2557 kg/ha.Farmers were able to realize a gross monetary return of Rs. 107394 per hectare and the net monetary return Rs.75700 per hectare. The average input: output ratio from mustard crop was 1:3:38.

Prioritization of major Constraints perceived by farmers in production of mustard crop

In order to provide farmers' feedback to the research and extension systems for taking corrective measures and enhance the mustard productivity in the Bharatpur district of Rajasthan. The present study (Table 22) also identified and prioritized the major constraints in mustard production with the farmers' participation.

Table 21: Returns and income against the cost incurred in the production of mustard

No of respondents	250
Av. cost of cultivation (Rs/ ha)	31694
Average yield (kg/ha)	2557
Gross Monetary Return (Rs/ha) @ Rs. 42/kg	107394
Net Monetary Return (Rs/ha)	75700
Input : Output ratio	1: 3.38

The methodology to identify the constraints was personal interview of selected respondents with different techniques of participatory rural appraisal and matrix ranking for prioritization of the constraints. Farmers from these villages identified 11 major constraints related to mustard production system and as per the intensity, the identified constraints in the area were ranked.

Table 22: Prioritization of major constraints perceived by farmers in production of mustard crop in study area (N=250)

Constraints	Respondent (%)	Rank
Lack of Knowledge about scientific mustard production technology & resources to access the required knowledge	86.0	I
Problem of stray animals	83.6	II
Lack of soil moisture/irrigation facility/rainfall	82.0	III
Lack of knowledge about micronutrients used in mustard	78.0	IV
Non availability and inferior quality of required inputs in time (seeds, fertilizers, pesticides, insecticides, etc.)	76.0	V
Problems of insect-pest and diseases	72.0	VI
High cost (inputs, Labourers, etc.)	70.0	VII
Lack of ability to identify attack/incidence of insect-pest and diseases timely, lack of knowledge of their management and unavailability of plant protection chemical sprayer in the local area	68.0	VIII
Non-availability of farm machinery on hire and skilled farm labour in time	66.8	IX
Problems of frost, fog, untimely rain, etc	65.2	X
Problem of saline water and soil	64.0	XI

The study (Table 22) reported that 86.0% respondents did not have the knowledge of scientific mustard production technology and resources to access the required knowledge. The majority of the farmers felt that improved technologies have been developed regularly but are not reaching to them timely and due to lack of resources, farmers are not able to keep themselves informed properly about the developed technology. Therefore, lack of knowledge about scientific mustard production technology and lack of resources to access the required knowledge was prioritized at first rank. In the study area, the problem of stray animals was another most important constraint in the mustard production which was reported by 83.6% respondents with second rank.

The low rainfall and lack of irrigation facility in the area resulted in lack of soil moisture were perceived third most important constraint by 82.0% farmers. It was found that farmers have been regularly using imbalance dose of fertilizers particularly urea, SSP and DAP and majority (78.0%) were not aware about importance of micronutrients for the crop.

The timely non-availabilityand inferior quality of required inputs particularly seeds, fertilizers, pesticides and insecticides were also reported one of the major constraints by 76.0% farmers that were prioritized at fifth rank. The 72% respondents reported problems of insect-pest and diseases particularly termite, painted bug, aphid, sclerotinia rot, white rust and *Orobanchae* and placed at sixth rank for causing low productivity of mustard in the area. The high cost of inputs and labourers were also responsible for low adoption of recommended mustard production technology which ultimately resulted in low productivity of the crop. This constraint was reported by 70.0% respondents which were prioritized at seventh rank.

The inability of farmers to timely identify attack/incidence of insect-pest and diseases, lack of knowledge of their management and unavailability of plant protection chemical sprayer in the local area were identified as major constraints by 68.0% farmers which were placed at eighth rank. The 66.8% respondents also reported the problem of non-availability of required farm machinery on hired basis and skilled farm labour timely and ranked at ninth major constraint. The problems of frost, fog, untimely rain, etc resulted in low productivity of mustard were reported by 65.2% farmers. The problem of saline water was also important constraint in the mustard production which was reported by 64.0% respondents.

Suggestions to overcome the identified constraints for increasing production of mustard crop in the area

Lack of knowledge about scientific mustard production technology, use of micronutrients and inability to identify insect-pest and diseases and their management are the constraints which can be overcome by effective extension system. The extension system should communicate and transfer the technology effectively to the farmers through various extension educational techniques/ programmes, so that farmers keep themselves abreast about the improved mustard production technology.

Further, effective measures are needed by the Govt and concerned agencies/departments to make the required quality inputs available to the farmers in time and make the policy for solution of stray animals problem. Regarding the problem of non-availability of farm machinery and farm labourers, farmers are required to work on cooperative basis.The research system should also come out with the effective technology suitable in problematic saline soil and water, because Bharatpur district has dry climate with hot summer, cold winter, short monsoon season with an average annual rainfall of 645 mm and salinity of soil and irrigation water. Under this condition, the farmers of the area have limited option for the change in the cropping pattern replacing mustard, as musard has low water requirement and can also tolerate the salinity of soil and water better than the other crops. In such a situation, it is imperative for the research system to speed up technology generation programme for enhancing mustard production.

NRCRM 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 (Ag. Extension)

The website of DRMR redesignedto improve the functionality and regularly being updated as per guidelines of ICAR. The URL of website of DRMR is www.drmr.res.in.The online web based tool developed for rapeseed-mustard information management and disseminations have also been updated. The DRMR holds a rich diversity of Brassica germplasm collected from different agro-climatic zones of India. Proper digital documentation of these germplasm resources is a basic requirement which allows best use of data, easy retrieval and supply. The online system RMpgis developedis the plant germplasm information system for the DRMR collections of Rapeseed-Mustard Genetic Resources. The system provides common access to information on germplasm collections by enabling searches for information relating to the passport data, characteristics, and evaluation of accessions held by the Centres.

As providing service to facilitate the research, scientists were facilitated in statistically analyzing their research data and presenting the information by plotting graphs using MS Excel and other statistical software. The most of computers of directorate are running on MS Window VISTA, MS-Window XP, Windows 8, Windows 10, etc operating system and MS-Office 2007, MS-Office 2003, etc application software. The main server of DRMR running on Linux. All problems related to these operating system and application software were solved by Computer cell. Establishment, management and administration of campus LAN/ WAN. Times to time on terminal (PC) trainings were given to the employees of 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 Investigators: Priyamedha, Scientist (Genetics and Plant Breeding)

A total of 10 candidate varieties (2 hybrids, 8farmers) of rapeseed-mustard have been grown as per guidelines of PPV&FRA for testing of 24 DUS characters with 5 reference varieties. Nine farmer's varieties have been characterized during first year for any species variation and/or mixture of species. One hundred and thirty-eight rapeseed-mustard varieties (96 varieties of Indian mustard (*Brassica juncea*), 2 varieties of brown sarson (*B. campestris*var brown sarson), 7 varieties of gobhisarson (*B. napus*), 5 varieties of Karan rai (*B. carinata*), 12 varieties of yellow sarson (*B. campestris*var yellow sarson) and 16 varieties of Toria (*B. campestris*vartoria) were maintained through appropriate mating systems. Twenty rapeseed-mustard varieties have also been 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), A.K.Sharma, Pr. Scientist (Ag. Extension)

A total 895.95 q TL seeds of rapeseed-mustard varieties were produced during 2018-19. The improved varieties *i.e.* DRMRIJ31, NRCHB 101, RH 749 and NRCYS-05-02 were included in the seed production programme. Quality seed production programme was conducted at ICAR-DRMR, KVK Kumher and Madhurikund (DUVASU) Farm in participatory seed production mode. After seed processing, grading, treating and packing, the quality seeds weresold to farmers and government agencies in the month September and October, 2019 during *beej pakhwara*.

Breeder seed production of rapeseed-mustard

Breeder seed of DRMRIJ31 (17.14 q), NRCDR02 (1.27q), NRCHB101 (5.61 q), and NRCYS 05-02(0.60q) was produced during 2018-19 and supplied during Rabi 2019-20 to indenters as per DAC & FW, New Delhi guidelines.

DRMR EA-10: Development of low glucosinolates and low phytic acid mutations for improving nutritional value of low erucic acid genotypes in Indian mustard

Project 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 PM21 and PM 30 were selected for mutagen treatment and irradiated with 1000 Gy & 1200 Gy doses of gamma ray.

Fig. 18: Variation in flower color and load of siliqua and short height

Three doses (0.25, 0.50 and 0.75%)of chemical mutagen EMS were used to treat the seeds of same varieties. Combined treatment of radiation and chemical mutagen was also used for seed treatment.

M_1 generation was sown along with controlin the month of October 2017. Single plants of M_2 generation from all treatments were harvested. Numbers of plants in each dose were counted to determine the dose effect on germination %. A large variation has been seen in the treatments.

DRMR EA-11: CRP on hybrid technology for higher productivity in selected field and horticultural crops (component Indian mustard)

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

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

Five multilocation trials (MLT) were conducted to evaluate experimental hybrids, F_1 crosses and inbred lines at four locations viz., ICAR-DRMR Bharatpur, ICAR-IARI New Delhi, PAU Ludhiana and CCS HAU Hisar. Six early maturing hybrids are being evaluated in MLT 1 alongwith 3 check Keshari, Pusa Mustard 25 and NRCHB 101. 20 and 15 experimental hybrids are being evaluated in two separate trials MLT 2 and MLT 3, respectively, alongwith 3 checks; Pioneer 45S46, NRCHB 506 and Giriraj. In MLT 4, 76 F_1 crosses comprising 22, 15, 19 and 20 from DRMR, IARI, CCSHAU and PAU, respectively alongwith 2 checks, Pioneer 45S46 and Giriraj are being evaluated in augmented block design. In MLT 5, 86 inbred lines comprised of 20, 23, 23, and 20 from DRMR, IARI, CCSHAU and PAU, respectively along with 2 checks, Giriraj and Pusa Mustard 25. In MLT 6, 19 CMS lines comprising 05 each from DRMR, CCSHAU and PAU and 04 from IARI alongwith respective maintainer line and 08 restorer lines (02 from each collaborating centre) are being characterized for agronomic traits. A hybridization block of seven lines and six testers has also been raised to attempt 42 F_1 Crosses.

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 (Ag. Extension)

The Institute Technology Management Unit (ITMU) is responsible for Intellectual Property (IP) protection, management and transfer/ commercialization of technologies developed by the institute and the institutes under AICRPRM project.

Technology commercialization and revenue generation

The research outcomes were disseminated in the form of technology licensing and commercialization to various end users. During April-December 2019, DRMR signed a MoU for licensing the Indian mustard hybrid NRCHB 506 with Nutranta Seeds Pvt. Ltd, Hyderabad on October 14, 2019. An amount of Rupee 1.50 Lakh was generated by licensing of NRCHB 506 with above mentioned seed companies.

Registration/renewal of varieties with PPV&FR

DRMR has registered the rapeseed-mustard varieties with PPV&FR for protection and management of intellectual property generated by the DRMR and AICRP Institute. During the period 16 rapeseed-mustard varieties were renewed and the Annual fees amount of Rs. 108000/- (one lakh eight thousand only) was processed for submition to PPV&FR as annual registration renewal charge for these 16 rapeseed-mustard varieties.

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

Heat tolerance

Advancement of Recombinant Inbred Lines (RILs)

Two RIL populations derived from the crosses NRCDR 02 x BPR 541-4 and NRCHB 101 x BPR 543-2 are being advanced to F_5. A Total of 256 F_4 seeds (NRCDR 02 x BPR 541-4) and 229 F_4 seeds (NRCHB 101 x BPR 543-2) were sown in single row of 2 m length spaced 30 cm.

Molecular analysis of RIL population

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

Mapping population was constituted of 190 F2 population developed from a cross NRCHB101 x BPR543-2. The population 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. A map was constructed using 55 SSR markers. 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 analyzed for mapping the QTLs associated with heat tolerance, yield and yield attributes related traits and phenological parameters.Out of 55 polymorphic markers 53 markers, were found suitable for mapping because 2 markers did not map to any of the linkage group and excluded from mapping. A linkage map was constructed using 53 SSR markers. These 53 SSRs were mapped to 7 linkage groups (C1-C7) of *B. juncea* genome.

