ANNUAL REPORT

2017-18

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
2017-18

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

Guidance : Dr. P.K. Rai

Editors : Pankaj Sharma
Ajay Kumar Thakur
Hariom Kumar Sharma
Priyamedha
Murli Dhar Meena

Photography : Rakesh Goyal

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

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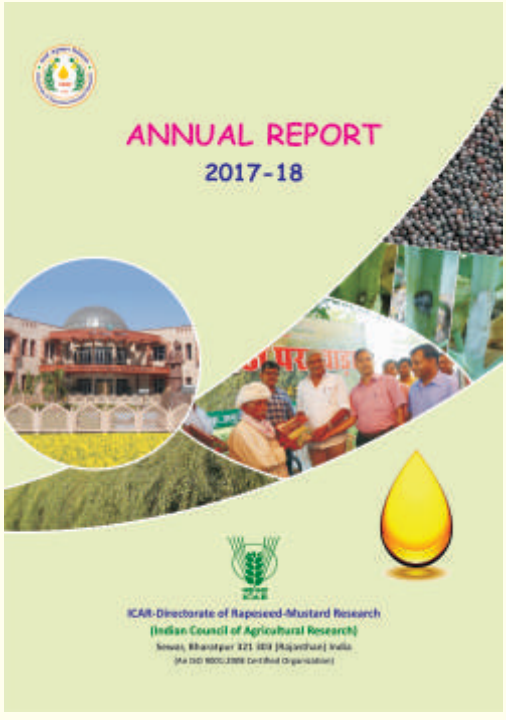

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Brassica science for oil and nutritional security
MISSION
Harnessing science and resources for sustainable increase in productivity of rapeseed-mustard
OBJECTIVES
• Utilizing frontier research for better exploitation of genetic resources.
• Development and identification of appropriate production-protection technologies.
• Capacity building and knowledge management through technology assessment, refinement and dissemination.

Preface

ICAR-DRMR, Bharatpur play a pivotal role in overall development of rapeseed-mustard crops. Since its inception it is acting as national repository for rapeseed-mustard genetic resources and undertaking basic, strategic and applied research to enhance the rapeseed-mustard productivity and quality of oil and seed-meal. It is a matter of great pleasure to present the 25th Annual Report of Directorate encompassing the research achievements made by this Directorate during year 2017-18.

Indian mustard variety DRMR 1165-40 (Bharat Sarson 8) was identified for timely sown rainfed conditions of Zone II on March 15, 2018 during 48th AGM of AICRP on Soybean at IGKV, Raipur. Three elite germplasm of Indian mustard (DRMR-2019, DRMR-2035 and DRMR MJA 35) were registeredfor white rust resistance byPlant Germplasm Registration Committee, ICAR, New Delhi. Seven white rust resistance donors (DRMR-1-5, DRMR 2035, DRMRJA 35, DRMRIJ 12-40, DRMRIJ 12-26, DRMR 2019, DRMRIJ 12-28) were identified during 24thAGM of AICRP-RM on August 3-5, 2017 at RARI (SKNAU), Durgapura, Jaipur. Entry DRMR 1153-12 was promoted to AVT-II for late sown conditions of Zone V. Two entries DRMR 4005 (early mustard) and DRMR 2035 (late sown) were promoted to AVT-I for zone II and zone III, respectively. DRMR 541-44 identified promising for low light stress, DRMRCI 70 and DRMR 1165-40 were identified promising for moisture stress conditions. A total of 2400 germplasm accessions of rapeseed-mustard regenerated, 600 Indian mustard germplasm were evaluated for terminal heat tolerance, 141 yellow sarson germplasm characterized for agro-morphological traits and 143 accessions were distributed as per indent.

Use of organic source increased the seed yield by 15.2 and 24.0% over conventional and absolute control (no fertilizer), respectively. Supplementing organic source with chemical fertilizers further augmented the seed yield by 22.4% due to MFM (50% RDF). Among the cropping systems, mono-cropping system (fallow-mustard) recorded highest seed yield (2861 kg/ha), however, under the double cropping systems i.e., green gram- mustard (2731 kg/ha) and maize-mustard (2676 kg/ha) recorded highest seed yield of mustard. Genotype RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695 and IC 511651 observed tolerant against Sclerotinia rot.

ICAR-DRMR organized 617 FLDs of improved varieties in different villages of Bharatpur district of Rajasthan under MGMG and institute/externally funded projects. Directorate organized 12 training programme, 4 sarson field days, 51 Kisangosthis, off campus trainings for effective dissemination of technology. Under Tribal Sub Plan, 2390 tribal farmer and farm women from Asom, Jharkhand, Madhy Pradesh and North Eastern states were benefitted through meetings, trainings, field days and exposure visits. A total 22 research papers, 21 technical folders and 3 book chapters were published during the period.

Directorate produced 1682.97 q TL and 36.15 q breeder seeds of rapeseed-mustard varieties during year 2016-17. Rs. 59.93 lakh income was generated by various resources.

I extend my sincere thanks and gratitude to Dr. T. Mohapatra, Secretary DARE Govt. of India & 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. Chakrabarty, Assistant Director General (Oilseeds & Pulses), ICAR and esteemed member of RAC for guidance, help rendered to Directorate.

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

June 30, 2018

30.6.18

(P. K. Rai)
Director (Acting)

List of Acronyms

AAU	Assam Agricultural University
ADG	Assistant Director General
AICRM	All India Coordinated Research Project
AICRP-RM	All India Coordinated Research Project on Rapeseed-Mustard
ANMR	Additional Net Monitory Return
ARS	Agriculture Research Station
ATMA	Agricultural Technology Management Agency
AVT	Advance Varietal Trial
BARC	Bhabha Atomic Research Centre
BAU	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
FIGS	Farmer Interest Groups
FIRBS	Furrow Irrigated Raised Bed System
FLD	Front Line Demonstration
FYM	Farm Yard Manure
GCV	Genotype Coefficient of Variance
IAA	Indole Acetic Acid
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
IBCR	Incremental Benefit Cost Ratio
ICAR	Indian Council of Agricultural Research
IIAB	Indian Institute of Agricultural Biotechnology
IIOR	Indian Institute of Oilseed Research
IHT	Initial Hybrid Trial
IJSC	Institute 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 Phule Krishi Vidyapeeth
MS	Murashige Skoof
MSI	Membrane Stability Index
MSI	Mustard Straw Incorporate
MSL	Mean Sea Level
MTC	Model Training Course
MUFA	Mono Unsaturated Fatty Acid
NAARM	National Academy of' Agricultural Research and Management
NAAS	National Academy of Agricultural Sciences
NBPGR	National Bureau of Plant Genetic Resources
NC	National Check
NCD	North Carolina Design
NDN	National Disease Nursery
NGO	Non-Governmental Organization
NIFM	National Institute of Financial Management
NPTC	Network Project on Transgenic in Crops
NRCPB	National Research Centre of Plant Biotechnology
NSSO	National Sample Survey Office
PAU	Punjab Agricultural University
PCR	Poly cyclic Chain Reaction/Polymerase Chain Reaction
PCV	Phenotypic Coefficient of Variance
PPV&FRA	Protection of Plant Varieties & Farmers Rights Authority
PMC	Pollen Mother Cells
PRWC	Percent Relative Water Content
PSB	Phosphorus Solubilizing Rhizobacteria
PUFA	Poly Unsaturated Fatty Acid
RAC	Research Advisory Committee
RCBD	Randomized Complete Block Design
RDF	Recommended Dose of Fertilizers
RCT	Resource Conservation Technology
RFD	Results-Framework Document
RLB CAU	Rani Laxmi Bai Central Agricultural University
R&M	Rapeseed & Mustard
RRS	Regional Research Station
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
RWC	Relative Water Content
SAC	Space Applications Centre
SAU	State Agricultural University
SDA	State Department of Agriculture
SDAU	Sardar Dantiwada Agricultural University
SGM	Sesbania Green Manure
SIAM	State Institute of Agriculture Management
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SOC	Soil Organic Carbon
SPS	Single Plant Selection
SSG	Supporting Staff Grade
STMS	Sequence Tagged Micro-satellites
TSP	Tribal Sub Plan
UAS	University of Agricultural Sciences
VPKAS	Vivekanand Parvatiya Krishi Anusandhan Sansthan
WHO	World Health Organization
WP	Wettable Powder/Whole Package
WSC	Wide Spaced Crop
WUE	Water Use Efficiency
ZC	Zonal Check

Executive Summary

- DRMR 1165-40 (Bharat Sarson 8) was identified on March 15, 2018 during 48th AGM of AICRP on Soybean at Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur for timely sown rainfed conditions of Zone II (Jammu, Punjab, Haryana, Delhi and Rajasthan).
- Germplasm DRMR-2019 (IC0598622; INGR17077) DRMR-2035 (IC0598623; INGR17078) and DRMR MJA 35 (IC0622804, INGR 17048 CMS line) of Indian mustard (*B. juncea* L.) was registered for white rust resistance by Plant Germplasm Registration Committee, ICAR, New Delhi.
- Seven white rust donors DRMR-1-5, DRMR 2035, DRMRJA 35, DRMRIJ 12-40, DRMRIJ 12-26, DRMR 2019, DRMRIJ 12-28 were identified during 24th Annual Group Meeting of AICRP-RM on August 3-5, 2017 at RARI (SKNAU, Jobner) Jaipur.
- Entry DRMR 1153-12 was promoted to AVT-II for late sown conditions of Zone V. Two entries DRMR 4005 (early mustard) and DRMR 2035 (late sown) were promoted to AVT-I for zone II and zone III, respectively
- A total of 2403 germplasm accessions of rapeseed-mustard regenerated, 604 Indian mustard germplasm were evaluated for terminal heat tolerance and 141 yellow sarson germplasm were characterized for different agro-morphological traits. 143 accessions of rapeseed-mustard were provided as per indent.
- Use of organic source increased the seed yield by 15.2 and 24.0% over conventional absolute control (no fertilizer), respectively. Supplementing organic source with chemical fertilizers further augmented the seed yield by 22.4% due to MFM (50% RDF).
- Among the cropping systems, mono-cropping system (fallow-mustard) recorded highest seed yield (2861 kg/ha) followed by double cropping systems i.e., green gram-mustard (2731 kg/ha) and maize-mustard (2676 kg/ha).
- RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695 and IC 511651 observed tolerant (lesion size <3.0 cm and disease incidence<10%) to Sclerotinia rot.
- A total 337 FLDs of four improved varieties Giriraj (DRMRIJ 31), RH 749, RH 406, and NRCHB 101 were conducted in different villages of Bharatpur district of Rajasthan which showed yield improvement of 11.6, 11.3, 6.8, and 3.78%, respectively over prevailing varieties.
- ICAR-DRMR successfully organized 12 training programme for KVK personnel, field level extension workers and farmers for effective dissemination of technology.
- In Mera Gaon-Mera Gaurav (MGMG) programme, farmers were provided scientific advisories through 280 FLDs on mustard, 5 on wheat, 4 sarson field days, 51 Kisan gosthies, off campus trainings, literature and linkages with line departments.
- Under Tribal Sub Plan, 2390 tribal farmer and farm women from Asom, Jharkhand, Madhy Pradesh and North Eastern states were benefitted through meetings, trainings, field days and exposure visits.
- A total 21 research papers, 21 technical folders and 3 book chapters were published during the period.
- A total 1682.97 q TL seeds of improved rapeseed-mustard varieties were produced during rabi 2016-17.
- 36.15 q breeder seed of DRMRIJ31 (14.26 q), NRCDR02 (7.65 q), NRCHB101 (6.30 q), DRMR601 (5.43 q) and NRCYS 05-02 (2.51 q) was produced during 2016-17.
- Rs. 59,93,449 income was generated from various resources.