Fifty three polymorphic SSR markers distributed on seven *B. juncea* linkage groups were used to map the QTLs associated with yield related traits, growth parameters, phenological parameters and physiological parameters in 190 NRCHB101 x BPR543-2 F2 Population (Table 23). Composite interval mapping (CIM) analysis by WinQTL Cartographer 2.5 revealed a total of 41 QTLs for various heat related, yield and other traits in *B. juncea*. Out of these identified QTLs, 11 QTLs were for yield and related attributes, 1 QTL was for phenological traits (days to flowering initiation) and 29 QTLs for physiological trait.

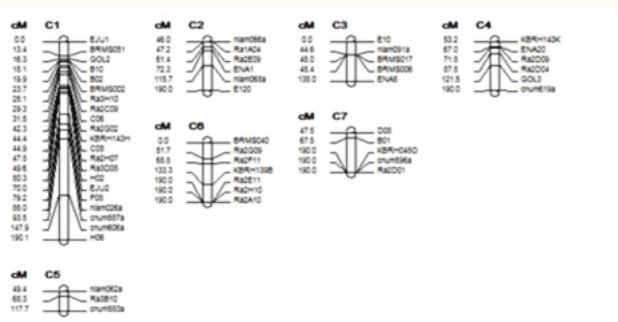


Fig.19: Linkage map of *Brassica juncea* generated using 53 SSR markers in F_2 population derived from NRCHB101 x BPR543-2 in Indian mustard

Results of present study suggest that in terms of Heat QTL, the most important linkage group is 1 and 2 with spanning major QTL for the entire heat–influencing traits. Most prominent clustering signifying multifunctional QTL region was observed in the LG 1 and 2. This multifunctional QTL region in the LG 1 contains at least one major QTL for different traits. Similar multifunctional QTL regions were also detected in LG 2, 4 and 7 with QTLs distributed for many agronomic traits within a small narrow region. It might be possible that the narrow multifunctional QTL regions on linkage group 1 and 2 are contributing towards heat tolerance and its related traits (Yield traits) promoting heat related adaptations in *B. juncea*. 29 heat related QTLs identified in our study firstly need to be confirmed in other populations and then fine mapping of these heat related QTLs have to be done so that we can identify markers for marker assisted selection and breeding for heat tolerant genotypes in *B. juncea.*

Stem rot

Advancement of Recombinant Inbred Lines (RILs)

A RIL populations derived from the cross (EC 597328 x RH 749) was advanced to F4.

Molecular analysis of RIL population

F_2 population of the cross (EC 597328 x RH 749) was genotyped for the QTL mapping. A total of 160 individuals were selected along with parental genotypes *i.e.* EC 597328 (P_1) and RH 749 (P_2) for the QTLs mapping. Genomic DNA was isolated from F_2 population with their parents i.e. EC 597328(P1) and RH 749 (P2) and quantified using agarose gel electrophoresis.

Parental Polymorphism survey

A total of 484 polymorphic SSR markers were used for screening the parental genotypes *i.e.*EC 597328 and RH 749to identify the polymorphism among them. Out of these markers, 35 SSR markers were polymorphic and 343were found monomorphic and 106 SSR were not amplified with the parents.

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

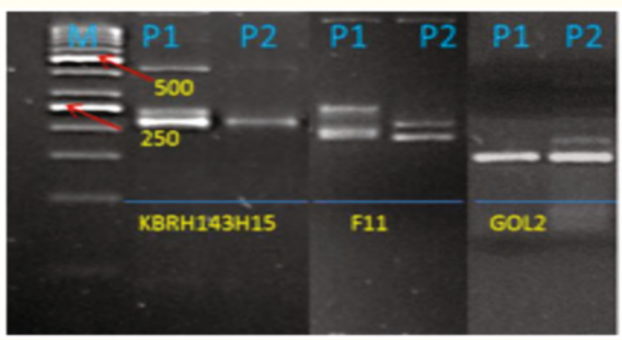


Fig. 20: Agarose gel showing PCR amplification of markers (KBRH143H15,F11,GOL2) for polymorphism survey among parental genotypes. M: 50 bp ladder, P1: EC 597328, P2 :RH-749.

Table 23: Summary of the QTLs identified for heat tolerance and other agronomic traits in NRCHB101 x BPR543-2 F2 Population in Indian mustard

S. No.	Trait No.	Trait Name	Qtl Name	Chrom-osome	POSITION (cM)	LOD	Peak Marker	Peak Marker Name	Marker position	Additive	R2%	DPE
1.	1	DFI	$qDFI_{7.1}$	7	90.01	8.1	2	BRMS051	13.4	3.4	2.0	B
2.	5	SB	$qSB_{1.1}$	1	8.01	4.4	1	EJU1	0	-1.2	57.2	N
3.	6	FZL	$qFZL_{1.1}$	1	42.31	9.2	10	Ra2G02	42.3	-2.0	4.4	N
4.	7	MSL	$qMSL_{1.2}$	1	42.31	9.2	8	Ra2C09	29.3	-0.9	1.3	N
5.	8	SOMS	$qSOMS_{1.1}$	1	37.51	8.2	10	Ra2G02	42.3	-3.7	12.1	N
6.	9	SL	$qS.L._{1.2}$	1	52.31	11.4	15	H02	50.3	0.2	8.1	B
7.	10	S/S	$qS/S_{1.3}$	1	70.01	15.2	16	EJU2	70	-0.7	17.2	N
8.	11	S/P	$qS/P_{1.1}$	1	115.51	25.1	19	cnum587a	93.5	-17.3	7.2	N
9.	11	S/P	$qS/P_{3.1}$	3	45.41	9.9	4	B10	18.1	14.6	7.3	B
10.	12	Y/P	$qY/P_{1.3}$	1	185.91	40.4	20	cnum606a	147.9	-1.5	0.3	N
11.	12	Y/P	$qY/P_{2.1}$	2	36.31	7.9	4	B10	18.1	-1.8	5.5	N
12.	13	TW	$qTW_{2.1}$	2	58.31	12.7	4	B10	18.1	-0.2	14.1	N
13.	14	SPAD	$qSPAD_{2.1}$	2	23.41	5.1	3	GOL2	16.3	-0.9	9.7	N
14.	15	CHLa	*qCHLa1.2*	1	19.91	4.3	5	B02	19.9	0.2	13.1	B
15.	15	CHLa	*qCHLa1.3*	1	60.31	13.1	15	H02	50.3	0.2	14.6	B
16.	15	CHLa	*qCHLa1.4*	1	181.91	39.5	20	cnum606a	147.9	0.1	6.7	B
17.	15	CHLa	*qCHLa3.1*	3	44.01	9.6	1	EJU1	0	0.0	4.2	B
18.	16	CHLb	*qCHLb1.4*	1	74.01	16.1	16	EJU2	70	0.1	7.5	B
19.	16	CHLb	*qCHLb1.5*	1	83.21	18.1	17	F08	79.2	0.1	7.2	B
20.	16	CHLb	*qCHLb1.6*	1	119.51	26.0	19	cnum587a	93.5	0.5	4.3	B
21.	16	CHLb	*qCHLb2.1*	2	32.31	7.0	4	B10	18.1	0.0	8.4	N
22.	16	CHLb	*qCHLb2.2*	2	50.31	10.9	4	B10	18.1	-0.6	8.7	N
23.	16	CHLb	*qCHLb3.2*	3	45.01	9.8	3	GOL2	16.3	-0.2	7.3	N
24.	16	CHLb	*qCHLb4.2*	4	110.31	24.0	5	B02	19.9	0.3	55.3	B
25.	17	TCHL	*qTCHL1.1*	1	19.91	4.3	5	B02	19.9	0.0	5.9	B
26.	17	TCHL	*qTCHL1.2*	1	29.11	6.3	7	Ra3H10	25.1	0.0	7.6	B
27.	17	TCHL	*qTCHL1.3*	1	49.61	10.8	14	Ra3D08	49.6	0.0	6.7	N
28.	17	TCHL	*qTCHL1.4*	1	76.01	16.5	16	EJU2	70	0.0	6.3	B
29.	17	TCHL	*qTCHL1.5*	1	81.21	17.7	17	F08	79.2	0.0	6.3	B
30.	17	TCHL	*qTCHL2.2*	2	26.31	5.7	4	B10	18.1	0.0	4.5	B
31.	17	TCHL	*qTCHL2.3*	2	44.31	9.6	4	B10	18.1	0.0	10.2	B
32.	17	TCHL	*qTCHL7.2*	7	98.01	21.3	2	BRMS051	13.4	0.0	1.7	B
33.	18	CART	*qCART1.3*	1	64.31	14.0	15	H02	50.3	0.5	13.9	B
34.	18	CART	*qCART1.4*	1	107.51	23.4	19	cnum587a	93.5	0.2	4.4	B
35.	18	CART	*qCART2.2*	2	52.31	11.4	4	B10	18.1	-0.7	7.1	N
36.	18	CART	*qCART7.1*	7	20.01	4.4	2	BRMS051	13.4	0.2	5.8	B
37.	19	RWC	*qRWC1.1*	1	52.31	11.4	15	H02	50.3	1.1	4.3	B
38.	19	RWC	*qRWC2.2*	2	119.71	26.0	5	B02	19.9	-3.3	6.6	N
39.	20	CSI	*qCSI1.2*	1	187.91	40.9	20	cnum606a	147.9	1.7	9.9	B
40.	20	CSI	*qCSI4.1*	4	106.31	23.1	5	B02	19.9	0.4	2.9	B
41.	20	CSI	*qCSI7.1*	7	74.01	16.1	2	BRMS051	13.4	0.0	1.2	B

(Genetics and Plant Breeding)

Co-Investigators: Pankaj Sharma, Pr. Scientist (Plant Pathology), Ibandalin Mowlong, Scientist (Plant Biochemistry), Reema Rani, Scientist (Biotechnology), Priyamedha, Scientist SS (Genetics and Plant Breeding)

Quality traits

Glucosinolate

A total of 506 samples of BC_3F2 seeds were subjected to biochemical analysis. The total glucosinolate content was found to be < 35 µmol/g among the crosses namely NRCHB101 x RLC-3, NRCHB101 x HEERA,DRMR150-35 x RLC-3,DRMRIJ-31x PDZ-1, DRMRIJ-31x RLC-3 and NRCDR-02 x RLC-3.Whereas, in case ofNRCDR-02 x PDZ-1, glucosinolate content was found below 45µmol/g. Among crosses NRCHB101 x RLC-3 and DRMR150-35 x RLC-3 total glucosinolate content was found to be < 20 µmol/g.

Erucic acid estimation

Erucic acid content in BC_3F2 seeds found to be < 15 % among the crosses NRCHB101 x RLC-3, NRCHB101 x HEERA , DRMR150-35 x RLC-3,DRMRIJ-31x PDZ-1, DRMRIJ-31x RLC-3, NRCDR-02xPDZ-1 and NRCDR-02xRLC-3. In case of samples derived from cross NRCHB101 x RLC-3, the erucic acid content was found to be below 3% whereas, erucic acid content below 5% was reported in case of crosses NRCHB101 x HEERA,NRCHB101 x RLC-3,NRCDR-02xRLC-3 and DRMRIJ-31x PDZ-1.

Glucosinolate and Erucic acid estimation of F_4 generation

A total of 1208 samples of F_4generation were subjected to biochemical analysis. The total glucosinolate content and erucic acid content is depicted below in Table 24.

Foreground selection of BC_3F_2 using linked markers

Foreground selection of BC_3F_2 usingmarkers linked to Glucosinolate loci (GER-1MRPR + IP3GER-1F (Q1); Myb28 (Q2); At5g41 (Q3); At5GAJ67 (Q4) and GER-5FPF + GER-5MRPR (Q5), CAPS markers for erucic acid loci is under progress.

Table 24: Total Glucosinolate content (µmole/g seed) range and Erucic acid (%) content range in F4 generation

	Total glucosinolate content (µmole/g defatted seed meal) range						Erucic acid content (%)				
F_4 generation	0-20	21-40	41-60	61-80	>100	Samples analysed	<2	2-10	11-20	>20%	Samples analysed
NRCHB101 x HEERA	1	34	82	35	59	211	48	42	20	9	119
NRCHB101 x RLC-3	6	33	84	70	63	256	14	23	23	17	77
DRMR150-35 x RLC-3	1	-	2	1	3	7	-	-	5	1	6
NRCDR-02 x RLC-3	-	3	4	1	-	8	1	2	2	-	5
NRCDR-02 x PDZ-1	-	-	2	2	4	8	2	1	-	-	3
DRMRIJ-31 x RLC-3	-	8	-	-	2	10	-	1	4	-	5
DRMRIJ-31 x PDZ-1	-	1	1	3	1	11	4	3	2	-	9

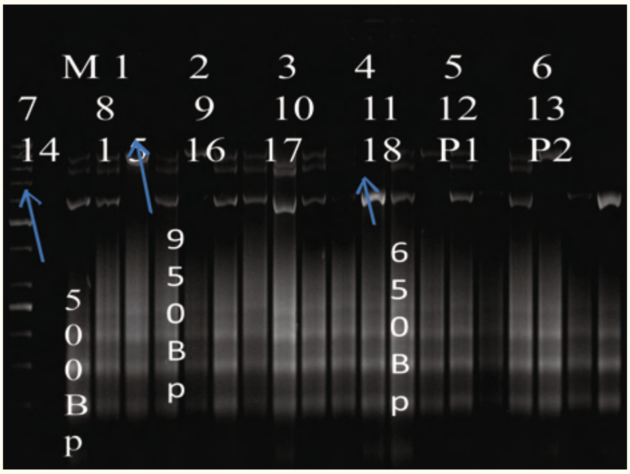


Fig. 21. Agarose gel showing Validation of markers linked to quality (Glucosinolate); GER-1MRPR+ IP3GER-1F (Q1) M-100bp ladder Plant No.1-18 BC_3F_2 (DRMR150-35XPDZ-1), P1-DRMR150-35, P2-PDZ-1.

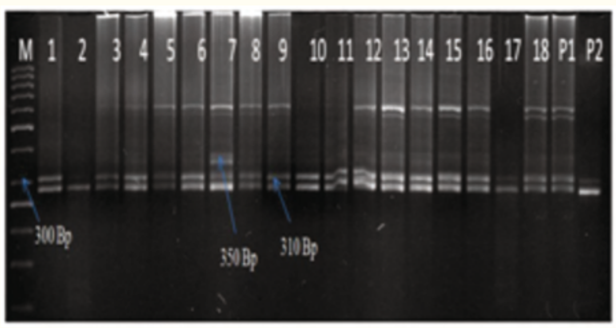


Fig. 22. Agarose gel showing Vealidation of markers linked to quality (Glucosinolate); GER-5FPF + GER-5MRPR (Q5) M-100bp ladder Plant No.1-18 BC_3F_2 (DRMR150-35XPDZ-1), P1-DRMR150-35,P2-PDZ-1

White Rust

White rust screening at offseason nursery in Wellington

Total 13 plants derived from backcross generations of DRMR-150-35xBioYSR,DRMR-150-35xBEC-144, DRMRIJ 31xDonskaja and NRCDR-02xDonskaja were found white rust resistant.

Foreground selection of BC_3F_2 using linked markers

Foreground selection of BC_3F_2using white rust resistant markers (At5g41560 and At2g36360) for the crosses DRMR-150-35xBioYSR, DRMR-150-35xBEC-144 and NRCHB101xBioYSR is under progress.

White rust screening at ICAR-DRMR

A total of 170 samples (BC_3F_2, BC_2F_4, $BC_3F_3$and BC_3F_5 generation) for white rust resistance screeningwere sown under late sown conditions at DRMR, Bharatpur for screening. Disease inoculums were sprayed regularly. Screening for white rust is under progress.

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)

96 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, were recorded.

DRMR EA-17: Creation of Seed-Hubs for enhancing quality seeds availability of major oilseed crops-rapeseed-mustard

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

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

Co-Investigator: Ram Lal, 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,Sriganganagar (SKRAU); RLBCAU, Jhansi; KVK, Mirzapur (BHU) and DKVK, Ramkrishna Mission, Saragachi, Murshidabad (WB). A total target of 5950 qt certified seed production was allotted to eight seed hub centres for 2019-20. A total budget of Rs.

60 lakhs were sanctioned to eight seed hub centres during the financial year 2019-20. Rs 7.5 lakhs for revolving fund was sanctioned to each seed hub centre. The breeder seed of Indian mustard improved varieties *i.e.* DRMRIJ-31, NRCHB101 and RH-749 was made available from ICAR-DRMR, Bharatpur to all centres as per their requirement. Timely effective monitoring of seed production programme was conducted under the guidance of Director, ICAR-DRMR.

DRMR EA-18: NEH component: Enhancement of rapeseed-mustard production in Tripura and Imphal

Principal Investigator: P.K. Rai, Director, ICAR-DRMR

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

A total 373 Frontline Demonstrations of rapeseed-mustard were conducted in an area of about 335.4 hectares in 5 clusters *i.e.* Imphal West District cluster I (132); Imphal East District cluster II (54); Bishnupur District cluster III (133); Kakching District cluster IV (43); Thoubal District cluster V (10) and Chandel district cluster VI (1) of Manipur region during 2019-20. The cluster demonstrations were conducted with the help of Central Agricultural University, Imphal, Manipur. Seeds of improved varieties NRCHB-101, TS-38, TS-46 and TS-67 were distributed to farmers for cluster demonstrations.

EEQ/2018/000003 (SERB Funded): Developing low cost sulphur fertilizers by using municipal solid waste for sustainable mustard production

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

Sulphur enriched MSW compost is being encouragingly used for sustainable production of oil seeds crops because S is an important component of proteins, vitamins, amino acids, and enzyme. The concentrationof total S (TS), water-soluble S (WSS), HCL extractable S and available S were significantly different in composts prepared through different byproduct of S with municipal solid waste (MSW). WSS varied from 4.6 to 5.9% of TS after 120 days of the composting period, whereas, available S varied from 14.5 - 8.6% of TS. At the end of 30 days of composting, total C ranged from 40.1 to 38.9%. Total C further decreased from 60 to 90 days of the composting over initial C content at 30 days of composting.The highest amount of NH_4^+-N was registered for S5 (1577 mg/kg) compost, followed by S3 (1484 mg/kg), at 30 days of the composting period.S enriched MSW compost had lower C/N, C/S ratio and higher nitrification index as well as phyto-toxicity, indicating that composts are well-matured and stabilized. Highest compost quality index(0.97) was recorded with compost prepared from organic waste + gypsum. Arylsulphatase activity significantly increased with compost maturity. The DHA values varied from 96.3 to 62.6 µTPF/g compost/h, significantly higher DHA had observed for S5 compost and the lowest being with S0 compost at the end of 90 days of composting.Results stated that all S enriched composts maintained higher amount of plant nutrients and quality indices, indicating that S enriched compost could be a possible substitute to costly chemical fertilizers.

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 Thakur, Senior Scientist (Biotechnology)

This project initiated in January, 2019. In the crop season 2019-20, 145 Indian mustard germplasm accessions belonging to Trait-specific Reference set for yield component traits was sown in the field for their phenotyping for nine yield component traits. Further, genomic-DNA had been extracted from the young leaves of all the accessions and genotyping work with SSR markers is in progress.

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

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

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

During 2019-20, 1215 FLDs on rapeseed-mustard and 7 trainings of extension officers/workers/ input dealers with a total budget outlay of Rs. 31.68 lakh were approved by Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture, Govt. of India for ICAR-DRMR. These FLDs were laid out by 26 cooperating centres of AICRPRM/ICAR institutes/ Ag. Universities in 57 districts across 15 states during rabi season of 2019-20. The results will be reported after harvesting crop. Besides conducting FLDs, seven trainingprogrammes will be organized by ICAR-DRMR and different cooperating centres during the Jan-Feb. 2020 for upgrading the knowledge and skills of grass root extension workers of States Department of Agriculture on research developments in the field of rapeseed-mustard.

Training programmes

Seven training programmes of two days each for extension workers were also approved under the FLDs. One training programme each was allotted to Kanpur, Varanasi, Morena, Kota and Sriganganagarcentres, while two training programmes were allotted to ICAR-DRMR.

3 Transfer of Technology

Beej Pakhwada

ICAR-DRMR's popular endeavour, 20th Beej Pakhwada was organized during Sept, 15 to Oct, 10, 2019 to sale the quality seeds of improved varieties namely DRMRIJ 31, NRCHB 101, RH-749 and NRCYS-05-02 to the rapeseed-mustard farmers. The seed were sold to farmers on the first come first serve basis. Record number of farmers from different states visited the Directorate during beej pakhwada and purchased seeds of different improved varieties of Indian mustard. Farmers were also provided counseling for situation specific varietal selection along with advise on scientific cultivation of rapeseed-mustard. A large quantity of seed of different varieties were also purchased by a number of Krishi Vigyan Kendras and Agriculture Universities this year for conducting frontline demonstration in their respective districts/ states across the country so that production potential of improved varieties can be shown farmers for their wide adoption in different agro climatic situations of the country. A total 895.95 q TL seeds of improved varietiesof Indian mustard were sold during *Beej Pakhwada*.

Training programmes organized

ICAR-DRMR organized 4 trainings and 3 exposure visit-cum-trainings programmes of 2 to 5 days each under ATMA/NGOs/KVKs/ APART/other schemes.

These trainings were organized for farmers during 26-30 August 2019 (30 participants) on "Scientific production technology of mustard and agriculture management", sponsored by PD ATMA, Dholpur (Raj.); and 2-6 Sept. 2019 (30 participants) and 3-7 Dec. 2019 (30 participants) on "Bee keeping and scientific production of mustard", sponsored by PD ATMA, Tonk (Raj.). One training programme of 5 days during 23-27 Sept. 2019 (34 participants) was organized on "Oilseed production Technology and its usefulness" for ATM/BTM/TA working in different districts of Uttar Pradesh, sponsored by State Institute of Agriculture Management, Rehamankheda, Lucknow (UP).

Three exposure visit-cum-training programmes during 11-13 Dec. 2019 on "Improved production technology of mustard" for 21 farmers from Latehar district of Jharkhand sponsored by Mobile Agricultural School & Services (MASS) under ATMA, Latehar (Jharkhand); 17-19 Dec. 2019 on "Addressing value chain of mustard under APART Project" for 19 agriculture officers sponsored by Department of Agriculture, Govt. of Assam under APART scheme and 30-31 Dec. 2019 on "Scientific production technology of mustard" for 21 OZONE FPO farmers from Sitapur (UP) sponsored by ROUTES and Krishi Vigyan Kendra-II, Sitapur (UP).

A total of 185 farmers, extension workers and officers were benefitted through these trainings and exposure programmes during the period April-Dec. 2019.

Mera Gaon Mera Gaurav Programme

The "Mera Gaon Mera Gaurav" (MGMG) programme has been actively taken up by ICAR-DRMR during April-Dec. 2019 to provide farmers with required information, knowledge and advisories on regular basis in adopted villages. Six interdisciplinary groups of five members comprising both, scientific and technical staff was constituted at ICAR-DRMR. Each group identified and adopted five villages in the vicinity of the institute and had conducted meetings with farmers of their respective villages before the start of mustard season. Thus, a total of 30 villages were adopted under MGMG programme by ICAR-DRMR during the period. The group members visited their respective adopted villages during different stages of farming operations to give necessary instructions. Benchmark reports were made about the farming, climate and social and economic conditions of selected villages. A total of 300 frontline demonstrations with different improved varieties viz. DRMRIJ 31, CS-60 and RH-725 were conducted in selected villages to show the production potential of these improved varieties at farmers' field along with other technological interventions like Sulphur application, Zinc application, seed treatment with Carbandazim to the farmers and extension workers. Regular visits to the adopted villages were done for interaction meeting with farmers, monitoring of FLDs, providing first hand solution of the problems faced by the farmers, etc.