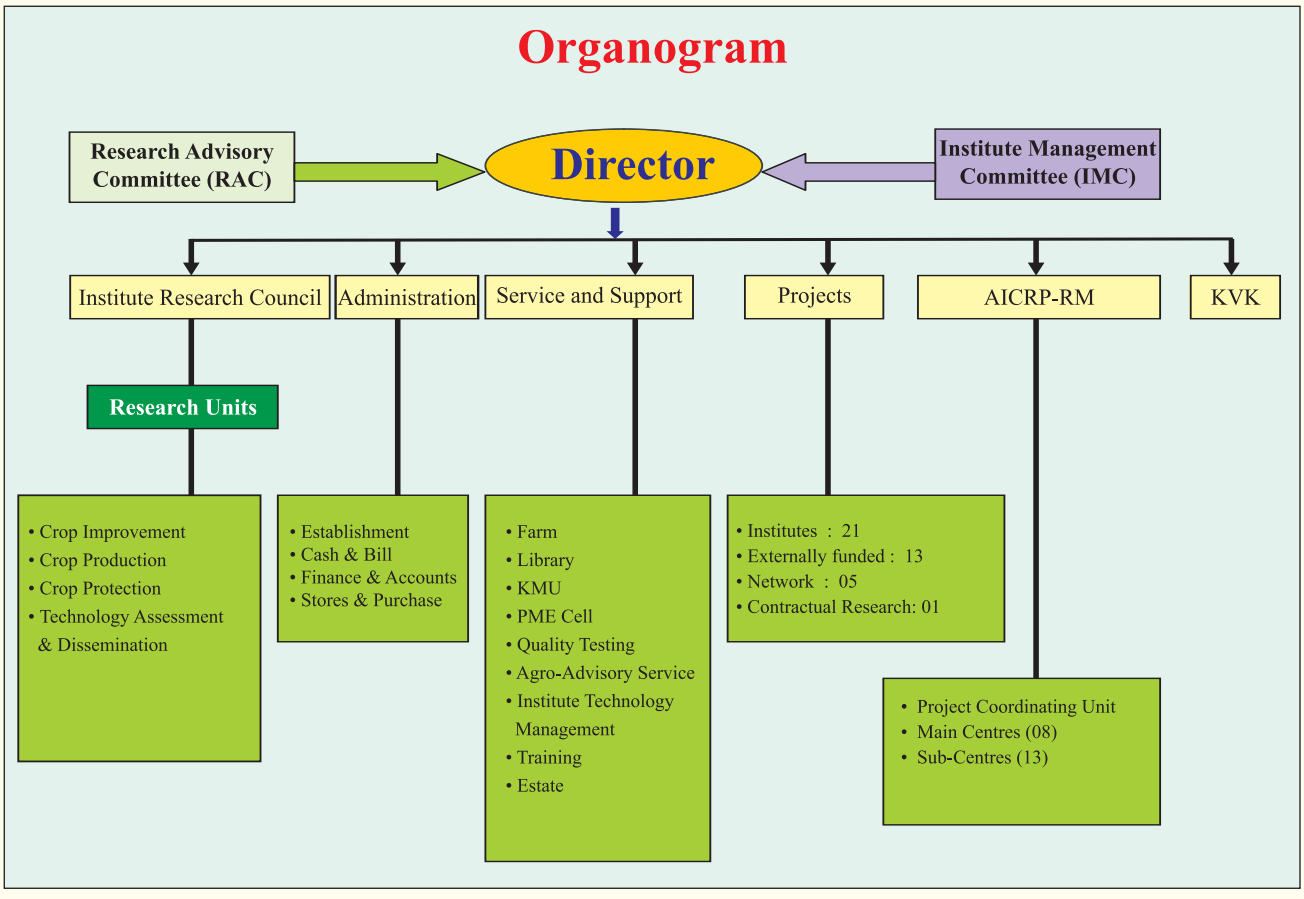
1 ICAR-DRMR: *An Overview*

Indian Council of Agricultural Research established All India Coordinated Research Project on Oilseeds (AICRPO) in April, 1967 for the improvement of oilseeds in the country. Setting up separate Project Coordinating Unit in the V plan (1974-79) further strengthened the research program on oilseeds, especially rapeseed-mustard. Accordingly the rapeseed-mustard project coordinating unit was established on January 28, 1981 at Haryana Agricultural University, Hisar. During VII Plan (1992-97) on October 20, 1993 ICAR established the National Research Centre on Rapeseed-Mustard (NRCRM) to carry out basic, strategic and applied research on rapeseed-mustard at adaptive trial centre of the state department of agriculture, Govt. of Rajasthan at Sewar, Bharatpur on the recommendation of the task force constituted in 1990. The centre has been upgraded as Directorate of Rapeseed-Mustard Research in the XI Plan (2007-12). Besides, generating basic knowledge and materials, it also engages in developing ecologically sound and economically viable agro-production and protection technologies. The Directorate also has the responsibility to plan, coordinate and execute the research program through a wide network of 8 main and 13 sub-centres across the country in addition to need-based verification centres under the umbrella of AICRP-RM to augment the production and productivity of rapeseed-mustard. The Directorate is located 7 km and 3 km away from the Bharatpur railway station and bus stand, respectively on Agra-Jaipur national highway. Bharatpur, internationally known for Keoladeo National Bird Sanctuary, is on the Delhi-Mumbai main railway track just 36 km ahead of Mathura (UP) and well connected with Jaipur, Delhi, and Agra by road and rail. The campus of the Directorate is spread over an area of 44.21 ha of which about 80% is experimental, and the rest is covered by administrative-cum-laboratory building and residential complex. It is located at 77.27° E longitude and 27.12° N latitude and is 178.37m MSL. The DRMR functions as a fulcrum to support the production system research through different research, service and support units (see organogram) with basic technologies and breeding materials for rapeseed (yellow sarson, toria, taramira, gobhi sarson) and mustard (Indian mustard, Ethiopian mustard) crops.

Functions

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

Organogram



2 Research Achievements

2.1 Genetic enhancement for stress tolerance in Indian mustard

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

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

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

Variety identified

DRMR 1165-40 (Bharat Sarson 8) was identified on March 15, 2018 during 48th AGM of AICRP on Soybean at Indira Gandhi Krishi Vishwa Vidyalaya (IGKV), Raipur for timely sown rainfed conditions of Zone II (Jammu, Punjab, Haryana, Delhi and Rajasthan). DRMR 1165-40 has shown 11.7, 13.7, and 12.4 per cent yield superiority over RGN 48, Kranti and RH 406, respectively in 12 environments across the Zone II of India on pooled basis of three years testing.

Fig 2.1 A field view of DRMR 1165-40 (Bharat Sarson 8)

Contribution and performance of entries in AICRP-RM trials

Five promising entries viz; DRMRCI-72 (timely sown, rainfed), DRMRCI-92 (timely sown, rainfed), DRMRCI-85 (timely sown, irrigated), DRMRCI-91 (late sown), DRMRCI-106 (early sown) were contributed for multi-location testing in AICRP-RM trials during 2017-18.

Entry DRMR 1153-12 was promoted to AVT-II for late sown conditions of Zone V. DRMR 541-44 identified promising for low light stress, DRMRCI 70 and DRMR 1165-40 for moisture stress conditions.

Evaluation of promising entries in station/ advanced trials

Entry DRMRCI-85 (2828 kg/ha) and DRMRCI-91 (2818 kg/ha) recorded maximum yield in comparison to checks (Best check DRMRIJ-31 yield 2451 kg/ha) under irrigated timely sown trial. In station trial, entry DRMRCI-72 (1611 kg/ha) out yielded the best check RGN 48 (1347 kg/ha) under rainfed conditions. In early trial, entry DRMRCI-106 and DRMRCI-98 recorded more yield *i.e.* 2358 and 2318 kg/ha respectively in comparison to best check NPJ 112 (2280 kg/ha).

Observation nursery

Out of 100 advanced progenies grown in observation nursery along with checks (Kranti, DRMRIJ 31, RH 749 and NRCDR 2), on the basis of per se performance, following progenies were selected:

Table 2.1: Performance of selected lines under irrigated condition

Progeny (ies)	Seed yield (kg/ ha)	Oil content (%)	Oil yield (kg/ ha)	Test weight (g)
DRMR 1721-28-5	3132	41.9	1313	5.4
DRMR 1741-36-80	3014	42.9	1293	6.4
DRMR 1723-60-9	3014	42.1	1270	6.5
DRMR 1741-6-49	2955	43.1	1272	4.6
DHS 104-15	2896	42.3	1224	6.3
DRMR 1684-84-20	2895	40.3	1166	6.9
DRMR 1480-66-11	2895	39.9	1155	5.7
DRMR 1741-90-88	2896	42.4	1237	6.2
Best check (NRCDR 2)	2636	41.6	1096	6.9

Generation of breeding material

Fresh inter-varietal crosses attempted between RH 749/NPJ 124, NRCDR 2/RH 406, DRMRIJ 31/RB 50, RH 555/NPJ 112, NRCDR 2/DRMR 10-40, Kranti/NRCHB 101, RGN 48/RH 406, NRCHB 101/DRMR 541-44, RH 749/ DRMRIJ 31.

Rainfed

Observation nursery

Same set of observation nursery (100) was grown under rainfed conditions. On the basis of plot yield, following progenies were selected in comparison to best check.

Table 2.2: Performance of selected lines under rainfed condition

Progeny (ies)	Seed yield (kg/ ha)	Oil content (%)	Test weight (g)	Drought Suscep-tibility Index (DSI)
DRMR 1722-58-17	2718	41.4	5.5	0.79
DHS 18-15	2600	39.3	6.3	-0.25
DRMR 1566-63-10	2423	40.7	5.9	-0.32
DRMR 1686-76-12	2423	39.3	7.7	1.16
DRMR 1684-84-20	2364	40.6	6.98	0.57
DRMR 1717-12-3	2304	41.3	5.4	0.95
Best check RB 50	2488	41.4	6.6	

Agro-physiological traits for drought tolerance in Indian mustard

Total 18 genotypes including 4 cultivars were evaluated for agro-physiological traits under stress (moisture at 50% field capacity) vis-a-vis normal (moisture at 100% field capacity) conditions during 2016-17 in the cemented blocks. The Pearson's correlation matrix showed that leaf transpiration (0.86), leaf quantum (0.83) and root mass (0.73) were significantly correlated with seed yield under stress conditions (P value=0.05). Among the drought indices, ELWL (Excised Leaf Water Loss), RWC (Relative Water Content) and leaf chlorophyll content were significantly correlated with seed yield. Under stress conditions, the genotypes BPR1334-61-25-9, BPR1679-89-50-3 and YHS43-100 recorded the highest root mass. The maximum per cent ELWL was recorded in BPR1334-61-25-9, BPR1345-67-29-19, and BPR1187-50-6-17. Whereas, per cent RWC was maximum in BPR1334-61-25-9, BPR1187-50-6-17 and BPR1480-82-38-4. The minimum leaf water transpiration was recorded in BPR 18, BPR-1480-82-38-4, BPR-1345-67-29-19 and YHS-113-123.

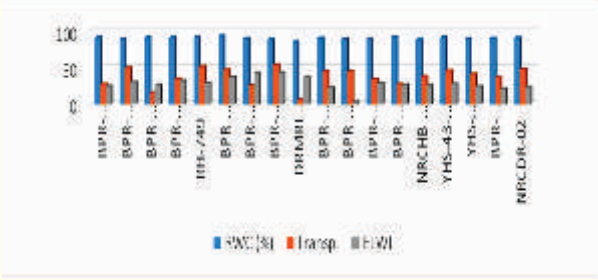


Fig. 2.2: Physiological parameters of drought tolerant genotypes of Indian mustard

Drought stress response of mustard genotypes

One hundred advanced genotypes of Indian mustard were analyzed for drought stress response. The genotypes DRMR 1566-7-101, DRMR 1741-97-2, DFS-21-115, DRMR 1723-58-60, DRMR 1566-4-63, DRMR 1741-44-2, DHS18-104, DHS14-103, YHS44-121, DRMR 1721-28-23 and DRMR 1686-39-83 had lower DSI values thus rated as drought tolerant. The overall values of DSI ranges from -1.056 (DRMR 1566-7-101) to 2.140 (DRMR 1741-9-2).

Selections from segregating generations

Under rainfed conditions, 210 SPS were selected from 8 F2 populations; 180 SPS from F3 generation for generation advancement. 80 single plants (*B. carinata* type) and 75 (*B. juncea* type) were selected from F5 generation.

Promising cultures of *B. carinata* for early maturity (135-150), oil content (41-42.5%) and test weight (5-6.5 g) were derived from F5 generation.

Table 2.3: Performance of advance lines of *B. carinata* under rainfed condition

Progeny (ies)	Seed yield (kg/ha)	Maturity (days)	Test weight (g)
DRMR 1738-3	1790	147	4.1
DRMR 1738-7	1740	140	5.4
DRMR 1738-4	1636	144	4.5

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

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

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

Development and cyto-morphological evidences for confirmation of chromosome doubling through aqueous colchicine in *Sinapis alba*

Successful induction of artificial auto-tetraploidy was achieved in two plants of *S. alba* (2n=24), a wild relative of cultivated Brassicas are highly promising as an valuable resource for resistance/tolerance against the major biotic stresses especially for Alternaria blight and Sclerotinia stem rot.

The colchicine-induced plants were robust from the initial stages of development and it was maintained till maturity, although different responses to colchicine were evident in the plants. The colchicine-induced tetraploid plants showed increase in plant height (117 cm), when compared with diploids (103 cm). Secondary branches per plant, length of petiole, length and width of leaflet, corolla length and width and siliqua length showed considerable increase in comparison with the corresponding diploids.

Cytologically, bivalents chromosome associations were observed more frequently (Fig. 2.3). However, few quadric-valents

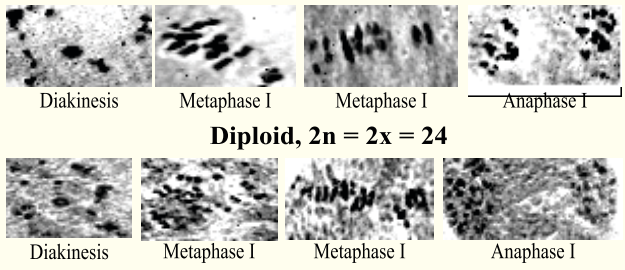


Fig. 2.3: Cytological examinations in diploid and colchicine – induced tetraploids of S.alba

frequency ranging from 2.38 to 3.12 and univalent frequency ranging from 3.43 to 4.02 per cell were characteristic of the colchicines-induced tetraploids. The anaphase I and II disjunction of bivalents/chromosomes was leading more or less regularly and equally to the formation of seeds from the synthesized plants. Significant enhancement in morphological traits as revealed in colchicine-induced plants and normal meiotic behaviour leading to a good seed set which ultimately result in providing the plant breeder with more variability.

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

Table 2.4: Performance of dwarf type genotype of *B. carinata*

Characteristics	ICAR-DRMR				KVK, Bansur	
	DRMRC-16-6	NRCKR-304	Kiran	NRCDR-2	DRMRC-16-6	NRCKR-304
Days to maturity	131	132	164	140	125	130
Plant height (cm)	83	155	235	202	88	160
Primary branches	8.2	3.8	8.7	5.6	7.6	6.3
Secondary branches	23	10.4	20.9	9.6	21	14.5
Main shoot length	60	80.5	40	84	65	87.1
Siliqua length	3.5	4.0	3.6	4.9	3.2	4.0
Seeds per siliqua	16.5	17.0	12.7	15. 8	15.6	16.4
1000 seed weight (g)	3.8	5.5	3.9	5.36	4.3	5.2
Oil content (%)	41.2	41.5	39.3	41.2	41.0	40.5

Evaluation of advance breeding line of *B. carinata* (DRMR-C-16-6) developed through inter-specific cross (*B. juncea*, cv. NRCDR-2 x *B. carinata*, NRCKR 304) was evaluated both at ICAR-DRMR and KVK, Bansur during 2017-18. The dwarf genotype possess some desirable characteristics, such as dwarf height, long pod size, high test weight, early maturing as compared with parental lines.

Evaluation of advance lines of brown seeded type *B. rapa*

Two advance lines (DRMR-YS-17-01 and DRMR- YS-17-02) developed through inter-specific cross between *B. tournefortii* and *B. rapa* cv. NRCYS 05-02 were advanced to F6 generation selected for brown seeded with tetralocular pods and another with brown seeded with bilocular pods types respectively. On morphological comparison with parent (NRCYS 05-02), leaf colour of both the selected lines were light green compared to NRCYS 05-02 with medium green (Fig. 2.4). Some of the salient characteristics of these lines such as tetra and bi-locular pods plant types. In tetralocular pods types (DRMRYS-17-01) plant height (136 cm), no. of days to maturity (119), primary branches (5), secondary branches (8.2), main shoot length (62 cm), no. of siliqua on main shoot (42.4), 1000 seed weight 2.4g and oil content was 42.15 % and in bi-locular pods type (DRMR- YS-17-02) plant height (150 cm), no. of days to maturity (119), Primary branches (5.2), secondary branches (8), main soot length (62 cm), no. of siliqua on main shoot (44), 1000 seed weight (3.1 g) and oil content was (39.8%), respectively as compared to NRCYS 05-02 (plant height 135 cm, no. of days to maturity 119, primary branches 7, secondary branches 4.3, main soot length 52 cm, no. of siliqua on main shoot 39, 1000 seed weight 3.5 g and oil content 42.0% respectively). Both these lines were self incompatible types and bulked during 2017-18. The data on relative water content, member stability index, SPAD and chlorophyll stability index has been observed. These lines may act as donor for further improvement of *B. rapa*.

Fig.2.4: Brown seeded type

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

During rabi 2017-18 three F2 progenies of (NRCDR-2 x GSL-1, RH 749 x *S. alba* and DRMRIJ-31 × *S. alba*) were planted in 15 paired row in 3m and single plant selection were made different component traits and yield attributes. Eight F3 progenies of *B. rapa*, cv. SKBR-1 × S. alba and four F3 progenies of *B. rapa*, cv. Pusa gold × *S. alba* were raised and single plant selection were made. 12 lines bulked from inter-specific cross *B. juncea* cv. NRCDR-2 × *B. carinata* cv. NRCKR-304, for early sown conditions during 2016-17 were grown in randomized block design in three replications during rabi season 2017-18 (September sowing) for early sown condition with checks NPJ112, PM 27, PM 28 and NRCDR 2. From the cross *B.juncea* cv. NRCDR 2×*B.carinata* cv. NRCKR304, 23 lines F7 and F8 generation with earliness, low height, oil content and other desirable traits were planted in 11 rows of 3m length each under late sown condition (November). The data on major contributing traits are being recorded and bulked.

Six lines (F7) were selected and bulked of inter specific *B. juncea* (Kranti) x *B. napus* (GCS-6) siliqua density and other important economic component traits and suitably numbered from DRMRIS18-1to DRMRIS18-6. The data on major contributing traits were recorded in these progenies.

Generation advancement of F3 progenies of inter-specific hybrids (*B. juncea*×*B. fruticulosa*) (4x, Colchi-tetraploid)

From the F3 progenies of inter-specific hybrids obtained between *B. juncea* cv. Rohini, Laxmi and Varuna × *B. fruticulosa* (Colchi-tetraploid), screened for mustard aphid infestation, selection

of single plant progenies were done in F3 generation. Screening for the mustard aphid infestation in the field conditions was performed against check BSH 1and JMM 927. Based upon the screening single plants selected (22) on the basis of aphid injury symptoms on 0 to 5 scale. Screening for Sclerotinia stem rot was also done using artificial stem inoculation. Six lines showed resistance/tolerance against Sclerotinia stem rot, segregating progenies also generated valuable genetic variability in terms of seed coat colour from light brown to pale yellow.

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, Pr. Scientist (Agronomy), M.S. Sujith Kumar, Scientist (Plant Biochemistry)

Genetic variability created through crossing for heat stress tolerance

The analysis of variance showed highly significant difference among the genotypes indicating sufficient amount of genetic variability in the material. Genetic variability parameters were studied to examine genetic worth of seed yield and heat stress traits, based on genetic variability estimates *i.e.*, PCV, GCV, heritability (h2) and genetic advance as percentage of mean. The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were high for proline (µmole/g FW), membrane stability index (%), population survival (%) at 25 DAS and seed yield per plant (g). The genotypic coefficient of variation was high for proline (µmole/g FW 98.3%) and membrane stability index (76.8%), which provides good opportunity for selection for desirable levels of these heat stress traits. High heritability estimates (broad sense) were noticed for proline content (98.3%), membrane stability index (98.0%), total antioxidant capacity (97.0%), radical scavenging activity (97.01%), water retention capacity (96.0%), 1000-seed weight (97.0%), seed yield per plant (96.0%) and population survival (94.0%) indicating that these characters were less influenced by the environmental factor and direct selection for these characters would be effective for further improvement. The high genetic advance was observed for membrane stability index (98.08%), proline content (82.14%), population survival 25DAS (56.45%) and seed yield per plant (55.72%).

Evaluation of promising crosses for high temperature stress tolerance and productivity

A total of 36 F1 crosses including 8 parents were evaluated in RCBD with two replications in two rows of 5m length for their *per se* performance with respect to their high temperature stress tolerance at seedling stage. Two hundred seeds of each cross including parents were sown in the field (17th September) during rabi 2016-17. The crosses differed significantly for productivity and physiological parameters namely; population survival (%) 25DAS, proline content, total antioxidant capacity, radical scavenging activity, relative water content, water retention capacity of leaves, excised leaf water loss, membrane stability index, 1000-seed weight, oil content, and seed yield per plant. The population survival decreased with increasing heat stress in all genotypes. But high survivability was observed in RH749 (53.32%), DRMRIJ31 x Urvashi (49.40%), DRMRIJ31 x BPR549-9 (48.57%), DRMRIJ31 x RH749 (45.0%) and Urvashi x BPR549-9 (41.24%). Per cent membrane stability index increased under heat stress in all the tested Indian mustard parents and crosses. Among the genotypes MSI was high in DRMRIJ31 x RH406 (52.2%), NRCHB101 x Urvashi (33.7%), DRMRIJ31 x RH749 (28.8%), and DRMRIJ31 x Urvashi (28.6%) under stress conditions, while it was low in NRCDR02 x Urvashi (2.1%) and RH119 x BPR549-9 (2.4%) at high temperature stress. Among the organic solutes, investigated proline content (µmole/g FW), total antioxidant capacity (mg/g AAE) and radical scavenging activity (%) recorded maximum in UrvashixBPR549-9 (19.5%), NRCDR02x BPR549-9 (17.8%) and RH119xBPR549-9(14.6%). Thermo-tolerant crosses have less percent excised-leaf water loss

compared to thermo-susceptible crosses. Cross DRMRIJ31xBPR549-9(27.8%), RH119xBPR549-9 (32.5%), NRCHB101 x BPR549-9(34.5%), and NRCDR02 x BPR549-9(34.6%) recorded minimum percent excised-leaf water loss. While, cross RH406xBPR549-9(62.4%), RH749xRH406 (61.7%), and NRCDR02 x RH749 (61.5%) recorded maximum percent excised-leaf water loss. With the study, it was concluded that heat stress-tolerant crosses of Indian mustard i.e. UrvashixBPR549-9, NRCDR02xBPR549-9 and DRMRIJ-31xUrvashi had higher capacity to tolerate/ avoid heat stress.

The significant co-efficient of correlation between seed-yield and other physiological traits ranged from 0.293-0.996. The seed yield plant-1 has significant positive correlation with population survival 25DAS (r=0.289*), relative water content (r=0.634**), membrane stability index (r=0.353*), and 1000-seed weight (r=0.398**), under heat stress conditions. The oil content (%) has significant negative correlation with radical scavenging activity (%) (r= -0.291*), and relative water content (%) (r= -0.528**) under heat stress conditions. The water retention capacity of leaves (%) has significant positive correlation with proline content (µmole/g FW) (r= 0.391**), radical scavenging activity (%)(r= 0.295*) and relative water content (%) (r= 0.996**) under heat stress conditions. While, at the same time, the relative water content (%) has significant negative correlation with total antioxidant capacity (mg/g AAE)(r= -0.500**) under heat stress conditions. The radical scavenging activity (%) has significant positive correlation with proline (µmole/g FW)(r= 0.387**) under heat stress conditions.

Relative performance of heat tolerant/ susceptible (donors) parents

Two hundred seeds of sixteen genotypes, including tolerant and susceptible, were sown in the field under heat stress (September 30, 2016) and late conditions (November 03, 2016) in RCBD with two replications in two rows of 5m length for high temperature stress tolerance at seedling stage and terminal heat stress tolerance evaluation, respectively. Under morphological observations, days to 50% flowering under early heat stress and terminal heat stress condition ranged from 44 to 52 and 49 to 55, respectively. While, the days to maturity under early heat stress and terminal heat stress condition ranged from 127 to 141 and 139 to 150, respectively. Among the genotypes, 1000-seed weight (g) was maximum in RH-555 (6.5; 4.2) followed by RH-119 (5.4; 4.8) and HP-30 (5.1; 4.8) under early heat and terminal heat stress conditions. Genotypes HP-30 (42.6; 39.3%), DRMR1165-40 (41.9; 40.5%), and BPR543-2 (41.5; 40.2%) attained the maximum oil content under early heat and terminal heat stress conditions. Among the genotypes, BPR549-9 (2720 kg/ha; 1279 kg/ha) recorded maximum seed yield followed by genotype BPR543-2 (2192 kg/ha; 1131 kg/ha) and DRMR-1165-40 (2562 kg/ha; 1095 kg/ha) under early heat and terminal heat stress conditions.

Generation advancement for earliness/high temperature stress tolerance

Three seed yield evaluation trials were conducted under early sown conditions. Two hundred fifty seeds of each line were sown in three trials during rabi 2016-17 in three rows of 5 m length. NPJ-112 was used as check variety for high temperature tolerance and earliness. A number of traits have been studied in Indian mustard for adaptation under high temperature stress. Selections were made for making a pool of earliness and late/medium maturity group of lines from F4 stage material and advanced to F5 stage.

Crossing Programme

Twenty genetically diverse parents i.e. varieties/germplasm of Indian mustard [*B. juncea* were crossed in Line × Tester mating design and 91 F1 crosses seeds were harvested.