Frontline Demonstrations (FLDs)

Frontline Demonstrations (FLDs) and other related activities on oilseeds during 2019-20 by DAC&FW (Oilseed Division), MoA & FW, (letter F. No. 1-2/2019/ oilseed/CA/ MoA & FW, DAC&FW dated 15th July 2019), ICAR-DRMR has been allocated 1215 FLDs to be conducted in 1215 acre area with a financial allocation of Rs. 29.16 Lakh. As per technical programme for FLDs finalized during 26th Annual Group Meeting of AICRP (R&M) held during August 3-5, 2019 at BAU, Kanke, Ranchi, Jharkhand and/or MoU, these FLDs were allotted and conducted by different AICRP-RM centres/Universities/Institutes in their respective jurisdiction areas during 2019-20 crop season.

Sarson Farm School

ATMA, Bharatpur, Department of Agriculture, Govt. of Rajasthan sponsored 25 Farm Schools (Mustard, Wheat and Gram) with a total budget

outlay of Rs..00 to be organized by ICAR-DRMR during the 2019-20 crop season in different villages of Bharatpur district of Rajasthan. However, ICAR-DRMR conducted following 32 Farm Schools successfully in different villages of 10 tehsils of Bharatpur district of Rajasthan during 2019-20. Seventeen farm schools on mustard in different villages of Roopwas (2), Bayana (2), Kama (2), Deeg (2), Kumher (2), Nagar (2), Nadbai (2), Sewar (1), Weir (1), Pahari (1) tehsils; 10 farm schools on wheat in different villages of Nadbai (3), Pahari (3), Kama (1), Deeg (1), Roopwas (1), Weir (1) tehsils and 5 farm schools on Gram in different villages of Sewar (2), Bayana (1), Weir (1), Roopwas (1) tehsils of Bharatpur district of Rajasthan were conducted.

"Sarson School on AIR" programme

To provide timely advise about various advanced production practices of rapeseed-mustard, enhance the knowledge and create confidence for adoption of improved technology among the farmers, an agreement was signed between ICAR-DRMR and AIR stations to broadcast Sarson School on AIR (Radio Krishi Shiksha Programme) through 11 All India Radio stations viz. Jaipur, Kota, Suratgarh, Alwar, Swai

Madhopur, Bikaner and Nagaur of Rajasthan and Mathura, Varanasi, Jhansi and Agra of Uttar Pradesh during Sept., 2019 to Feb., 2020. ICAR-DRMR's scientists, through this weekly radio programme communicated the scientific technology to the farmers and extension personnel of these states in 24 episodes.

Visitors Advisory Services of DRMR

Under Visitors Advisory Services, successfully organized/ coordinated interaction meetings and counselling sessions on rapeseed-mustard cultivation for 27 visiting groups of farmers and 11 groups of students from Rajasthan, Uttar Pradesh, Gujarat and Madhya Pradesh consisting of 1160 stakeholders including 638 farmers, 29 extension personnel, 458 students and 35 teachers. The visiting groups were educated/ trained through lectures, visits to Technology Park, experimental fields, museum and also provided literature. Besides, other visiting farmers were also provided timely technical advice to their problems in mustard cultivation.





4 Training and Capacity Building

4.1 Trainings

Topic	Venue	Duration	Participant
Management development programme on Priority setting, monitoring and evaluation of agricultural research projects.	ICAR-NAARM, Hyderabad	Jul. 18-23, 2019	Pankaj Sharma
Advanced statistical analysis of breeding data	ICAR-IASRI, New Delhi	Aug. 27 to Sept. 16, 2019	Priyamedha
CAFT Training on Next generation sequencing and its application to crop	New Delhi	Sept. 3-23, 2019	Ajay Kumar Thakur
Training programme on IP Strategy for startup and entrepreneurs	Yousufguda Institute Hyderabad.	Sept. 16-18, 2019	Bhagirath Ram

4.2 Participation in seminars, Symposia, Conference and Meetings

Workshop /National Seminar Attended	Venue	Duration	Participant
Joint Annual Group Meeting of 33rd AGM of AICRP-NSP & 14th ARM of ICAR Seed Project on Seed Production in Agricultural Crops	CCSHAU, Hisar	April 07-09, 2019	Bhagirath Ram
Brain Storming Session on National Mission on Edible Oils (NMEO)	ICAR-IIOR, Hyderabad	01-Jun-19	P.K. Rai
Annual Group Meeting of National Academy of Agricultural Sciences	NASC, New Delhi	June. 4-5, 2019	K.H. Singh
ZEARC meeting	ARS, (SKNAU) Navgaon, Alwar	06-Jun-19	Pankaj Sharma
Review meeting of CRP on Hybrid Technology	IARI, New Delhi	15-Jun-19	K.H. Singh
Rreview meeting of CRP-Molecular breeding	IARI, New Delhi	15-Jun-19	V.V. Singh
15th International Rapeseed congress	Berlin, Germany	June 16-19, 2019	Pankaj Sharma
Brainstorming on Translational Genomics for Agriculture	NASC Complex, New Delhi	02-Jul-19	P.K. Rai
15th International Congress on Advances in Natural Medicines, Nutraceuticals & Neurocognition organized by Conference Series llc LTD.	Berlin, Germany	July 08-09, 2019	Anubhuti Sharma
Brain Storming Session on "Technologies innovations and strategies for farmer's prosperity in Rajasthan"	NASC Complex, Pusa New Delhi	13-Jul-19	P.K. Rai Pankaj Sharma R.S. Jat

Meeting MoS MAFW	New Delhi	July,13, 2019	R.S. Jat
Oilseeds Seed Hub Review Workshop	IIOR, Hyderabad	July 19-20, 2019	P.K. Rai
26th Annual Group Meeting of AIRCP-RM	BAU, Ranchi	Aug. 3-5, 2019	P.K. Rai, V.V. Singh, K.H. Singh, Pankaj Sharma, O.P. Premi, P.D. Meena, A.K. Sharma, R.S. Jat, Bhagirath Ram, Arun Kumar, H.S. Meena, Ajay Kumar, H.K. Sharma, Priyamedha, M.L. Dotaniya
SAC meeting of KVK	Kumher, Bharatpur	Aug. 8, 2019.	V.V. Singh
Brain Storming Session on Speed Breeding	Indore	Aug. 25, 2019	K.H. Singh
Review meeting of CRP on Hybrid Technology- Mustard	IARI, New Delhi	Aug. 26, 2019	K.H. Singh
Review meeting of Incentivizing Research in Agriculture (IRA)	NASC, New Delhi	Sept. 09, 2019	V.V. Singh
Annual Conference & National Symposium on Microbial based strategies for improvement of soil and plant health	Karnataka University, Dharwad	Sept. 24-26, 2019	P.D. Meena
6th Review meeting of DUS test centers for Rabi cropsatus PPV&FRA	New Delhi	Sept. 26, 2019	Priyamedha
International Conference on Plant Genetics & genomics germplasm to genome engineering	NASC, New Delhi	Oct. 17-18, 2019	Bhagirath Ram
International conference on Global research for sustainable agriculture and allied sciences (GRISAAS-2019).	ICAR-NAARM, Hyderabad	Oct. 20-22, 2019.	Pankaj Sharma, H.K. Sharma, R.L. Choudhary
Farmer's – Scientist interaction video conferencing live streaming programme	NIC, Yojna Bhawan, Lucknow (UP)	Nov. 19, 2019	Bhagirath Ram
Brain storming meet on Incentivizing Research in Agriculture (IRA)	ICAR-NRRI, Cuttack	Nov. 27, 2019.	V.V. Singh
Third Global Meet (International Conference) on Science and technology for ensuring food and nutritional security	ICAR-NRCSS, Ajmer,	Dec. 1-3, 2019	P.K. Rai, Arun Kumar, H.S. Meena, H.K. Sharma
Seminar on Rabi crops	ZARS, Morena, M.P.	Dec. 07, 2019	P.K. Rai
International Conference on Innovation in Plant and animal science for sustainable agriculture and rural development (IPASSARD 2019)	RARI, Jaipur	Dec. 7-9, 2019	P.K. Rai, Pankaj Sharma, R.S. Jat

5 Awards and Recognitions

Dr. K.H. Singh received Best Scientist Award 2019, ICAR Directorate of Rapeseed Mustard Research, Bharatpur on 25th foundation day of ICAR-DRMR celebrated on 20th October 2019. Dr. K.H. Singh also recognized by Indian Society of Genetics and Plant Breeding for development of landmark Indian mustard variety “NRCHB 101”, on 25th August 2019 during Brain Storming session on Speed Breeding at Indore.

Dr. Pankaj Sharma participated in 15th International Rapeseed Congress, held at Berlin, Germany duringJune 16-19, 2019. He acted as Co-chairman of Sclerotinia workshop. Dr. Sharma received Outstanding achievement award by Astha Foundation during International Conference (GRISAAS-2019), held during Oct 20-22, 2019 at ICAR-NAARM, Hyderabad. Dr. Sharma got excellence in Research Award 2019 by National Agriculture Development Cooperative Ltd (NADCL), Srinagar, J&K in International Conference held at RARI, Jaipur during Dec 7-9, 2019. He also received best oral presentation award during the conference.

Dr. R.S. Jat, Pr. Scientist (Agronomy) received Fallow Award by the Society for Scientific Development in Agriculture & Technology, Meerut, U.P. in International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2019) held at ICAR-NAARM, Hyderabadduring 20-22 October, 2019.

Dr. Anubhuti Sharma Co-chaired the poster competition as judge in National conference on “Advances in Chemistry, Food Technology & Environmental Sciences towards sustainable development” organized by R.B.S. Engineering Technical College, Bichpuri, Agra during March 8-9, 2019. She also acted as Chairperson of one of the session in Conference.

Dr. H.K. Sharma, Scientist (Plant Breeding) received the Young scientist award in the field of Plant Breeding by the Society for Scientific Development in Agriculture & Technology in International GRISAAS-2019 held during October 20-22, 2019 at ICAR-NAARM, Hyderabad.

Dr. M.L. Dotaniya conferred Golden JUBILEE Commemoration Young Scientist Award-2019 by Indian Society of Soil Science, New Delhi in 84th annual convention of ISSS held at BHU, Varanasi during November 15-18, 2019.

Dr. R.L. Choudhary, Scientist (Agronomy) received Young scientist award and Outstanding/Best thesis award in the field of Agronomy by the Society for Scientific Development in Agriculture & Technology GRISAAS-2019,held during October 20-22, 2019 at ICAR-NAARM, Hyderabad.

6 Linkages and Coordination

Farmer's training programme

A two days farmer's training programme on "Rapeseed-Mustard Seed Production Technology" was held at ICAR-DRMR, Bharatpur during December 19-20, 2019 under ICAR seed project by involving 32 farmers from 20 adopted villages of Bharatpur under MGMG. Training included theory and practical sessions/exposures on scientific cultivation of rapeseed-mustard, introduction of rapeseed-mustard crops and seed production techniques, selection of suitable varieties of rapeseed-mustard, 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 at ICAR-DRMR.