Table 2.5: Earliness and late/medium maturity group from F_4 stage material and advanced F_5 stage

Early	DRMRHT-13-13-6-5; DRMRHT-13-13-5-2; DRMRHT-13-13-5-4; DRMRHT-13-13-5-5; DRMRHT-13-22-9-9; DRMRHT-13-22-9-10; DRMRHT-13-28-8 and DRMRHT-13-28-16	8 Advanced breeding lines
Late /Medium maturity	DRMRHT-13-22-3, DRMRHT-13-22-6, DRMRHT-13-22-7, DRMRHT-13-22-8, DRMRHT-13-22-11, DRMRHT-13-22-1, DRMRHT-13-22-2, DRMRHT-13-22-4, DRMRHT-13-22-5,: DRMRHT-13-13-1, DRMRHT-13-13-2, DRMRHT-13-13-3, DRMRHT-13-13-4, DRMRHT-13-13-6, DRMRHT-13-13-9; DRMRHT-13-28-1, DRMRHT-13-28-2, DRMRHT-13-28-3, DRMRHT-13-28-4, DRMRHT-13-28-5, DRMRHT-13-28-6, DRMRHT-13-28-7, DRMRHT-13-28-9, DRMRHT-13-28-10, DRMRHT-13-28-11, DRMRHT-13-28-12, DRMRHT-13-28-13, DRMRHT-13-28-14, DRMRHT-13-28-15, DRMRHT-13-28-17, DRMRHT-13-28-18 and DRMRHT-13-28-19	32 Advanced breeding lines

Development of mapping population for heat stress tolerance

Mapping population was derived from cross NRCHB-101/BPR-549-9 developed following single siliqua descent method. From each F2 plant a single siliqua was advanced to F3 generation as progeny row. In F3 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 F4 to F5 stage through selfing.

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

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

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

Entries in AICRP-RM

Four promising entries *viz.*, DRMR 2017-14 (early mustard), DRMR 2017-11 (timely sown irrigated), DRMR 2017-5 (timely sown rainfed) and DRMR 2017-15 (late sown irrigated) were inducted for multilocation testing under AICRP-RM trials during 2017-18.

Two entries DRMR 4005 (early mustard) and DRMR 2035 (late sown) were promoted to AVT-I for zone II and zone III, respectively. DRMR 4001 has been identified as high temperature tolerant at seedling stage and moisture stress tolerant under AICRP-RM physiological trials. Similarly, genotypes DRMR 2019 and DRMR 2035 were identified as resistant against white rust under plant pathological trials. 4 entries were inducted in physiological trials for evaluation of heat and drought tolerance and 10 entries in pathological trials for evaluation of disease reaction under NDN/UDN trials of AICRP-RM during 2017-18.

Germplasm registration

Germplasm DRMR-2019 (IC0598622; INGR17077) and DRMR-2035 (IC0598623; INGR17078) of Indian mustard (*B. juncea* L.) were registered by Plant Germplasm Registration Committee of ICAR-NBPGR, New Delhi for white rust resistance.

Re-synthesized *B. juncea* progenies

During rabi 2016-17, S3 progenies revealed good variability for different agro-morphological traits *viz.,* PH 126.0-305.0 cm, PB 4.0-22.0, SB 14.0-67.0, MSL 39.0-110.0 cm, SMS 40.0-134.0, SL 3.0- 7.4 cm, S/S 8.0- 22.0, OC 36.01- 44.30 %, 1000-SW 2.52- 8.38g, DF 27.0-68.0 & DM 103.0-157.0 days. Five progenies *viz.*, S3/100-8-1 (32.35), S3/108-2-5 (33.07), S3/100-8-18 (37.28), S3/100-8-2 (39.45) and S3/108-2-6 (42.21) revealed low GSL near to 30 µm/g of oil free meal.

During rabi 2017-18, 292 S4 and 27 S5 single plant progenies with 4 check genotypes (NRCHB 101, Giriraj, NPJ 112, RH 749, alternatively repeated after ten entries) were planted in the field for evaluation, selections and stabilization. The data were recorded on various agro-morphological traits and a considerable genetic variability for maturity, plant type, branching pattern, height, siliqua density, seed size, yield and other desirable traits has been observed. Nearly 270 single plants from S4 and 24 SPS from S5 progenies were selected.

Similarly, 50 S6 progenies from WR free SPS/progenies selected at off-season nursery, Wellington (Kharif 2017) were again screened and advanced at DRMR. Of them 26 progenies

revealed resistance against WR, 13 showed mixed reaction and 11 progenies were found susceptible. A total of 48 desirable SPS were selected from S6 progenies for further advancement and evaluation. About 105 S4 progenies, all 27 S5 progenies and 33 S6 progenies were artificially inoculated (five plants each) for Sclerotinia stem rot and the progenies showed resistant / tolerant reaction will be further screened rigorously.

Fifteen S2 progenies from inter-specific cross *B. rapa* x *B. nigra* (Jhumka x SKJ-2) were planted in pots (2 pot each) to select fresh re-synthesized *B. juncea* progenies. The progenies revealed true *B. juncea* type morphological features with observable variation for component traits. Three plants reverted towards rapa type, 7 revealed semi sterility and 4 were completely sterile. Seeds were collected from 39 individual plants to advance during next season. In addition, 8 S2, 35 S4, 12 S5 and 26 other genotypes were also maintained and advanced in pots.

Four progenies (F3) from *B. rapa* x *B. nigra* inter-specific crosses viz., Ragini x BN-2, YSH-401 x BN-2 and YSH-401 x SKJ-2 were planted in field. A good variability was observed for plants having traits like yellow sarson type plants with bilocular siliqua; toria type plants with tetralocular siliqua and brown seeds; toria type plants with bold seeds and hard stem; brown sarson type plant with bold seeds, long main shoot and high siliqua density, *etc.* Desirable plants were selected and harvested individually.

F4 progenies from crosses of amphidiploids

During 2017-18, 13 F4 single plant progenies from inter-specific cross between *B. carinata* and *B. napus* (NRCKR 304 x NRCGS-1) were planted in the field to derive improved *B. juncea* and *B. carinata*/*B. napus* genotypes with desirable traits. The progenies again revealed high segregation for carinata, intermediate, juncea type and sterile plants with sufficient genetic variability for desirable traits. About 40 desirable single plants were selected and harvested individually.

Selection from inter-specific F2 populations

Seventeen SPS from three inter-specific crosses NRCHB 101 x NRCKR 304 (6), NRCHB 101 x NRCGS-1 (4) and NRCHB 101 x *S. alba* (7) were selected during 2016-17 and their single plant populations/progenies (4-5 rows of 5m each) were planted in the field during 2017-18. Five plants from each row of each progeny (population) were artificially inoculated for Sclerotinia rot and data were recorded for disease development which revealed tolerance in many plants. Desirable 30 single plants were selected.

F2 population from a cross between *B. juncea* and *B. rapa* var. brown sarson (NRCHB 101 x Pusa Kalyani) was planted in pots which revealed a range of complete sterile, semi-sterile, fully fertile, juncea type, intermediate and rapa type of plants. Seeds from 34 single plants were harvested.

Evaluation of advanced breeding lines

Twenty advance lines along with 4 checks (RH 749, DRMRIJ 31, NRCHB 101 and Kranti) were evaluated in RCBD with 3 replications. The trial was sown in 5 rows of 5m with row to row distance of 45 cm and data were recorded on various traits. Entries DRMR 2017-16 (2776 kg/ha) and DRMR 2017-30 (2670 kg/ha) over yielded best check NRCHB 101(2522 kg/ha).

Generation advancement and selection from segregating generations

During rabi 2017-18, nineteen F2 populations of DRMRIJ 31 x (NPJ 112 x RRN 727), 749 x NPJ 112, DRMR 2035 x NPJ 112, RRN 727 x BPRQL 1-5 (DRMR 1-5), TM 106-1 x Navgold, TM 128 x Basanti, TM 215 x Basanti, TM 121 x Basanti, TM 215 x RH 1231, TM 4 x Basanti, TM 106-1 x RH 1231, NRCHB 101 x DRMR 2019, DRMR 2035 x NRCHB 101, NRCDR 2 x NPJ 112, RH 406 x RRN 727, NRCDR 2 x RH 406, RH 749 x NRCDR 2, [(RH 749 x NRCHB 101) x (NRCDR 2 x RH 406)] and [(RH 749 x Rohini) x (NRCDR 2 x RH 406)] crosses were planted in 35 rows of 5m each to select desirable plants for component traits and yield attributes. In addition, 50 more rows of F2 (DRMR 2035 x NRCHB 101) were also planted to develop a RIL (self seeds from more than 600 individual plants were collected) and about 155 plants were artificially inoculated for Sclerotinia stem rot and data were recorded. The symptoms of disease were developed only on 32 plants. Similarly, 153+29 F3 (9 crosses), 15 BC1F3 (one cross), 156 F4 (9 crosses), 50 F5 (3 crosses) progenies and 41

advanced lines from various crosses were grown for generation advancement and selection of desirable progenies/lines. The data were recorded on different traits and selections were made accordingly. A good genetic variability was observed for different component traits. A total of 623 SPS from F2, 168 F3, 148 F4, 32 F5 and 17 from BC1F3 progenies were selected.

Raising inter-varietal F1 crosses (*B. juncea*)

Forty two inter varietal crosses including 28 crosses between NRCHB 101, DRMRIJ 31, RH 406, RH 1301, RH 555, RH 1117, RH 1060 and NPJ 112 in 8 x 8 diallel fashion and 14 crosses *viz.*, DRMRIJ 31/ NRCHB 101, DRMRIJ 31/ RH 749, DRMRIJ 31/ Urwashi, DRMRIJ 31/ Pusa Bold, NRCHB 101/ Pusa Bold, NRCHB 101/ Urwashi, NPJ 112/ Urwashi, NPJ 112/ Pusa Bold, NPJ 112/ RH 555, NPJ 112/ BPR 543-2, RH 1222-28/ DRMRIJ 31, RH 1222-28/ NRCHB 101, RH 1222-28/ RH 406, RH 1222-28/ RH 555 generated during 2016-17 for various traits like high seed yield, bold seed, high temperature tolerance, long siliqua, disease resistance and adaptation under various sowing conditions. These were planted in field during rabi 2017-18 for evaluation and the data were recorded. F1 NRCHB 101 x RH 555 (13.85 %) and DRMRIJ 31 x RH 406 (13.08%) revealed heterosis over better parent for seed yield/plot.

Generation and maintenance of breeding material

During 2017-18 a total of 32 inter varietal/inter-specific direct crosses and 20 back crosses were generated and 96 germplasm lines / donors / genotypes of different species (*B. juncea*, Toria, BS, YS, *B. napus*, *B. carinata*, *B. alba*, *B. nigra*) for various traits were maintained.

Selection for tetralocular genotypes

The advance progeny DRMRTJ-2016 having tetra-locular siliquae and long main shoot with other desirable traits was advanced and evaluated along with check variety Geeta during 2017-18. Average plant height (cm), number of primary branches, main shoot length (cm), number of siliquae on main shoot (SMS), siliqua length (cm), seeds / siliqua, 1000-SW (g), oil content (%), seed yield/plant (g) were (262.6, 217.6), (13.4, 10.6), (118.4, 81.4), (133.2, 74.4), (4.42, 3.90), (20.4, 18.5), (5.33, 5.17), (38.56, 39.41), (32.7, 25.2) recorded in genotype DRMRTJ-2016 and Geeta, respectively.

Screening at off-season nursery, Wellington (TN)

During kharif 2017, about 85 genotypes including 33 S5 re-synthesized *B. juncea* progenies, 25 segregating (F5, F4, F3) progenies from three crosses [DRMR 2019 x NRCDR 2; DRMR 2035 x NRCHB 101; (DRMR 2035 x NRCHB 101 x DRMR 2019 x NRCDR 2)], 5 BC1F3 (DRMR 2035 x NRCHB 101/NRCHB 101) progenies, one F2 (NRCHB 101 x DRMR 2019), 8 M5 mutant progenies including purple mutant progeny, 01 white flower toria genotype and 6 advance breeding lines (DRMR 2035, DRMR 2019, DRMR 5206, DRMRTJ 16, WFYSM 15, WFBSM 15-1,) along with 6 check genotypes (BioYSR, Varuna, Kranti, NRCHB 101, Giriraj and Bhawani) were planted at off-season nursery, Wellington for screening against white rust and rapid generation advancement. Data were recorded on WR reaction and about 17 progenies including 8 re-synthesized *B. juncea* (S5), 5 F5 (DRMR 2019 x NRCDR 2), 2 advance lines (DRMR 2019 and DRMR 2035), one M5 mutant progeny and check BioYSR revealed complete resistance (score: 0.0), 21 progenies showed mixed reaction or segregation for resistant and susceptible plants (score: 0 to 9), M5 purple mutant progeny revealed moderate resistance with score of 4.0 and all other progenies were found susceptible. Resistant plants were selfed and seeds from 97 SPS were collected at maturity to further screen and advance during rabi season.

The 97 single plant progenies including 50 S6 progenies and 47 progenies from 2 F6 (DRMR 2019 x NRCHB 101 and DRMR 2035 x NRCDR 2), 1 F4 [(DRMR 2019 x NRCHB 101) x (DRMR 2035 x NRCDR 2)], 7 M6 progenies and 2 advance lines (DRMR 2019 and DRMR 5204) were planted during rabi 2017-18 at DRMR. Out of these 43 progenies, including advance lines, were revealed resistance for WR, 24 showed mixed reaction and 31 progenies were found susceptible.

DRMR-CI-16: Breeding for white rust and stem rot resistance/tolerance in Indian mustard

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

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

Generation of breeding material

Ninety five fresh crosses were generated using white rust and stem rot resistance/tolerance parents and high yielding genotypes including Bio YSR, DRMR 2035, DRMR 2019, RH 1222-28, RH 1034, DRMR 1542, DRMR1493, NRCDRIJ 31,NRCDR-02,NRCHB 101, RH 749, Pusa Bold, Varuna, Kranti and Basanti. Crosses were attempted using Lines × Testers mating design. Resistant donors and high yielding genotypes were planted and screened for white rust and stem rot.

Raising F1 Crosses

Four F1 Crosses (RH 1222-28 X RH 406, RH 1222-28 X RH 555, RH 1222-28 X NRCHB 101 and RH 1222-28 X DRMRIJ 31) were planted and screened for Sclerotinia rot resistance. crosses RH 1222-28 X RH 406, RH 1222-28 X RH 555 revealed tolerant reaction.

2.2 Designer Brassica for oil quality

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

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

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

Genotype DRMR 1-5 identified as white rust resistant double low line during annual group meeting of AICRP-RM, 2017 and approved by Institute Germplasm Registration Committee for registration. One line DRMRQ 4 contributed as a double low entry for IVT under AICRP-RM, 2017-18. A total of 78 and 55 near double low lines in F3 and F5 generation were advanced to F4 and F6 generation, respectively along with single plant selection for high yielding attributes.

Genotype DRMRQ 5-5-1-15 derived from the cross involving parents JR 042 and NRCDR-02 has been identified in F5 generation containing 45% oleic acid content in oil. This line also showed low erucic acid content (<2%) in oil. It possesses medium range of glucosinolate content (53.22 µM per gram defatted seed meal) with 42% oil content and 3.37g 1000 weight. Further generation advancement and selection has been done during rabi 2017-18.

Nutritional profiling of advanced breeding lines

Biochemical analysis for fatty acid in oil and glucosinolate content in seed meal as well as 1000 seed weight of 51 advanced breeding lines developed from different crosses involving quality and high yielding lines were done by using selfed seed. In these lines, saturated fatty acid (SFA) ranged from 3.61-5.07%, oleic acid from 23.08-44.92 %, linoleic acid from 27.16-38.59%, linolenic acid from 11.22-28.00%, erucic acid from 0.32-4.63 per cent, glucosinolate content from 14.95-31.59 µmole/g of defatted seed meal, oil content ranged from 40.89-43.83 per cent and 1000-seed weight ranged from 2.28-3.45g (Fig. 2.6 and Fig. 2.7). Out of these lines, a total of 44 lines have been evaluated for yield along with 4 checks (quality and high yield) in RBD with 3 replications. Agro-morphological observations were taken for 13 traits in these lines as well as checks.

Fig. 2.5: Plant type of genotype DRMR 1-5

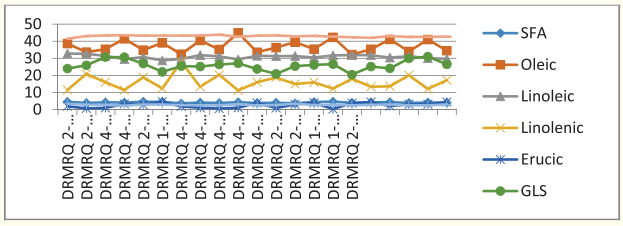


Fig. 2.6 Nutritional profiling of 21 advanced breeding lines.

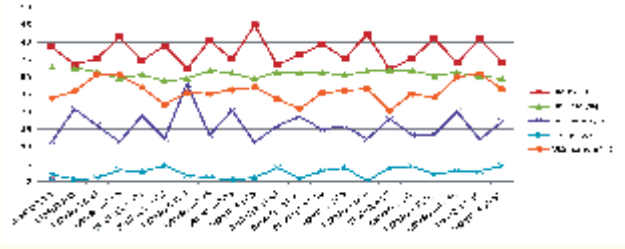


Fig. 2.7 Nutritional profiling of 30 advanced breeding lines.

Biochemical analysis of selfed seed of 88 single plant selection (SPS) of F5 generation of 4 crosses involving high yielding (NRCDR 2, NRCHB 101) and quality donor parents (LES 1-27, LES-44, LES-46, RLC-2) showed glucosinolate content ranging from 18.63 to 146.29 µmole/g of defatted seed meal with 37.39-43.81% oil content and 2.65-6.52g 1000-seed weight (Fig. 2.8). Forty one SPS with 30-55 µmole glucosinolate/g of defatted seed meal were analyzed for fatty acid profiling of seed oil. SFA ranged from 2.70-4.63%, oleic acid from 10.77-41.17%, linoleic acid from 16.37-37.09%, linolenic acid from 10.17-29.46%, ecosenoic acid from 3.68-16.46% and erucic acid from 0.22-38.64 % (Fig. 2.9).

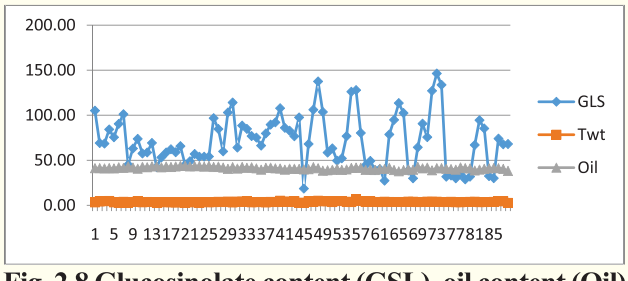


Fig. 2.8 Glucosinolate content (GSL), oil content (Oil) and 1000-seed weight (Twt) of 88 SPS (F_5 generation)

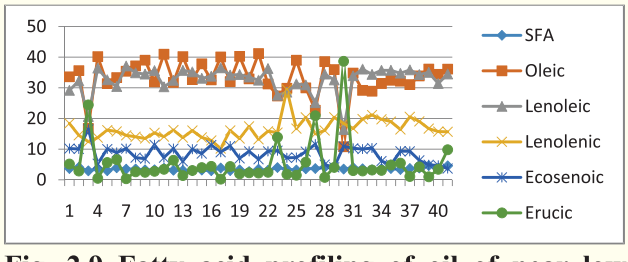


Fig. 2.9 Fatty acid profiling of oil of near low glucosinolate lines.

Biochemical analysis of seed samples of 145 SPS of F3 generation of 6 crosses developed by involving high yielding (NRCDR 2, NRCHB 101, Pusa Mustard 25) and quality donor parents (Heera, JN032) have been done. Out of which 103 SPS showed low to near low glucosinolate content ranging from 6.27 to 69.86 µmole/g of defatted seed meal with oil content ranging from 37.99-43.11 % and 1000-seed weight ranging from 1.37-4.45g (Fig. 2.10).

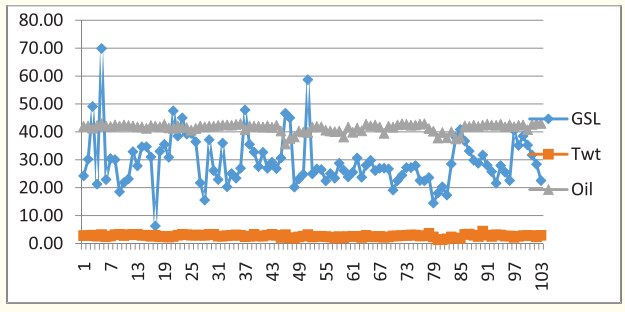


Fig. 2.10: Glucosinolate content, oil content and 1000-seed weight of 103 SPS (F_3 generation)

Generation of breeding materials

A total of 10 F1s were selfed to get F2 seed. Single plant selections were made from two large F2 populations for identification of any transgressive segregant having high yielding characters with quality traits. A total of 24 back crosses were attempted with both donor (quality line) and recipient (high yielding line) parents. Also, 14 single crosses involving quality and high yielding parents were generated.

DRMR B 7: Proteomic studies in oilseed Brassica

Principal Investigator: Ibandalin Mawlong, Scientist (Plant Biochemistry)

Co-Investigator: M.S. Sujith Kumar, Scientist (Plant Biochemistry), O.P. Premi, Pr. Scientist (Agronomy), Arun Kumar, Sr. Scientist (Cytogenetics)

Relationship studies between oil storage bodies and its structural protein

Standardization of the experiments for oleosin extraction and oil body size showed that the oil storage body and its protein are significantly correlated with each other. The oil content too was found to be positively correlated with size of

oil body and its structural protein. To understand further, we evaluated storage protein under different levels of nitrogen treatment.

Physico-chemical properties of oil under nitrogen fertilization

Twenty four genotypes for different pigments and oil colour under N_0 and N_{80} levels of fertilization were evluated. Most of the genotypes were found to have oil colour coordinates of L* 72 to 78, while a* and b* colour coordinates did not vary that much. Genotypes with a shift in L* coordinates from 78 to 72 under N_{80} had lower β-carotene content with a decreased by 11.30 % (IC212031) to 68 % (Maya). Among the two classes of pheophytin, pheophytin *a* was found to be dominant under N_{80}. Chlorophyll *a* was absent in almost all the oil samples. In N_{80} the rate of degradation of chlorophyll *a* into its product pheophytin *a* is greater over that of control as evident from the negative correlation of chlorophyll *a* and pheophytin *a* (r=-0.54). Peroxide value (PV) was found to be negatively correlated to all pigments under N_0. In case of acid value (AV) under N_0, the stability of oil seem to be more contributed by β-carotene, whereas under N_{80} the oxidative stability of oil, as indicated by AV and PV, appears to be contributed more by pheophytins. There was also improvement in oil stability index (OSI) under N_{80} treatment as compared to N_0 application.

DRMR B 8: Screening of oilseed Brassica germplasm for value addition

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

Co-Investigator: Ibandalin Mawlong, Scientist (Plant Biochemistry), K.H. Singh, Pr. Scientist (Genetics and Plant Breeding), Prashant Yadav, Scientist (Biotechnology)

Variation in anti-nutritional factors among different species of oilseed Brassica

The study was intended to understand the distribution and correlation of anti-nutritional compounds such as erucic acid, glucosinolates, phytic acid and crude fiber in different species of oilseed Brassica. Seeds of different species obtained from the germplasm ICAR-DRMR, were used for biochemical analysis. Forty five cultivated varieties of oilseed Brassica belonging to 7 different taxa were analyzed. Crude fiber content was estimated by FT-NIR. Fatty acid profiling was performed by gas chromatography to quantify erucic acid and other individual fatty acids. Seed meal was separated after homogenizing crushed seeds with hexane. Glucosinolate and phytic acid contents were estimated in the seed meal fraction by spectrophotometric methods following standard protocols.

Highest average erucic content was recorded in yellow sarson group (40.3%) with highest level in YSH-401 (48.5%). Varieties belonging to *B. napus* group had the lowest average content (20.7%) with the lowest level in Neelam (14.1%). Average glucosinolate content was found to be highest in the *B. rapa var. toria* group (172.80 µmol/g) with highest level recorded by variety PT 30 (204.77 µmol/g). Varieties belonging to the *Eruca sativa* (119.05 µmol/g) group were found to have the lowest average glucosinolate content while the lowest level was recorded by *B. carinata* variety Pusa Aditya (69.7 µmol/g). Highest average phytate content was recorded by the *B. carinata* group (3.3%) while highest level of phytate content was observed in Ragini (6.15%) which is a yellow sarson variety. Lowest average phytate content was recorded by *B. juncea* group (1.2%) with lowest level in variety RH 781 (0.2%). The mean crude fiber content was found highest in Brown sarson group (10.9%) and lowest in yellow sarson (7.5%). *B. carinata* (1.73%) showed highest total phenol content while it was lowest in toria (1.2%).

DRMR B-9: Quantitative and qualitative

estimation of glucosinolates and fatty acids in oilseed Brassica

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

Co-Investigator: Arun Kumar, Sr. Scientist (Cytogenetics)

Biochemical characterization of aliphatic glucosinolate was carried out in two selected varieties *i.e.* Giriraj and PDZ 4 using hexane. Extraction time with hexane was increased to get large number of phytochemicals. Hexane extract also showed large variation in the type and amount of bioactive compounds. Aliphatic glucosinolate content was found to be highest in the hexane extract as compared to the methanolic extract (Table 2.6). Aliphatic glucosinolate content was recorded 44.34 µmol/g in PDZ-4 whereas Giriraj shows 52.67 µmol/g. Other biochemical parameters including erucic acid, phytic acid, beta carotene content in the seed meal was also studied. GC analysis of core set showed presence of important fatty acids (e.g. palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, eicosanoic acid, & erucic acid). However GC-MS analysis showed presence of various medicinally important phytochemicals. Major identified compounds are ketones, thiols, aldehydes, fatty acids, carbohydrates.