7 All India Coordinated Research Project on Rapeseed-Mustard

26th Annual group meeting of All India Coordinated Research Project on Rapeseed-Mustard was held at Birsa Agricultural University Ranchi from August 3-5, 2019. The inaugural session started with 'Kulgeet' of Birsa Agriculture University, and ICAR song followed by the welcome speech by Dr. D.N. Singh, Director (Research), BAU, Ranchi. He welcomed all delegates and participants of annual group meeting and gave an overview of green revolution era, which transformed India from food deficit to surplus position. Similar increase in oilseed productivity can be achieved by making the oilseed farming more remunerative in oilseed production, capturing rice-fallow area under rapeseed mustard cultivation. Shri A.K. Singh, Member of Governing Body, ICAR raised his concern about import of edible oil with worth of Rs.75000 crores each year. He stressed upon the need of reducing the import of edible oil and enhancing the farmers income through the technological interventions. He further emphasized that rapeseed mustard can be a good option for increasing the yield and farmers income along with bee keeping and animal husbandry. Dr. S.K. Jha, ADG (Oilseeds & Pulses) expressed his satisfaction over the rise in productivity during the last 30 years, the productivity has tripled in rapeseed mustard. He expressed his concern that area has not increased in rapeseed-mustard during the last 3 five year plans. He also emphasized to popularize this important crop in non-traditional areas and increase in productivity of those states where average productivity is lesser than national average. Dr. P.K. Rai, Director, ICAR-DRMR, Bharatpur, presented the research highlights, global and National scenario of rapeseed mustard area, production and productivity as well as area, production and productivity in Jharkhand state. He also presented the action taken report. He informed that the overall seasonal weather conditions during the year 2018-19 across the rapeseed mustard production zones were normal and favorable for crop growth and development. He mentioned that 158 strains including 10 of toria, 5 of yellow sarson, 132 of Indian mustard, 10 of gobhi sarson, and 1 of taramira were tested in 35 performance evaluation trials at 46 locations across the 6 agro-climatic zones. Dr. Rai informed that 256.32 q of breeder seed of 61 rapeseed mustard varieties against the DAC indent of 84.76 q was produced indicating a surplus availability of 171.61 q. In agronomic trials the crop responded up to 150% RDF in the long term experiment. He appraised the house that in total 2080 FLDs were conducted in 67 districts across 14 States during the last year. Prof. S.S. Banga, National Professor, PAU, Ludhiana expressed satisfaction on the work done by the Scientists in the rapeseed mustard field as the productivity of Haryana has increased up to 2 t/ha. Further he emphasized on the need of science based selections and breeding of elite rapeseed mustard lines. He also emphasized upon the novel breeding techniques such as genome sequencing and MAS in rapeseed mustard improvement. He showed his concern over the narrow genetic base and the genetic duplicates in the development of rapeseed mustard varieties. Dr. R.S. Kureel, VC, BAU, Ranchi gave a brief account of the research and development in oilseeds at BAU. He emphasized that India is importing 15 mt edible oils which is third largest imported commodity after petroleum products and gold. The MSP and import-export policy need to be relooked to increase the area and production in rapeseed mustard. A quality control and quality research must be emphasized. Dr. Z.A. Haider, Chairman Dept. Plant Breeding and Genetics presented the vote of thanks to the Chair, delegates,University authorities and media persons.

Inaugural session followed by presentation of annual progress report of different disciplines by respective PIs. Dr. K.H. Singh, PI, Plant Breeding & Genetics presented the highlights of the plant breeding programme. A total of 6605 accessions were maintained through appropriate mating system. Fourty four new accessions were collected and 849 accessions were evaluated. On the basis of germplasm evaluation promising donors were identified for different traits, with a view to improve seed yield, earliness, seed size, disease/pest resistance, high temperature tolerance, quality and high oil content. In total 946 crosses were attempted in Indian mustard along with 80 crosses in toria and 36 crosses in yellow sarson. Two mapping populations were advanced for mapping of genes/QTLs for drought tolerance and high oil content. A total of 849 advanced breeding lines including 107 of toria, 47 of yellow sarson and 662 of Indian mustard, 22 of gobhi sarson and 11 of taramira were evaluated. In Indian mustard 7081 single plants were selected for different traits. In evaluation trials a total of 153 strains consisting of toria (10) yellow sarson (5), gobhi sarson (10), taramira (1) and Indian mustard (127) were evaluated at 46 locations across the 6 agro-climatic zones of the country. On the basis of superiority for seed/oil yield/earliness/quality over best check, 32 strains comprising toria (01), gobhi sarson (07) and Indian mustard (24) were promoted for advanced stage evaluation. Dr. A. K. Pradhan emphasized that results and recommendations should come from evaluation of germplasm so it can be further used for breeding purpose.

Dr. O.P. Premi, PI, Agronomy presented progress report of Agronomy. Six experiments on various crop production aspects of rapeseed-mustard were conducted at 23 cooperating centres across 5 zones. In long term fertility experiments on 8th year, crop responded up to 50% higher dose of NPK in Zone I & V and balanced fertilizer application with supplementary use of fertilizers and manures in zone II, III and V. In agronomic evaluation of promising entries, under saline/alkaline conditions, entry CS 508-1P2 produced 6.9 % higher seed yield than the best check at Karnal centre only. Among different cropping systems green gram-mustard system gave higher seed yield of mustard in Chata, Pantnagar and Morena. On an average, raised bed technique recorded 17.2 and 26.9 % higher seed yield of mustard over conventional and zero tillage practice, respectively. The house expressed concern over infestation of *Orobanche* in Haryana and Rajasthan states.

Dr. Pushp Sharma, PI, Plant Physiology reported that five experiments were conducted to evaluate mustard genotypes from different agro-climatic zones to abiotic stresses while sixth experiment was conducted at three locations to test efficacy of PGR's under rainfed condition. Thirty seven genotypes of Indian mustard (*B. juncea*) were tested for high temperature tolerance at seedling stage both under field and laboratory conditions. In both field and laboratory condition, two genotypes PM 25 and PM 29 showed tolerance to high temperature at seedling stage. DRMR 2059 was thermo tolerant at seedling and terminal stage. RH 749 holds promise for low light and heat stress. Foliar spray of brassinolide @20 ppm and salicylic acid @200 ppm at Hissar, Kanpur and Ludhiana centers improved seed yield under rainfed condition.

Dr. P.D. Meena, PI, Plant Pathology presented the results of experiments and informed that disease pressure was moderate during the season. He also reported promising resistant/ tolerant sources against various diseases. In Screening of *Brassica* germplasm and breeding materials, 71J0002 of *B. juncea* was found resistant to WR at all six locations. Under Uniform Disease Nursery for major diseases, many genotypes of *B. juncea* showed resistance to WR over the years may be screened in vitro before recommendation for use in the breeding program. Genotype DRMR 2018-44 of *B. juncea* was reported tolerant to SR at 5 locations. In National disease nursery (NDN) for WR, DRMRMJA 35, DRMRIJ 12-26, DRMRIJ 12-39, PDZ-3 of *B. juncea* showed immune reaction to WR at three locations. In NDN for Sclerotinia rot, DRMRSJ-25 and DRMRSJ-22 of *B. juncea* showed resistant reaction to white rust. Under integrated management, 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, no irrigation during 25th Dec to 15th Jan was the best in minimizing AB, WR, DM, PM, SR disease as per first year data.

Dr. A. K. Pradhan suggested that WR resistant sources should be tested in lab and field for allelic relations and to identify any independent loci for white rust resistance. Dr. Archana Anokhe, presented the highlights of entomology and reported that moderate to high population development of mustard aphid on different Brassica species. She also reported some promising entries, which showed resistance/ tolerance to mustard aphid. Losses in seed yield due to insect-pests ranged from as low as 1.8 to as high as 60.9%. Mustard aphid remained active from 6th to 13th SMW with peak during 7th and 11th SMW. Low to moderate population of painted bug (0.7-6.5 bugs/ mrl) was observed from 44^{th} – 47^{th} SMW in the bio-intensive IPM module experiment, although dimethoate 30 EC @ 1 ml/l was the best treatment, spray of azadirachtin 3000 ppm @ 5 ml/l effectively controlled the aphid population and has the potential to be incorporated as 1st spray against aphid whenever population crosses economic threshold level. Among new molecules tested, all were found effective in controlling the mustard aphid population, but among all clothianidine 50 WDG @ 0.12 g/l, thiamethoxam 25 WG @ 0.2 g/l and imidacloprid 17.8 SL @ 0.25 ml/l were more effective compared to dimethoate 30 EC @ 1 ml/l and acetamiprid 20 SP @ 0.1 g/l.

Dr. Anubhuti Sharma, PI, Biochemistry, presented the highlights and reported that important breeding materials and IVT/AVT quality entries were evaluated at different centres. Among the 15 genotypes analyzed, the oil content ranged from 40.88% in DRMRQ1-16-27 to 35.73% in LES 59. Oil stability index which is the ratio of MUFA: PUFA ranged from 0.65 in RH-749 to 1.31 for RLC-7. DRMRQ 4-7-23, PDZ 11, PDZ 12, LES 54, LES-57, LES 58, LES 59, RLC 8, RCH 3, RLC 7 and RLC 9 had < 2% erucic acid content. Total protein content ranged from 32.59% (7IJ0002) to 35.92% (LES-58). Total phenol content ranged from 3.47% (PM-29) to 5.16% (DRMRQ 1-16-27). Phytic acid content < 2% was reported in RCH-3, PM-29, RCH-1, DRMRQ 1-16-27. Total glucosinolate content < 30 micro mol per gram of defatted seed meal was reported in RLC 8, RCH 3, RLC 10, RLC 7, RCH 1, DRMRQ 4-7-23, PDZ 11, PDZ 12, DRMRQ 1-16-27, PDZ 1, 7IJ0002, RLC 3 and RLC 9. β-carotene content > 5 ppm reported in RLC 10, RH (OE) 1705, PM-29, Kranti and 7IJ0002. Tocopherol content was >160 mg/100g seed in 7I J0002, PDZ 1, DRMRQ 4-7-23, DRMRQ 1-16-27 and Kranti.

In FLDs session, PI, Dr. Ashok Kumar Sharma Pr. Scientist, (Ag Extension), presented the results of 2080 frontline demonstrations (FLDs) on rapeseed-mustard conducted in 67 districts across 14 states during 2018-19. He reported that Rajasthan had maximum FLDs (533) followed by Manipur (450), Assam (320), Uttar Pradesh (236) and Madhya Pradesh (129). All the demonstrations were conducted under whole package demonstrations in two different situations viz., irrigated (1129) and rainfed (951). The maximum average yield of 2,754 kg/ha from the IP under irrigated conditions was in Haryana followed by Rajasthan (2,443 kg/ha); Punjab (2,093 kg/ha); Gujarat (1,999 kg/ha) and Madhya Pradesh (1,858 kg/ha). 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. More than 160 scientists/ personnel associated with rapeseed-mustard research and development in the country participated in this meeting. With the plenary session chaired by Dr. D. K. Yadava, ADG (Seeds) ICAR, the meeting was successfully concluded on 5^{th} August 2019.

8 Publications

8.1 Research Papers

1. Jat, R.S. and Choudhary, M. (2019). Nitrogen utilization efficiency variability in genotypes of Indian mustard (*Brassica juncea*) under contrasting N supply. *Journal of Plant Nutrition*. 42 (19): 2435–2446.

2. Kaur, R., Sharma, A.K, Rani, R., Mawlong, I. and Rai, P.K. (2019). Medicinal qualities of mustard oil and its role in human health against chronic diseases: A Review. *Asian Journal of Dairy and Food Research*, 38 (2):98-104.

3. Kumari, S., Singh, H. V., Jat, R. S., Yadav, G. L., Dotaniya, M. L. and Choudhary, R. L. (2019). Impact of transplanting on productivity and profitability of Indian mustard: A pilot study. *International Journal of Current Microbiology & Applied Science*. 8(9): 1658-1665.

4. Mawlong, I., M.S., Sujith Kumar, Kandpal, B.K., Premi, O.P. and Gurung, B.(2019) A comparative study of C-allocation to seed storage compounds among genotypes of Indian mustard under N fertilization. *Plant Physiology Reports* 1-11.

5. Mawlong, I., M.S., Sujith Kumar; Kandpal, B.K., Premi, O.P., Joshi, A. and Gurung, B. (2018). Comparing oil color and oxidative stability among mustard genotypes under nitrogen fertilization. *Agronomy Journal* doi:10.2134/agronj2018.03.0212.

6. Meena, M., Singh, H. V., Jat, R. S., Yadav, G. L., Dotaniya, M. L., Meena, M.D., Choudhary, R. L. and Meena, M.K. (2019). Economics and yield affected by herbal extracts in Indian mustard (*Brassica juncea* L.). *International Journal of Current Microbiology & Applied Science*. 8 (12):628-633.

7. Meena, P.D., Gupta, R., Sharma, P., Rai, P.K., Meena, H.S., Singh, S.K. (2019). Isolation and characterization of a new fungal species, *Fusariumequiseti* (Corda) Sacc., from *Brassica juncea* in Bharatpur. *Journal Oilseed Brassica* 10(2): 130-133.

8. Meena, P.D., Mehta, N., Rai, P.K. and Saharan, G.S. (2019). Geographical distribution of rapeseed-mustard powdery mildew disease in India. *Journal of Mycology and Plant Pathology*. 48: 60-79.