Table 2.6 Bioactive compounds after hexane and methanolic extraction

RT± 0.5 (min)	Components after Hexane extraction	% area	RT± 0.5 (min)	Components after methanolic extraction	% area
3.69	Methallyl cyanide	11.14	-	Methallyl cyanide	-
3.88	Acetic acid	10.98	6.58	Oxime-, methoxy-phenyl-	0.63
5.151	Allyl Isothiocyanate	1.39	7.52	1,3-Cyclopentanedione	0.87
5.95	Oxime-, methoxy-phenyl-	0.38	16.63	3,4-Altrosan	8.67
6.732	1-Butene, 4-isothiocyanato-	4.19	-	1-Butene, 4-isothiocyanato-	-
9.85	4H-Pyran-4-one, 2,3-dihydro-3, 5-dihydroxy-6-methyl-	1.97	8.82	4H-Pyran-4-one, 2, 3-dihydro-3, 5-dihydroxy-6-methyl-	1.57
11.39	2-Furancarboxaldehyde, 5-(hydroxym ethyl)-	15.42	12.40	2-Furancarboxaldehyde, 5-(hydroxym ethyl)-	20.69
17.06	Methyl .beta.-d-galactopyranoside	23.21	17.09	.alpha.-D-Galactopyranoside, methy	19.81

Identification of Potential furans (5-Hydroxymethyl-2-furancarboxaldehyde)

The chromatographic separation of the methanolic extract was done on a capillary column of fused silica HP-5m (0.25 mm × 30 m× 0.25 µm film thicknesses) in GC-MS. The extract (2 µL) was injected in the split mode (1:50) by empty baffled liner at 280°C (Agilent no.5183-2037). The initial temperature was 50°C for 2 min which was programmed to 280°C at a rate of 5°C/min and finally held at 280°C for 3 min. HMF has been considered for the treatment of sickle cell disease.

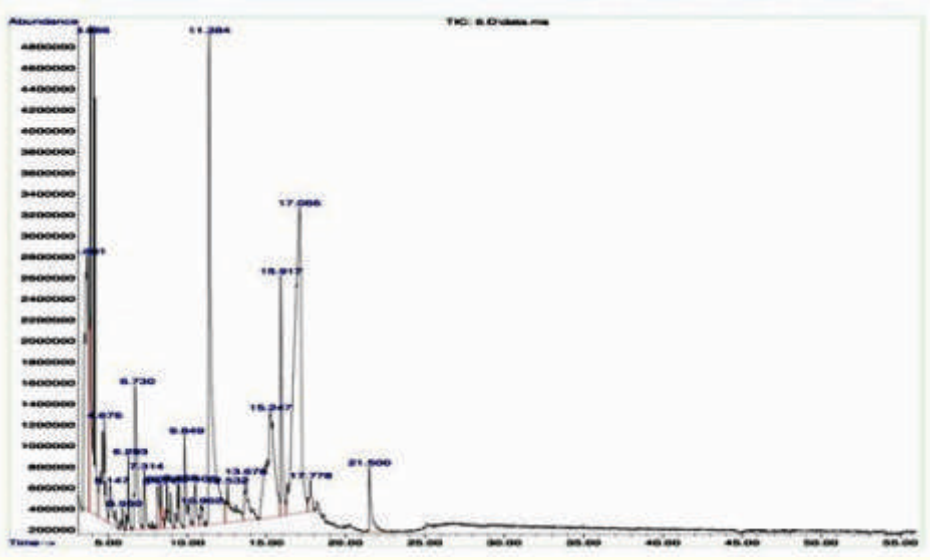


Fig. 2.11: Chromatogram showing 5-Hydroxymethyl-2-furancarboxaldehyde (HMF)

2.3Breeding for yield and quality enhancement in rapeseed-mustard

DRMRCI 05: Development of hybrids in Indian mustard

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

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

Eight strains, including three experimental hybrids, DRMRIJ16-51, DRMRIC 16-38, DRMRIJ 16-66, DRMRIC 16-38, DRMRHJ 918, DRMRHJ 2517, DRMRHJ 2503, and DRMRIJ 16-66, were inducted for evaluation under AICRPRM during 2017-18. One genetic stock, DRMR MJA 35 (IC0622804, INGR 17048), a CMS line of *B. juncea* was registered by Plant Germplasm Registration Committee, ICAR for white rust resistance.

Table 2.7: performance of experimental hybrids

Ex. hybrid	SY (kg/ha)	Heterosis %
HJ 1108	2785	11.7
HJ 1403	2756	10.5
HJ 308	2948	18.2
HJ 918	2919	17.0
DMH 1 (Check)	2494	

Thirty six experimental hybrids were evaluated in multiplication trials at four centres; ICAR-DRMR Bharatpur, ICAR-IARI New Delhi, PAU Ludhiana and CCSHAU Hisar. One experimental hybrid HJ 303 (1307 kg/ha oil yield) surpassed the highest yielding check DMH 1 (1266 kg/ha oil yield) by a margin of 3.2% on the basis of mean oil yield. However, four experimental hybrids, HJ 303, HJ 1403, Pusa MH 5 and PHR 3326 excelled the varietal check NRCHB 101 (oil yield 1138 kg/ha) for oil yield by a margin of 14.9, 12.3, 6.1 and 5.3% respectively. Twenty three experimental hybrids were evaluated alongwith 4 checks; Giriraj, RH 749, NRCHB 506 and DMH 1, in Station Trial 2, keeping plot size of five rows of five m length with three replications. On the basis of seed and oil yield experimental hybrids; HJ 308, HJ 1108, HJ 1403 and HJ 918 were found promising.

In addition, 12 pureline entries including 4 of *B. carinata* and 8 of *B. juncea* were evaluated in replicated trial along with four checks; PC 6, Pusa Swarnim, Giriraj and RGN 73. On the basis of seed yield two entries; IJ 13-5-3 (seed yield 3210 kg/ha, pedigree: MJA 27/MJR 4//DRMRIJ 20) and IJ 14-5 (Seed yield 3086 kg/ha, pedigree: IJ 31 X LET 36) out yielded the best check RGN 73 (2938 kg/ha) by a margin of 9.3 and 5.0%, respectively.

Sixty six F_1 crosses, contributed by each of four cooperating centres were, pooled and evaluated

under two multilocation trials at all four centres to identify the heterotic combinations, out of these, two crosses, RH 1556 X NPJ 112 and PHR 3330 were identified for high heterosis. 128 F_1 crosses were evaluated in augmented block design with 2 checks; Giriraj and DMH 1. MJA 11/MJR 34, MJA 8/MJR 34, MJA39-3-2-1/MJR8, MJA 15/ HB 9914 and OJA 39-3-2-2/ OJR EC399307 expressed 20.1, 22.8, 21.8, 15.0 and 17.5 % heterosis for seed yield, respectively, over best check DMH 1.

Conversion of CMS and restorer lines

Thirty one backcrosses were attempted for conversion of CMS line and eleven backcrosses were attempted to advance the generation of restorer lines under conversion programme

Advanced A and R lines maintained

Twelve CMS lines; MJA 5, MJA 8, MJA 3, MJA 9, MJA 10, MJA 14, MJA 15, MJA 24, MJA 25, MJA 35, MJA 38, MJA 31, MJA 37 were maintained/multiplied through raising respective A and B lines under net. Eight restorer lines MJR 3, MJR 8, MJR 9, MJR 13, MJR 17, MJR 18, MJR 19 and MJR 20 were maintained through selfing.

Generation of F_1 crosses to identify heterotic combinations

170 new crosses were attempted involving, two Line X Tester (11x6 and 14x4) and 48 test crosses.

LT (14 X 4): Lines - MJB 3, MJB 10, MJB 37, IJ 31, MJB 14, MJB 8, MJB 11, MJB 24, MJB 25, MJB 9, MJB 5, MJB 4, MJB 15, HB 9925; Tester: RGN 73, RH 749, EH 2, IJ 17-40

LT (11 X 6): Lines – MJA 11, MJA 24, MJA 25, MJA 9, MJA 5, MJA 4, MJA39, MJA 10, MJA 14, MJA 39-3-2-2, MJA 37; Tester - MJR 1, MJR 20, MJR 21, MJR 8, RP 7-3-1-14, RP 10-2-1-10

Seed production of experimental hybrids in isolation

Seed of 22 experimental hybrids was produced in isolation.

Screening and selection of plants for desired trait

Twenty seven lines which have expressed resistant reaction against white rust during 2016-17, were screened at IARI Regional station Wellington during off season 2017 against white rust and resistant lines were selfed. Resistant lines were multiplied at DRMR, Bharatpur during *rabi* season 2017-18.

Development of inbreds

Single plant selection was practiced from segregating populations of crosses. F_2: MJA37 X MJR4009, MJA10 X MJR3, PEMH-8; F_3: IJ31 X EH2, NRCHB 101 X EH2, EC 597313 X MJR 13 (F_2 4-4); F4: IJ31 X LET 36 (F_3 1-8), MJA 9 X MJR13 (F_3 6-3). Eighty three progeny rows were grown in augmented block design to evaluate the performance of progenies for agronomic traits.

Table 2.8: Mean estimates and range for different characteristics in progeny rows

	DFI	DFS	DM	Seed yield (g/plot)	Seeds/ siliqua	1000-SW (g)	OC (%)	PH (cm)	MSL (cm)
Mean	53.6	90.1	128.7	394	16.2	4.9	41.7	190.5	76.9
Variance	36.5	47.6	30.2	008	3.0	1.5	0.48	209.3	134.2
Range	34	38	24	576	8.9	5.6	3.2	98	56
Minimum	42	82	119	074	11.8	2.7	39.8	145	46
Maximum	76	120	143	650	20.8	8.3	43.1	243	102

One hundred forty three inbred lines were classified into two groups; early maturity and medium maturity on the basis of maturity duration and were planted in two separate experiments in augmented block design for evaluation of their agronomic traits. Early group involved 51 inbred lines and medium maturity group included 92 inbred lines. Mean, variance and range for different agronomic traits are presented in following table. 143 inbred lines were maintained through selfing and three inbred lines; DRMRIJ 16-51, 16-66 and 16-38 were multiplied under net.

Table 2.9: Mean, variance and range for agronomic traits among inbred lines of *B. juncea*

Head	DFI	DFS	DM	S/S	1000 SW (g)	OC (%)	PH (cm)	MSL (cm)
Inbred (Early maturity)								
Mean	44.1	91.4	120.9	14.1	4.7	40.7	181.7	75.2
Variance	152	165.0	35.0	5.2	1.0	1.0	321.8	178.7
Range	45	47	29	9.9	4.3	3.8	75	61.2
Minimum	27	62	103	7.7	2.7	38.8	142	50
Maximum	72	109	132	17.6	7.1	42.6	217	111.2
Inbred (Medium maturity)								
Mean	54.1	94.2	129.4	-	4.7	41.2	184.7	77.6
Variance	127.9	119.3	85.0	-	1.3	1.3	320.3	181.3
Range	52	59	37	-	4.8	5.84	84	82.75
Minimum	31	65	111	-	2.6	37.8	130	34.2
Maximum	83	124	148	-	7.4	43.6	214	117

Estimation of genetic diversity among inbred/ germplasm resources

One hundred germplasm/inbred lines along with two checks *i.e.* Kranti and Giriraj were grown in paired row in augmented block design. Observations on days to flower initiation, days to maturity, plant height (cm), seeds/siliqua, main shoot length (cm), 1000-seed weight (g), oil content (%) and seed yield were recorded.

2.4 Oilseed *Brassica* genetic resource management

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

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

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

Regeneration and maintenance

A total of 2403 germplasm accessions of rapeseed-mustard including 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 were regenerated and multiplied by adopting proper pollination control techniques.

Characterization and evaluation

Eighty Nine accessions of Indian mustard were screened for heat tolerance at seedling stage in ABD with five blocks. A total of 604 germplasm accessions of Indian mustard were sown in November, 2017 for evaluation of terminal heat tolerance in augmented block design. A total of 303 lines of trait specific reference set and core set of Indian mustard were sown for revalidation of different agro-morphological traits. About 200 single plant selections of rapeseed-mustard were on the basis of siliqua bearing, siliqua length, plant height. Twelve Hundred germplasm accessions of Indian mustard were screened for resistance to stem rot disease through artificial stem inoculation technique. Selfed seeds were harvested from tolerant plants which will be revalidate in next growing season under sick plot.

A total of 141 germplasm accessions of yellow sarson (*B. rapa* var. *yellow sarson*) were characterized for different agro-morphological traits in augmented block design.

Germplasm distribution

A total of 143 accessions of rapeseed-mustard germplasm were distributed to different indenters.

2.3 Biotechnological interventions to improve rapeseed - mustard productivity

DRMR BT-01: Enhancing the level of resistance/tolerance against Alternaria blight in Indian mustard (*Brassica juncea* L. Czern. & Coss.) using biotechnological approaches

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

Introgression of Alternaria blight tolerance from wild crucifers

During 2017-18, 200 crosses of *B. juncea* var. Giriraj and wild crucifer, *S. alba* were attempted for introgression of genes imparting Alternaria blight tolerance to Indian mustard. 10-12-day old ovaries were excised and after surface sterilization with 0.1% $HgCl_2$ for 2-3 minutes followed by washing with sterile distilled water three times, were cultured on to MS medium supplemented with 2.5 mg/l BAP & 500 mg/l casein hydrolysate. Casein hydrolysate was added to the molten MS medium by membrane filter sterilization. The ovaries were excised and the developing embryos were rescued and cultured on the same medium after 30-45 days. Shoot regeneration could take place within 10-12 days after culturing. However, the frequency of shoot development from the excised embryos was very much low (Table 2.10). The shoots were multiplied and maintained on MS medium containing 2.5 mg/l BAP. Each shoot arising from an embryo was considered as a single independent F1 progeny/event. These F1 plants were then multiplied on the same shoot regeneration medium. For confirmation of hybridity of F1 plants using SSR markers, genomic-DNA had been extracted and purified from 7 F1 plants along with both of the parents.

Table 2.10. Introgression of Alternaria blight tolerance from *Sinapis alba* into *Brassica juncea* through embryo rescue

Cross combination	Days of ovary culture (No. of days after pollination)	No. of ovaries cultured	No. of ovules further inoculated	No. of ovules showing further germination
Giriraj x *S. alba*	10-12	750	16	7

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 (*B. juncea*) productivity through organics under semi-arid region of Rajasthan.

The long term replicated experiment under a fallow-mustard system is in progress since 2005-06, 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 twelfth harvest of mustard crop indicated that green manuring with sesbania significantly increased mustard seed yield by 24.1% over control. Supplementary incorporation of MSI @ 2.5t/ha further augmented the seed yield by 9.9% over SGM alone and by 36.4% over control (Table 2.11). Application of balance fertilizer (F8) increased the seed yield at least by 28.4% over sub optimal doses F1, F2, F3 and F4.. Adoption of MSI + SGM system further augmented the seed yield at F8 at least by 31.8% over sub optimal doses (F1 to F4) indicating better nutrient recycling and availability for sustainable higher yields. The main effect of SOC management strategies over the period is presented in Fig 2.12.

Table 2.11: 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	1602	1865	1963	2062	2423	2456	2554	2686	**2201**
Sesbania (SGM)	2134	2417	2439	2822	2921	3017	3053	3151	**2732**
Mustard straw @ 2.5 t/ha + *Sesbania* (MSGM)	2661	2342	2632	2929	3220	3384	3350	3481	**3003**
Mean	**2133**	**2184**	**2345**	**2604**	**2855**	**2952**	**2986**	**3106**	**-**
CD (P=0.05)	CS: 110, Fertility level: 162, CS x Fertility level: 215								

*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)

In general, MSGM improved the microbial biomass carbon by 52.4 and 75.2% higher over SGM and CP, respectively. Similarly, the SOC increased by 0.13% and 0.02% over SGM and CP, respectively.

Evaluation of nutrient management strategies for sustainable mustard production

A dynamic mustard production system of higher resilience to biotic stress and changing climate is utmost important for sustainable productivity. Under this project 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

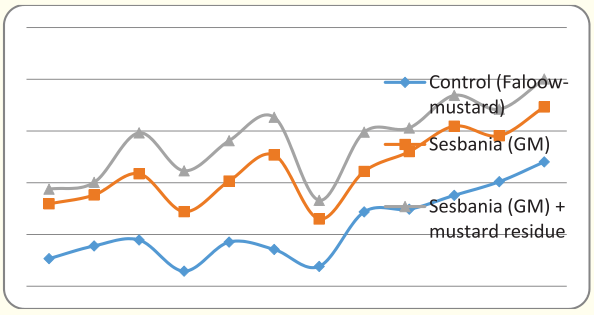


Fig. 2.12: Temporal effect of various mustard production systems

mustard straw incorporation, MSI+SGM, MSM: 2.5t/ha mustard straw mulch, FYM: 2.5t/ha farm yard manure and VC: 2.5t/ha vermicompost) in sub plot. The trial is being conducted in AxB+2 control randomized design keeping absolute control and conventional control (100% RDF) as checks.

Overall, use of organic source increased the seed yield by 15.2 and 24.0% over conventional absolute control (no fertilizer), respectively. Supplementing organic source with chemical fertilizers further augmented the seed yield of OSB by 22.4% due to MFM (Table 2.12).

Table 2.12 Effect of fertilizer management 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)	3269	2589	3626	2459	2912	2907	2960
MFM: Moderate (50% RDF)	2626	1945	2708	1945	2139	2399	2294
SFM: Subsistence (no fertilizer)	1966	1739	2226	1674	1772	1869	1874
Mean	2620	2091	2853	2026	2274	2392	-
AC: Absolute control- 763 CC: Conventional control (100%RDF)- 1627	CD 5%: 177						

Among the organic sources, MSI + SGM produced significantly higher seed yield than rest of the organic sources. It was followed by SGM and VC.

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 climate

Three tillage practices; permanent bed (PB), zero tillage (ZT) and conventional tillage (CT), and six mustard based cropping systems; Fallow-Mustard (F-M), Cluster bean-Mustard (CB-M), Green gram-Mustard (GG-M), Maize-Mustard (M-M), Pearl millet-Mustard (PM-M) and Sesame-Mustard (S-M) were studied under split plot design. Crop residues (anchored crop stubbles) retained in the permanent beds and zero tillage whereas, no residues in conventional tillage. Irrigation was applied through drip irrigation system. Zero tillage recorded significantly higher seed yield of mustard (2726 kg/ha) compared to bed planting (2486 kg/ha) and conventional tillage (2432 kg/ha) in the second year of experimentation. Among the cropping systems, mono-cropping system (fallow-mustard) recorded highest seed yield of

mustard (2861 kg/ha), however, under the double cropping systems, green gram-mustard (2731 kg/ha) and maize-mustard (2676 kg/ha) recorded highest seed yield of mustard. The yield of kharif crops converted to mustard equivalent yield and calculated the system productivity. The overall system productivity was recorded higher in ZT (3261 kg/ha) followed by PB (3247 kg/ha). Among the cropping systems, the highest system productivity was recorded in GG-M (3688 kg/ha) and M-M (3642 kg/ha) which was significantly higher over F-M. The system productivity of PM-M (2440 kg/ha) was lower than F-M (2861 kg/ha) might be due more residue load of pearl millet and temporary immobilization of the nutrients.

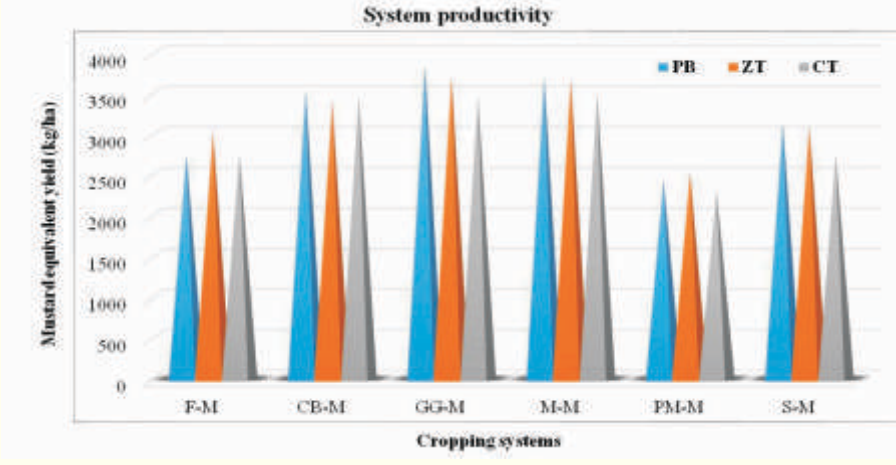


Fig. 2.13 Effect of tillage and cropping systems on system productivity

Ascertaining novel strategies to control broomrape in mustard

A preliminary trial with an array of control measures including bio pesticides, herbicides, fungicides and soil amendments were conducted at farmer's field (hot spot) in the Bayana Tehsil of Bharatpur district to control the broomrape. Among the different treatments, the maximum control in terms of number of broomrape plants per square meter were recorded with herbicides and also with neem oil (seed treatment). The minimum number of broomrape plants were recorded with pre plant application of metsulfuron methyl (3/m^2) followed by imezathapyr+imezamox (6/m^2), oxyflorfen (10/m^2), and neem oil (seed treatment) (11/m^2) as compared to control (32/m^2).

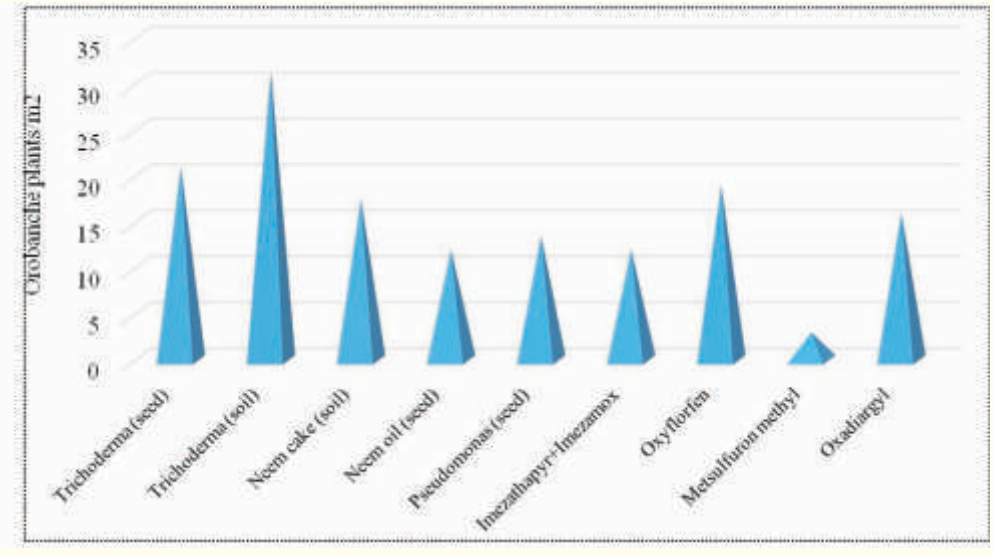


Fig. 2.14: Effect of bio pesticides, herbicides, fungicides and soil amendments on Orobanche plant population

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

An experiment comprising 15 treatment combinations replicated thrice, was laid out in split plot design with three treatments of FYM level (Control, @5 t/ha and @10 t/ha) and five treatment of sources of nutrient (control, 2.5 kg Zn + 1 kg B+ 5 Kg Fe + 10 kg S/ha, 5 kg Zn + 2 kg B+ 10kg Fe +20 S kg/ha, 2.5 kg Zn + 1 kg B+ 5 Kg Fe +10 kg S enriched FYM @ 500 kg/ha and 5 kg Zn + 2 kg B+ 10kg Fe+20 kg S enriched FYM @ 500 kg/ha). Application of micro and secondary nutrient by their enrichment with FYM significantly increased their availability in soil solution and also increased nutrient content in seed and stover results in significantly increases yield of mustard over control. Result showed that significantly highest seed yield (2964 kg/ha) 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 ($Zn_2B_2Fe_2S_2$ En) but at par effect was observed under the treatment in which micro and secondary nutrient applied at the rate of 2.5 kg Zn + 1 kg B+ 5 Kg Fe +10g S enriched FYM @ 500 kg/ha ($Zn_1B_1Fe_1S_1$En). Interactive effect of different level of FYM and sources of nutrient on seed yield of mustard revealed that half dose (@5 t/ha) of FYM is sufficient to obtained significantly highest seed yield of mustard when micro and secondary nutrient are applied by enriching with FYM. 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 ($Zn_2B_2Fe_2S_2$ En) increased the seed yield by 27.48 and 3.96 per cent over control and $Zn_1B_1Fe_1S_1$En, respectively.

DRMR CP-18: Growth and yield response to plant density and stage of transplanting in Indian mustard

Principal Investigator: Har Vir Singh, Scientist (Agronomy)

Co-Investigators: R.S. Jat, Pr. Scientist (Agronomy), M.K. Meena, Scientist (Soil Science)

Seedlings (10-14 days old) of Indian mustard variety RH 406 were transplanted at 30 x 30 cm, 45x30 cm and 60x60 cm spacing in field on 3 dates at about 10 days interval starting from October 13 to November 01. Recommended fertilizer dose 80 kg N and 17.5 kg P/ha was applied. All the P and half of the N were applied basally before planting; the other half of N was top-dressed at 30 days after sowing. Other package of practices, including insect, pests and weed control were followed according to local agronomic practices.

Significantly higher seed yield (4.01 t/ha) was obtained at October 13 transplanting. A decreasing trend in biomass production was observed with delayed transplanting. However, the geometric trend was observed to 45x30 cm>30x30 cm>60x30 cm. The yield trend in planting dates was recorded in October 13>October 22> November 01. The significant variation in yield and its attributes were also observed between the plant geometry and dates of transplanting (Table 2.13).