9. Sharma, A., Aacharya, M., Punetha, H., Sharma, S., Kumari, N. and Rai, P.K. (2019). Biochemical characterization and correlations in *Brassica juncea* genotypes. *International Journal of Current Microbiology and Applied Science* 8(1): 2408-2417. https://doi.org/10.20546/ijcmas.2019.801.254

10. Singh, H, Choudhary, R.L., Meena, M.D., Dotaniya, M.L., Meena, M.K., Jat, R.S., Premi, O.P. and Rai, P.K. (2019). Productivity enhancement of Indian mustard (*Brassica juncea*) through innovative crop establishment technique. *Indian Journal of Agricultural Sciences*. 89 (10): 1669–73.

11. Singh, H., Meena, M.K., Choudhary, R.L Dotaniya, M.L., Meena, M.D., Jat, R.S., Premi, O.P. and Rai, P.K. (2019). Effect of direct sowing and transplanting on yield performance of Indian mustard. *International Journal of Current Microbiology & Applied Science*. 8(2): 509-515.

12. Singh, V.V., Mawlong, I., Dubey, M., Paliwal, P. and M.S.Sujith Kumar (2018). Variability in total glucosinolate content in F_2 generation of *B.juncea* and their molecular validation. *International Journal of Current Microbiology and Applied Science* 7(12):3346-3357.

13. Singh, V.V., Priyamedha, Sharma P, Dubey, M., Paliwal, P., Garg, P., Rani, R. and Rai, P.K. (2019). Molecular characterization of oilseed Brassica referance set for stem rot disease. *Indian Journal of Plant Genetic Resources*. 32 (1): 85-92.

14. Thakur, A.K., Singh, K.H., Sharma, D., Parmar, N. and Nanjundan J. (2019). Breeding and genomics interventions in Ethiopian mustard (*Brassica carinata* A.

Braun) improvement – A mini review. *South African Journal of Botany*. 125: 457-464.

15. Verma, A., Sharma, A., Rai, P.K. and Kumar, D. (2019). Effect of microwave pretreatment on quality parameters in Indian mustard. *Journal of Pharmacognosy and Phytochemistry*. 8(4): 1134-1137.

16. Verma, A., Sharma, A., Rai, P.K. (2019). Effect of microwave pre-treatment on quality parameters in Indian mustard.*Journal of Food Science & technology*. 56: 4956–4965. https://doi.org/10.1007/s13197-019-03967-4.

8.2 Book Chapter

1. Dotaniya ML, Dotaniya CK, Solanki Praveen, Meena VS, Meena MD, Choudhary RL (2019) Microbial resources in management of C sequestration, greenhouse gases, and bioremediation processes. In: Singh JS (ed) New and future developments in microbial biotechnology and bioengineering. Elsevier, US, pp. 77-92 DOI: https://doi.org/10.1016/B978-0-12-818258-1.00005-4

2. Dotaniya ML, Meena VD, Meena BL (2019) Use of wastewater for sustainable agriculture. In: Sustainable agriculture (Meena RS, Ed), Scientific Publishers (India), pp. 71-87.

3. Dotaniya ML, Kumar K, Meena MD, Dotaniya CK, Solanki P, Doutaniya RK (2019) Use of composts in problematic soils and agro-ecosystems. In: Choudhary AK, Dhar S, Dass A (Eds), Advances in compost production technology. IARI, New Delhi, pp 95.

4. Dotaniya ML, Aparna K, Choudhary J, Dotaniya CK, Solanki P, Narwal E, Kumar K, Doutaniya RK, Lal R, Meena BL, Lata M, Singh M, Singh U (2020) Effect of soil pollution on soil microbial diversity. In: Nayak SK, Mishra SK (Ed), Frontiers in Soil and Environmental Microbiology. CRC Press, New York, pp 255-272.

5. Solanki P, Dotaniya ML, Khanna N,Udayakumar S, Meena SS, Narayan M, Srivastava RK,Dotaniya CK, Meena VS, Meena MD, Choudhary RL (2019) Phycoremediation of industrial effluents contaminated soils. In: Singh JS (ed) New and future developments in microbial biotechnology and bioengineering. Elsevier, US, pp. 245-258 DOI: https:// /doi.org/10.1016/B978-0-12-818258-1.00016-9

6. Kumawat NK, Kumar R, Khandkar UR, Yadav RK, Saurabh K, Mishra JS, Dotaniya ML, Hans H (2019)Silicon (Si)-and zinc (Zn)-solubilizing microorganisms: role in sustainable agriculture. In: Biofertilizers for sustainable agriculture and environment (Giri B, Peasad R, Wu QS, Verma A, Eds), Springer international, pp 109-135

7. Meena BL, Raja R, Dotaniya ML, Meena RS (2019) Integrated nutrient management for sustainable rice-based cropping systems and soil quality. In: Sustainable agriculture (Meena RS, Ed), Scientific Publishers (India), pp. 1-12.

8. Lakaria BL, Dotaniya ML, Meena BP, Wanjari RH, Biswas AK (2019) Soil health: concept, components, management and opportunities. In: Choudhary AK, Dhar S, Dass A (Eds), Advances in compost production technology. IARI, New Delhi, pp 95.

9. Sharma Anubhuti, Garg Meghna,Rai PK, (2019) Major seed oils and their significance Glucosinolates: Discovery publishing House, New Delhi pp.

10. *Singh H., Choudhary R.L., Meena M.D., Dotaniya M.L., Meena M.K., NarjaryB.*(2019) Profitable rapeseed-mustard cultivation in changing climatic scenario. https://www.scribd.com/document/420623176/Mustard Epublication Final?secret_password=RQK3EzVAb6Z4mVLp5UEF

11. *Singh H., Dotaniya M.L., Meena M.D., Choudhary R.L., Meena M.K. (2019)* Green Seeker: A Modern tool for N Application. *Biomolecule Reports- An International Newsletter*. BR/08/19/05:1-5

12. Gupta, N.C., Mahesh Rao, Pankaj Sharma. (2019). The necrotrophic pathogen *Sclerotiniasclerotiorum* and its management in oilseed Brassica. Adaptive Crop Protection Management Strategies Editors: D. Prasad, Gopal Lal and Imtiyaz Ahmad ISBN: 978-93-88317-08-5 Write and Print Publications, New Delhi. pp. 173-186.

8.3 Folders

1. Dotaniya ML, Meena MD, Sharma AK, Rai PK (2019) Role of soil carbon in mustard production, published by ICAR-DRMR, Bharatpur.
2. Meena MK, Dotaniya ML, Meena MD, Rai PK (2020) Role of vermicomposting in organic farming, published by ICAR-DRMR, Bharatpur.
3. Sharma H.K., Sharma P., Singh V.V., Kak A., Priyamedha, Kumar A., Meena H.S., Rai P.K. 2019. Rapeseed-mustard: Status of trait specific germplasm registration. Technical folder 3/2019.
4. हरिओम कुमार शर्मा, पंकज शर्मा, वी वी सिंह, पी के राय. 2019. राई सरसों की उन्नत किस्में, तकनीकी फोल्डर. 4/2019.

9 Research Programmes and Project

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-7	Ibandalin Mawlong
Screening of oilseed Brassica germplasm for value addition	DRMR B-8	M.S. Sujith Kumar
Quantitative and qualitative estimation of glucosinolates and fatty acids in oilseed Brassica	DRMR B-9	Anubhuti Sharma
Programme 3. Breeding for yield and quality enhancement in rapeseed-mustard		**K. H. Singh**
Development of hybrids in Indian mustard (*Brassica juncea*)	DRMR CI-5	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 Thakur**
Biotechnological interventions for development of Orobanche tolerance in Indian mustard (*Brassica juncea* L.)	DRMR BT-5	Reema Rani
Enhancing the repertoire of microsatellite markers for genomics interventions in Indian mustard (*Brassica juncea* L. Czern. & Coss) crop improvement	DRMR BT-7	Ajay Thakur
Development of *Orobanche* tolerance in Indian mustard	DRMR BT-8	Prashant Yadav
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-6	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	Mukesh 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
Yield maximization through best crop management strategies in mustard based cropping systems	DRMR CP-20	Harvir Singh
Climate smart agro-techniques for enhancing water productivity of mustard based cropping systems under moisture stress	DRMR CP-21	R.L. Choudhary
Management of poor quality water for sustainable mustard production	DRMR CP-22	M.L. Dotaniya
Programme 7. Management of biotic stresses in India mustard		**P.K. Rai**
Managements of Sclerotinia rot in rapeseed-mustard	DRMR PP-1	Pankaj Sharma
Epidemiology and managements of White rust	DRMR PP-5	P.K. Rai
Management of collar rot caused by *Sclerotium rolfsi* rapeseed-mustard crops	DRMR PP-6	P.D. Meena
Morphological, biochemical and molecular basis of host resistance in Brassica–Alternaria Interaction	DRMR PP-7	P.D. Meena
Programme 8. Technology assessment and dissemination		**A.K. Sharma**
Participatory extension for dissemination of rapeseed-mustard technology	DRMR TAD-4	A.K. Sharma
Development of application software for rapeseed-mustard information management	DRMR CA-1	Vinod Kumar

9.2 Externally Funded Projects

Name of project	Project code	PI/Leader
Characterization of rapeseed-mustard varieties for distinctness uniformity and stability (DUS) testing	DRMR EA-2	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	DAC &FW, GOI	P.K. Rai
Genome wide association mapping for yield contributing traits in Indian mustard (*Brassica juncea* L. Czern. & Coss)	SR/WOS-A/LS-84/2017	N. Parmar
Garmin Krishi Mausam Sewa	DRMR EA-8	O.P. Premi
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
NEH component: Enhancement of rapeseed-mustard production in Tripura and Imphal	DRMR EA-18	P.K. Rai
Newton Bhabha UK- India Pulses and Oilseed Research Initiative (PORI), Funded by BBSRC, Govt. of UK and DBT, MoST, GoI	DRMR EA-19	P.K. Rai
Developing low cost sulphur fertilizers by using municipal solid waste for sustainable mustard production, Funded by SERB	EEQ/2018/000003	M.D. Meena

10 Institute Research Council

ICAR-DRMR organized its 29th Institute Research Council (IRC) meeting during October 4-5, 2019 under the Chairmanship of Director of the institute. Scientists presented progress of their project work during year 2018-19 and proposed technical program for the year 2019-20.

The Chairman called for strengthening inter-disciplinary linkages and to make all out efforts for research development in rapeseed-mustard for achieving self-sufficiency in oil seeds. The chairman suggested using resources judiciously. PI of the project should take care of all the issues raised by IRC and work of Co-PIs should be justified. The chairman expressed his concern that there was no proposal for varieties identification this year. However, some good materials are in pipeline. The possibility should be explored for seed production and hybrid experimentation at farmers' field or other institute, he added. The chairman suggested for complying the recommendations of the RAC/QRT/Council. The IRC expressed satisfaction on the progress made under various projects during 2018-19 and approved the technical program for 2019-20 with given modifications/observation.

11 Scheduled Tribe Component and Scheduled Caste Sub-Plan

Scheduled Tribe Component (erstwhile TSP)

ICAR-DRMR signed MoU with ICAR-Agricultural Technology Application Research Institute, Patna, Bihar with a total budget outlay of Rs. for a collaborative project "Augmenting Rapeseed-Mustard Production of Tribal Farmers of Jharkhand state for Sustainable Livelihood Security under Schedule Tribe component (Erstwhile TSP)" for implementation in Jharkhand state during 2019-20. As per the MoU, it was decided that ICAR-ATARI, Patna will be Nodal implementing centre of the STC programme of ICAR-DRMR. The programme will be implemented in East Singhbhumi, West Singhbhumi, Ranchi and Gumla district of Jharkhand through respective Krishi Vigyan Kendras under the direct supervision of ATARI, Patna and ICAR-DRMR, Bharatpur (Raj.).

The activities of conducting Front line demonstrations, organizing institutional trainings, exposure visits, awareness camp/ field days/ Kisandiwas / gosthi / on farm trainings, local farmer's fair, distribution of Storage bins, small farm implements like, Gruber, Wheal hoe, Dutch hoe, sprayer, etc. are being carried out by respective KVKs under the programme.