Table 2.13: Mean grain yield (q/ha) under different planting geometry and date of transplanting

Planting geometry (PG)	Date of transplanting (DOT)		
	October 13	October 22	November 01
30 x 30 cm	39.0	37.9	29.2
45 x 30 cm	43.6	41.5	32.5
60 x 30 cm	37.7	31.0	25.9
CD (P = 0.05)	PG :2.3, DOT: 2.8, PG x DOT: 1.4		

Among planting geometry 45 x 30 cm out yielded than other spacing, which was 10.7% and 24.4% higher over 30x30 cm and 60x30 cm, respectively. The interaction indicated that transplanting of mustard on October 13 at 45 x 30 cm spacing found the best option among the farmers to get maximum yield.

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

Recently composting of low grade sources of minerals with crop residues is getting importance as an organic fertilizer for improving mustard productivity and soil health. The aim of this research is to prepare low cost nutrient enriched compost using mustard stover mixed with rock phosphate, waste mica and feldspar and their effect on mustard yield and soil fertility. Low-grade rock phosphate (RP) from Rajasthan State Mines and Minerals Ltd., Udaipur, Rajasthan, India, was collected, for preparation of low cost nutrient enriched compost. The powder of RP (100-mesh) contained 12.91% total phosphorus (P). Feldspar was collected from Beawar of Ajmer district and it contained around 10.2% total potash (K). Another source of K, waste mica a K-bearing mineral, was obtained from the surroundings of mica mines located at Koderma district of Jharkhand, India. It belongs to muscovite mica (white mica), which has the theoretical composition of $(OH)_4K_2(Si_6Al_2)Al_4O_{20}$. The ground (2 mm sieve) mica contained 10.0% total K and very less amounts of water soluble K however, exchangeable and non-exchangeable amounts of K were 160 and 270 mg kg^{-1}, respectively. Mustard stover was collected from the experimental farm of ICAR-DRMR. Chemical characterization of mustard stover for nutrient content was completed.

2.7 Management of biotic stressed in Indian mustard

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

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

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

Maintenance of geographical isolates of *S. sclerotiorum*

Sixty five isolates of *S. sclerotiorum,* collected from different geographical regions of oilseed Brassica growing areas in the country, were cultured, purified and maintained.

Screening of *Brassicas* germplasm for stem rot tolerance

A total 1523 oilseed Brassica germplasm screened at ICAR-DRMR during *rabi* 2017-18. After artificial stem inoculation the lesion size and per cent infection were recorded. Among all the tested germplasm fifty two germplasm showed tolerance (lesion size <3.0 cm), and will be further evaluated under Sclerotinia sick plot during next season.

A total 189 *Brassica* lines from core set, exotic and mutant were screened under sick plot at DRMR sown on 26 Oct 2017 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design with two replications. Pathogen inoculum was mass multiplied on autoclaved sorghum grain and mixed with soil prior to sowing to create epiphytotic conditions. Further, the plants were stem inoculated with the mycelial bit of pathogen. Data for disease reaction was recorded. After artificial stem inoculation, the lesion size and per cent infection were recorded. Among all the tested germplasm RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695, IC 511651 and JM 6012 showed tolerant reaction (lesion size <3.0 cm and disease incidence<10%).

Epidemiology

Epidemiological study was conducted using seven dates of sowing starting from Oct 8, 2017 at weekly intervals with three replications in plot size of 4.5x5 m using cultivar DRMRIJ 31 of Indian mustard. Data for soil moisture at weekly intervals and disease incidence were recorded apart from petal infection and weather data to identify the suitable conditions for disease development. During the cropping season Sclerotinia stem rot incidence was low as weather condition was not much favourable for disease development. Data analysis revealed that maximum incidence was observed in 29 Oct (13.7%) followed by 22 Oct while it was minimum in 19 Nov (4.6%) sown crop. Incidence of Sclerotinia rot is always positively correlated with soil moisture, maximum and minimum temperature and bright sun shine hours (BSSH) and combination of these variables during critical stage of 60-70 DAS (flowering period) favoured higher Sclerotinia rot incidence (Fig 2.15). The highest seed yield was recorded in 8 Oct (36.4 q/ha) followed by 15 Oct (36.0 q/ha) while it was lowest in 19 Nov (12.6 q/ha) sown crop. Per cent petal infection (PPI) resulted, initiation of SR incidence in first standard week but later it was not increased due to unfavourable weather conditions for Sclerotinia rot development.

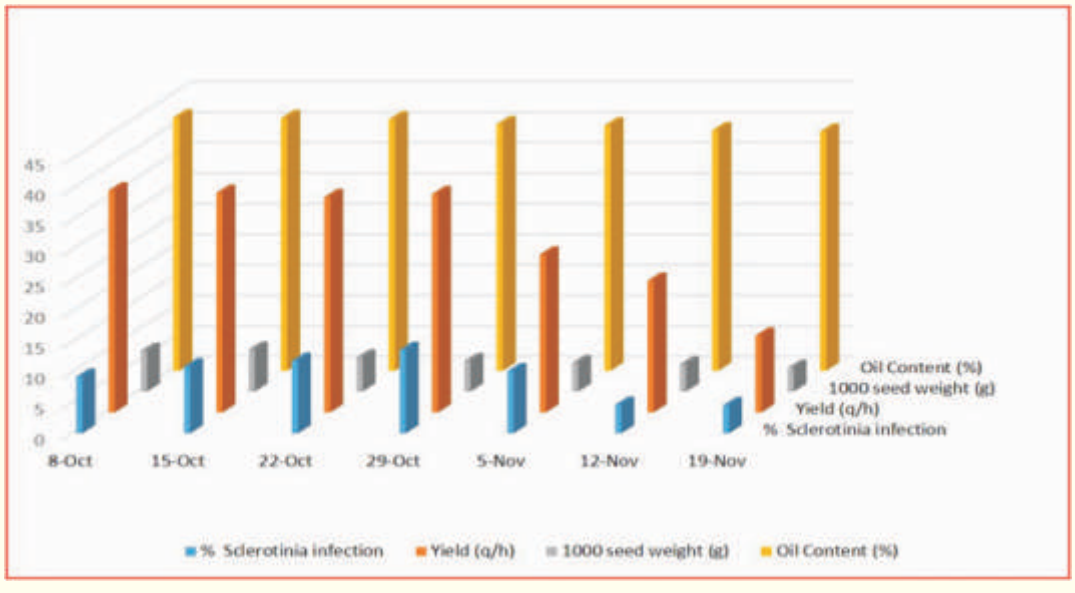


Fig. 2.15: Sclerotinia infection and yield attributes at different dates of sowing

Management of Sclerotinia rot

An experiment on management of Sclerotinia rot was laid out in randomized block design with 8 treatments (including control) in three replications on Sclerotinia infested plot at experimental farm, DRMR. The crop was sown on 26 Oct 2017 with T1: Seed treatment (ST) carbendazim 50WP 2g/Kg seed T2: T1+ No irrigation during 25th Dec to 15 Jan; T3: T1+T2+Foliar spray (FS) (Carbendazim 50 WP @2g/l at 60-65 DAS); T4: T1+T2+FS at 45-50 and 65-70 DAS; T5: T1+T2+FS (Propicanozole 25 EC@0.05% 60-65 DAS); T6: T1+T2+FS (*Trichoderma* 6g/l 60-65 DAS; T7: Control (no treatment;30x10cm) and T8: Control (no treatment; 45x15cm). Among different treatments, T4 and T5 given highest yield (30.3 and 30.1 q/ha) and minimum per cent disease incidence (2.3 and 1.9%) followed by T3 (27.5 q/ha) as compared to control T7 (22.2 q/ha and 14.4%).

Development of RILs

Based upon already identified resistance sources development of recombinant inbreed lines (RILs) was initiated. EC 597328 (*B. juncea*, China) was crossed with high yielding *B. juncea* varieties. F2 population of 256 plants (EC 597328 x RH 749) sown under sick plot condition and selfed. After artificial stem inoculation, 84.5 per cent population showed tolerance (lesion size <3.0 cm and disease incidence<10%) against Sclerotinia rot. Plants from F2 population were advanced through single seed descent (SSD) method.

Fig. 2.16 Tolerant and susceptible reaction in RIL

In vitro antagonist action of *Trichoderma*

Two strains of *Trichoderma* were isolated from ICAR-DRMR experimental farm soil and mycelia growth on sclerotia. These isolates were purified by the monospore cultures technique using serial dilutions and coded as TS-1 and TS-2. The antagonistic activity of both species of *Trichoderma* was studied on 65 geographical isolates of *S. sclerotiorum* by dual culture technique. On Petri dishes with PDA and placing equidistantly a disk (5 mm in diameter) with mycelium of *S. sclerotiorum* and on the other side of the Petri dish, a disk of mycelium of the same diameter of *Trichoderma* strains. The plates inoculated were incubated at 22±1°C until the growth of control treatment (with only *S. sclerotiorum* disk), covered the Petri dish. The effect of *Trichoderma* strains on plant pathogens was determined by the percentage of mycelia growth inhibition in cm calculated. The mycelia growth inhibition of *S. sclerotiorum* were 51.5-99.3% and 52.6-100% respectively by the effect of TS-1 and TS-2 strains. TS-2 inhibited in higher proportion to *S. sclerotiorum* isolates, 42 isolates were inhibited more than 60% while 9 isolates more than 90% inhibition. On the other hand TS-1, 28 isolates inhibited more than 60% and 3 isolates more than 90% (Fig 2.17).

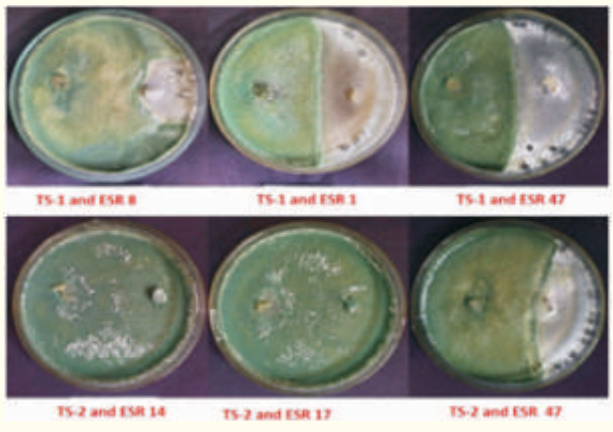


Fig. 2.17: Mycelial growth inhibition of *S. sclerotiorum* with *Trichoderma*

The days to contact between the *Trichoderma* and phytopathogen species were between two to three days. The levels of antagonism according to the Bell's scale were different between the two species of *S. sclerotiorum* and for *Trichoderma* strains were mainly grouped into I and II class. TS-2 was the most efficient species with the highest antagonist effects against *S. sclerotiorum in vitro*. The antagonism produced by *Trichoderma* classified as follows:

Table 2.14: Categorisation of *Trichoderma* spp. according to mycelial inhibition characteristics

Category	Characteristics	Isolates antagonistic with TS-1	Isolates antagonistic with TS-2
Class I	*Trichoderma* overgrows completely to pathogen and covers the whole surface of the medium	ESR 4,27, 58 (3)	ESR 3,14,17,25,26,27,29,39,42,45 (10)
Class II	*Trichoderma* overgrows two-thirds of the surface of the medium	ESR2,5,6,29,34,37,41,43, 46,57,59,62,63,65 (13)	ESR 3, 5, 9, 15, 16, 21-24,28,30,31,32,3437,38,40,41,43,48,52,53,54,56,58 (25)
Class III	*Trichoderma* and pathogen colonized each half of the surface and nobody seems to dominate the other	ESR 7 (1)	Nil
Class IV	Pathogen colonizes the 2/3 parts of the media surface and resists invasion by *Trichoderma*	Nil	ESR 44 (1)
Class V	Pathogen overgrows completely to Trichoderma covers an area total culture media.	Nil	Nil

Enzymatic activity

Polygalacturanase (PG) and Pectin trans eliminase (PTE) enzyme were studied by viscosity method in 23 geographical isolates. The highest enzyme activity (46% and 51% in 60 min) was seen in ESR5, ESR8, ESR1 and ESR37 genotypes. Cell wall synthesizing compounds were identified as carboxylic acids and esters, fatty acids and proteins. Further standardization and re-validation of results is under way.

DRMR PP-5 Epidemiology and management of White rust

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

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

Epidemiology of white rust

Experiment was laid out with 7 dates of sowings i.e. 08th, 15th, 22nd, 29th October, 05th , 12th and 19th November 2017 for epidemiological observations. Periodical data on disease incidence was taken. Highly susceptible variety 'Rohini' was used in the experiment. Data on different epidemiological parameters viz., Relative Humidity, Sunshine hrs, temperature were recorded to correlate it with white rust outbreak. Maximum (24.4%) disease severity was recorded on 19th November sown crop fallowed by 12th November sown crop (17.22%). Minimum (5.77%) disease severity was recorded on 8th October sown crop fallowed by 22nd October sown crop (8.77%) (Fig2.17)