Scheduled Caste Sub Plan (SCSP)

Under ICAR Scheduled Caste Sub Plan, ICAR-DRMR, Bharatpur organized eight one day training at ICAR-DRMR Bharatpur to enhance mustard production and farm income, climate change and crop production, soil organic C management, water and nutrient use efficiency, mustard crop yield, soil health management, sustainable agriculture. In this sequence, two trainings were conducted at KVK Kumher on dissemination of scientific research to farmers for boosting farm income by mediating mustard crop yield. In addition, training also conducted on scientific rearing of goat at ICAR-CIRG Mathura to enhance livelihood sustainability of marginal and small SC farmers. In these training programmes quality seed, fertilizers sickle, sprayer, training kit and literature were distributed and more than 543 SC farmers were benefited. Under this scheme total Rs. 36.87 lakhs was utilized for the welfare of farmers and enhancing the farm income.

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

On Farm Trials

Nine technologies were assessed through 110on farm trials at different locations onpopularization of newly released high yielding wheat variety (HD-3086), integrated management of chickpea wilt complex, lower productivity and profitability in cotton due to imbalanced application of nutrient, assessment of plant spacing on growth and yield of cauliflower, low productivity of onion due to injudicious use of potassium and sulphur fertilizers, shoot and fruit borer management in brinjal, assessment of effect of probiotic on milk production, effect of Azolla on milk production in goat and low milk production in buffalo.

Front Line Demonstrations (FLDs)

A total 207 FLDs were conducted at farmer's field covering 207hectare area in different villages of Bansur Tehsil of Alwar District.During Kharif season, 20 FLDs were conducted under NFSM pulses on green gram with 45 farmers. In Rabi 2019, total 60 FLDs were conducted on chickpea benefitting 101 farmers. Under NFSM oilseeds, 60 FLDs were conducted on sesame while in Rabi, 50 FLDs of mustard conducted at 86 farmers' field. 14 FLDs were conducted in vegetables and fruits at 70 farmers' field. The 48 component FLDs were also conducted in pearl millet, groundnut, mustard, cotton at 103 farmers' field.

Trainings

Krishi Vigyan Kendra, Bansur conducted 70 trainings on different need based subjects in all disciplines including 58 On and Off campus trainings,05 extension functionaries and 07 sponsored trainings, which benefited 1665 farmers and farm women, 109 rural youths, 94 extension functionaries and 202 sponsored farmers.

Extension activities

To popularize the technologies, 10 field days on different crops in different villages were organized among434benefitting farmers, farm women, extension functionaries and rural youths.Apart fromfield days,08 Kisan Gosthies on different topics tobenefit 289 farmers,12 exhibitions were displayed in different events for farmers, 77 scientist visits to farmers fields, 189 advisory services to14275 farmers, farm women and rural youths,28 film shows were shown to 647farmers,08 self-help groups to benefit 160 farmers farm women and rural youths, 37 diagnostic visits to benefit 149 farmers, , 02 plant animal health camps to benefit 71 farmers, 10 method demonstrations to benefit 65 farmers, 01 exposure visit to benefit 70 farmers, 22 special day celebrations to benefit 982 farmers, 03 kisan melaand 06 important days celebration were organized by the KVK.

Seed Sale

During rabi-2019-20, 1312kgmustard seeds was sold to 506 farmers by the KVK.

Swachh Bharat Abhiyan

The Swatch Bharat Abhiyan was launched by Hon'ble Prime Minister of India on 2014 with a dream of a “Clean India”.KVK (ICAR-DRMR),

Gunta-Bansur observed the Swachh Bharat Abhiyanduring 15-30September, 2019 with 460 participants. During this period,

KVK staffs participated in the cleaning of the KVK premises. During the Abhiyanthe villagers and students were also motivated through awareness rallies and cleaning campaigning in school campus.

Jal Shakti Abhiyan Mela

Krishi Vigyan Kendra, Gunta-Bansur, Alwar-II organized a Jal Shakti Abhiyan Mela on 03rd September 2019 andon 02nd October 2019 with an aim to creating the awareness about the acute shortage of water and the need to develop and rejuvenate water harvesting structures and the use of surface water to reduce ground–water exploitation among the farmers of Gunta and Ramnagar villages and also among the farmers of Behror and Neemrana Tehsils. KVK also conducted JSA campaign with school students to emphasize the need for "water conservation" and "changing climatic situation". Afarmers–scientists interaction programme was also conducted tounderstand the perspective of the farmers and to provide them with appropriate solutions to water problem. Over 1000 farmers and students took participation to make the campaign successful.

World Soil Day

World Soil Day was celebrated on 5th December, 2019 at KVK (ICAR-DRMR), Gunta-Bansur. The programme was successfully organized to create awareness about the importance of soil health for sustaining agriculture production and productivity. The main objective of this programme was to make awareness among farmers about the importance of healthy soil and eco-friendly methods of soil management.

Mahila Kisan Divas

MahilaKisan Divas was celebrated at Ramnagar village on 15th Oct, 2019 with 92 participants. A programme was organized to aware the farm women about their rights and facilities available for them to take benefits and improve livelihood. All staff members with Sr. Scientist and Head of KVK participated and delivered lectures on different aspects related to farm women and a quiz related to agricultural aspects was also organized and prize distributed to first, second and third best participants.

Animal Health Campaign

Two Animal Health Camps were organized in the Mehanpur and Daulat Singh Ki Dhani villages. The animals were examined by Dr. A.K Verma, SMS, Animal Science and course of treatment was suggested along with treatment of some cases. Among more than 205 livestock examined, the most common problems were ticks and internal parasites followed by diarrhea, poor health, repeat breeding, prolapse, worm infestation and infertility. The farmers were advised to do routine deworming and vaccination along with feeding of the supplemented mineral-vitamin mixture to improve their body nutrient status and overall health. The farm families showed their active participation in the programme for ensuring their livestock health and productivity.

National Foot and Mouth Disease Programme

On the occasion of the launch of National Animal Disease Control Programme (NADCP) for FMD and Brucellosis and National Artificial Insemination Programme(NAIP) by Hon'ble Prime Minister on 11-09-2019 in Mathura, Uttar Pradesh, an elaborative programme was planned to kick start NADCP and NAIP, making animal diseases free India and genetic upgradation of indigenous cows. The live webcast was shown to the farmers. In this programme 95 farmers and two State Animal Husbandry department officials were present along with all KVK, staff. After webcast of the programme, 28 animals were vaccinated against FMD and Brucellosis disease in a nearby village Ramnagar.

M-Kisan Advisory

Through M-Kisan portal, KVK, Gunta-Bansur send total 244 messages in Hindi language on different topics to 192798 farmers in the area.

Other extension programme

11popular articles on different subjects, 01 technical bulletin, 04 extension literature, 08 radio talks,24 TV talks, 22 newspaper coverage, 02 animal health camps were organized by the KVK.

Seed production

In Rabi 2018-19 mustard seed 21.1 q was produced and a revenue of Rs. 77,590/- was generated.

Units established at KVK

Azolla and vermin–compost units were

established at KVK during 2019.

Fertilizer Awareness Week

KVK, Gunta, Bansur organized a Fertilizer Awareness Week on 22nd October, 2019 in which 203 farmers participated.

Storage Development & Regulatory Awareness & Training Programme

Storage Development & Regulatory Awareness & Training Programmesponsored by NIAM was conducted by KVK Gunta Bansur on 17th August 2019 in which 50 farmers participated.

Farmers-Scientists interaction: KVK conducted a farmers–scientists interaction meeting during 22–23 July 2019 in which 28 farmers participated. The aim of the programme was to have a good dialogue among KVK Scientist and Farmers regarding Kharif crops.

Rural Agricultural Work Experience (RAWE) Programme

In this programme 15 students participated from Pacific College of Agriculture, Pacific Academy of Higher Education & Research University, Udaipurbetween 15th July 2019 to 10th September 2019 in Gunta, Sahpur and Mahanpur villages of Bansur tehsi. Activities focused on intensive observations/ analysis of socio-economic and technological profile of the farm families in rural areas of Bansur and acquaintance with farming situations, farm practices and interaction with progressive farmers.

13 Distinguished Visitors

Name	Designation and Affiliation	Date
Sh. Sushil Kumar	Additional Secretary (DARE) & Secretary ICAR, New Delhi	April 11, 2019
Sh. Pawan Kumar Goyal	Commissioner, Agricultural Production and Additional Secretary, Agriculture and Horticulture, Govt. of Rajasthan	May 29, 2019
Sh. Akhilesh Kumar Singh	Member, Governing Body ICAR, New Delhi	May 29, 2019; October 22, 2019
Sh. Kailash Choudhary	Minister of State (Agriculture and farmers welfare) Govt. of India	August 17, 2019; September 28, 2019
Smt. Ranjita Koli	Member of Parliament, Bharatpur	August 17, 2019
Dr. Arvind Kumar	Vice Chancellor, RLBCAU, Jhansi	October 20, 2019

14 Personnel

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. K.H. Singh, Principal Scientist (Genetics & Plant Breeding)
3. Dr. Bhagirath Ram, Principal Scientist (Genetics & Plant Breeding)
4. Dr. Arun Kumar, Principal Scientist (Cytogenetics)
5. Dr. H.S. Meena, Senior Scientist (Genetics & Plant Breeding)
6. Dr. Hariom Kumar Sharma, Senior Scientist (Plant Breeding)
7. Dr. B. L. Meena, Scientist SS (Genetics & Plant Breeding)
8. 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.D. Meena, Scientist, SS (Soil Science)
4. Dr. M.L. Dotaniya, 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)
3. Dr. Archana Anokhe, Scientist (Entomology)[#]

Plant Biotechnology

1. Dr. Ajay Kumar Thakur, 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. IbandalinMawlong, 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, Senior Technical Officer (STO)
7. Sh. Sanjay 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. RadhaCharanRajpoot, 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. VimlaMeena, Clerk
8. Sh. Srikant Kumar Singh, LDC
9. Sh. Prashant Kumar, Steno[##]

Audit and Accounts Unit

1. Sh. R.S. Bhat, Finance& Account Officer (FAO)***

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. S.K. Sharma, Senior Scientist & Head
2. Dr. Rupendra Kaur, T-6
3. Sh. Sandeep Rastogi, T-6
4. Sh. Sunil Kumar, T-6
5. Sh. Prem Chand Garhwal, T-6
6. Dr. Arvind Kumar Verma, T-6
7. Sh. Sangam Wadhwa, Steno[###]

* Director (Acting) Since January01, 2017

** Superannuated on 31 July, 2019

*** FAO, Central Goat Research Institute, Mathura, Additional charge of ICAR-DRMR, Bharatpur

[#]Fresh joining on April 15, 2019

[##]Fresh joining on April 01, 2019

[###]Fresh joining on April 01, 2019

15 Panorama

15th International Rapeseed Congress at Berlin, Germany

Dr. Pankaj Sharma, Principal Scientist participated and made presentation in 15th International Rapeseed Congress (IRC). The congress was organized by Union for Oilseed Promotion (UFOP), Germany and GCIRC, France at Berlin Congress Centre, Berlin, Germany during June 16-19, 2019. Mr. Wolfgang Vogel, UFOP, German Farmers' Association (Germany), Michael Stübgen, Parliamentary State Secretary, Federal Ministry of Food and Agriculture (BMEL) (Germany), Prof. Wolfgang Friedt, President, International Consultative Group of Research on Rapeseed (GCIRC) opened the congress. There were about 842 participants from 43 countries.

The Congress was divided into eight parallel thematic area keynotes. In total nine plenary key note and twenty three technical sessions comprising 170 oral presentations on different aspects of oilseed *Brassica* were delivered. Presentation over 330 poster papers covering a spectrum of diverse rapeseed-mustard research areas and six workshops including Sclerotinia: current and future breeding methods were another significant highlight of the congress. Dr. Pankaj Sharma presented research paper on Identification of *Brassica juncea* germplasm resistant to *Sclerotinia sclerotiorum* and study of inheritance in early generations. Dr. Sharma also co-chaired the Sclerotinia workshop on June 19, 2019 with Dr. Lone Buchwaldt, Canada.

International Yoga Day

ICAR-DRMR celebrated "International Yoga Day" on 21st June 2019 as per common Yoga guidelines issued by Ministry of Ayush, Govt. of India and ICAR.On this occasion, discussions on various topics including Yoga and consciousness were made. The Asanas were conducted under the supervision of trained Yoga instructor, who apart from conducting the exercises, also informed the benefits of each asana. A Yoga practice session was conducted in the morning. Scientists, Technical, Administrative and Skilled supporting staff of ICAR-DRMR enthusiastically participated in the activities of International YogaDay.

Independence Day Celebration

ICAR-DRMR celebrated the 73rd Independence Day on 15th August 2019 with pride and honour to 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 the duty of every Indian citizen to protect the same and to strive hard for sustainable growth and prosperity of the country. He emphasized the importance of team work and holistic work culture to make novel strides in the research front of the Directorate since the country is looking towards us for break throughin oilseed research specially in the rapeseed-mustard to meet out the growing demand of edible oil.

Parthenium Awareness Week

14th *Parthenium* awareness week was observed from 16-22 August, 2019 at ICAR-DRMR. During awareness week, various activities such as uprooting of *Parthenium* in the ICAR-DRMR campus discussions among the scientific and supporting staff of ICAR-DRMR were performed. Scientists shared their knowledge about this notorious weed which causes many diseases like skin allergy, hay fever, breathing problems in human beings and animals.

Swachh Bharat Mission

Under Swachh Bharat Mission, cleanliness drives were successfully conducted every month from April 2019 to December 2019 in the ICAR-DRMR office premise, staff quarters, glasshouse premise, basic science complex, farm area, and outside office premise. All staff members including Scientists, Technical, Administrative, and Supporting staff rendered their services in the cleanliness drives. A drawing competition was organized by involving primary class students of the nearby school on Swachh Bharat Abhiyan. Dr M.D. Meena, Nodal Officer, 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 cleanliness.

Kisan Samwaad programme

ICAR-DRMR organized KisanSamwaad with Hon'ble Union Minister of State for Agriculture and Farmers' Welfare Sri Kailash Choudhary on 17th August 2019. In his address, Hon'ble Minister informed about various Farmers welfare schemes launched by the Govt. of India. It is the dream of Prime Minister Sh. Narendra Modi to double the farmer's income by 2022. If farmers can commit it, they can achieve this by their hardship and perseverance. He emphasized that to make agriculture profitable, farmers themselves have to try and take advantages of the various schemes of government and advance techniques developed by the scientists. He also informed that government has aimed to establish ten thousand Farmer Producer Organization (FPO) to help farmers. On this occasion, Hon'ble MP Bharatpur, Smt. RanjitaKoli requested to the Union Minister to help in solving the problems of the farmers.

Dr P.K. Rai, Director ICAR-DRMR, welcomed the Hon'ble Mos and appreciated his farmers friendly efforts. He also expressed his gratitude to the Hon'ble Minister for participating in the "KisanSamwaad". Dr. P.K. Rai said that rapeseed-mustard has an important place in the economy of India. It is possible to become self-sufficient in the field of edible oil by adopting the high yielding varieties and advance techniques developed by the scientists. The Directorate has always worked for the farmers and assist them in every possible way. Scientists of the Directorate are informing the farmers about various agricultural techniques by different platforms like Front line demonstration (FLD), Kisan-Gosthi, Exhibitions, Kisan Mela and Radio education programs. More than 400 Farmers have participated in the "Kisan Samwaad" programme.

Inauguration of the Community Hall and Plantation

The inauguration of the Community Hall was done by the Hon'ble Union Minister of State for Agriculture and Farmers' Welfare Shri Kailash Choudhary on 17th August 2019. Hon'ble MP Bharatpur, Smt. RanjitaKoli also graced the occasion. Dr P.K. Rai, Director ICAR-DRMR expressed his gratitude to both the dignitaries. Hon'ble Union Minister along with the Scientists, Technical and Administrative staff had planted 600 saplings in the campus of ICAR-DRMR. After that, Hon'ble Union Minister visited the Directorate.

ICAR-DRMR Celebrated 'Sadbhavana Diwas'

In order to promote the national integration and communal harmony among people of all religion, language and regions, ICAR-DRMR Celebrated 'SadbhavanaDiwas' on the occasion of the birthday of our Ex-Prime Minister Shri Rajeev Gandhi on August 20, 2019. The Sadbhavana pledge was taken on 20th August 2019 in the conference hall of the Directorate. All the Scientists, Technical, Administrative and Supporting staff participated in the pledge taking ceremony.

Hon'ble Union Minister of State for Agriculture and Farmers' Welfare, Sh. Kailash Choudhary visited the Directorate

Hon'ble Union Minister of State for Agriculture and Farmers' Welfare Sri Kailash Choudhary graced the event as Chief Guest. Dr P.K. Rai, Director ICAR-DRMR requested the farmers to regularly visit the Directorate and learn about the advance agriculture techniques for various crops along with rapeseed-mustard production techniques. He also expressed his gratitude to the Hon'ble Union Minister Sri Kailash Choudhary for showing his attentionto the farmers problems.

Hon'ble union Minister, in his address to the farmers, emphasized to do agri-business along with the traditional agriculture to become prosper. Farmers should also practice animal husbandry, fisheries, apiculture along with routine agriculture to double the income. He emphasized that strong farmers build strong nation. He requested to the farmers that they should adopt the advance agricultural practices demonstrated by the scientists of ICAR and KVKs and always use quality seeds. Hon'ble Sri Kailash Choudhary has also informed the farmers about "Kishan Pension Yojna" and "Kishan Samman Nidhi Yojana" in detail. He also distributed Knapsack Sprayer, fertilizer, seed and blankets to the farmers in this programme. Financial help was provided by ICAR, New Delhi. Scheduled caste farmers from Havivpur, Sinpini and Ludhawai villages have participated in this program.

ICAR-DRMR, Bharatpur celebrated its 26th Foundation Day

ICAR-DRMR celebrated its 26th Foundation Day on October 20, 2019. Prof. Arvind Kumar, Vice Chancellor Rani Lakshmi Bai Central Agricultural University, Jhansi, UP was Guest of Honour on this occasion. Dr. M.S. Chauhan, Director ICAR- Central Institute for Research on Goats, Mathura and Dr. Raghvendra Singh, Director ICAR-Central Sheep and Wool Research Institute, Avikanagar graced the occasion as chief guests. Dr. M.S. Chauhan appreciated the work done by the Directorate over the last 26 years. On this occasion he highlighted 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 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. During foundation day publications including book, newsletter and technical folders were released by the dignitaries.

Dr P.K. Rai, Director ICAR-DRMR welcomed all the guests and apprised about the work done by the Directorate. He said that in order to increase the production and productivity of rapeseed-mustard, a better coordination among research institutes, State Departments of Agriculture, KrishiVigyan Kendra, SAUs, Seed

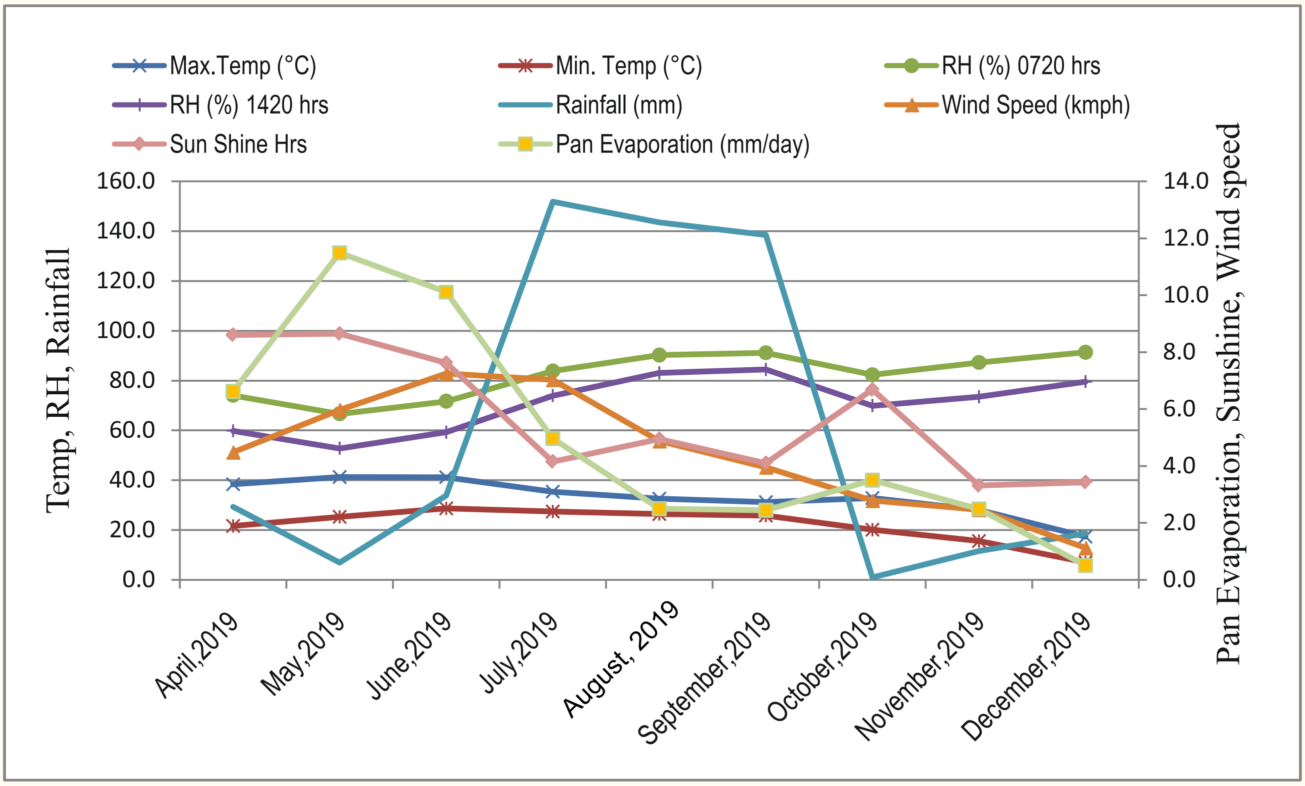
Corporations etc. need to be established by the Directorate. On this occasion,

ICAR-DRMR Celebrated "Constitution Day"

On the 70th anniversary of the adoption of the constitution of India, ICAR-DRMR celebrated the "Constitution Day" on 26th November 2019. On this occasion, Dr P.K. Rai, Director ICAR-DRMR unfurled the Tricolour flag and address the staff of the Directorate. He briefed about the development of the constitution of India before and after Independence and its various amendments. He emphasized on the Fundamental Duties of the citizen of India along with the Fundamental Rights. All the Scientists, Technical, Administrative and Supporting staff read the Preamble of the constitution of India and took pledge to affirm their faith in the constitution of India and choose the path of non-violence in case of any dispute.

16 Meteorological Data

During this year the maximum temperature was recorded 41.3°C in the month of May and minimum in the month of December, 2019 (7.0°C). Relative humidity was ranged 66.7 to 91.5% and 52.8 to 84.5% at 0720 hrs and 1420 hrs, respectively. Maximum rainfall received in the three months of rainy season [July (151.9mm), August (143.6mm) and September (138.5mm)] and rest of the months received small precipitations except October (1.0mm). The wind speed varied from 1.1 Kmpl in December and 7.3Kmpl in June 2019. Maximum sunshine (hour) was recorded in the month ofApril and May (8.6hrs) whereas, the lowest in November 2019 (3.3hrs).



17 Budget and Resource Generation

Budget (Rs in Lakhs)

Head	Sanctioned	Utilized
DRMR	1037.24	1037.24
AICRP	915.53	915.53

(From 1st April 2019 to 31st December 2019)

Resource Generation (Rs.)

Account Head	Amount (Rs)	Account Head	Amount (Rs)
Sale of farm produce	39,73,328	Training	45,000
Sale of tender forms	5000	Guest House	3,14,895
License Fee	1,91,875	Transport charges	25,000
Analytical testing fee	1,61,392	DRMR	12,65,400
Total income generated			**59,81,890**

NOTE

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch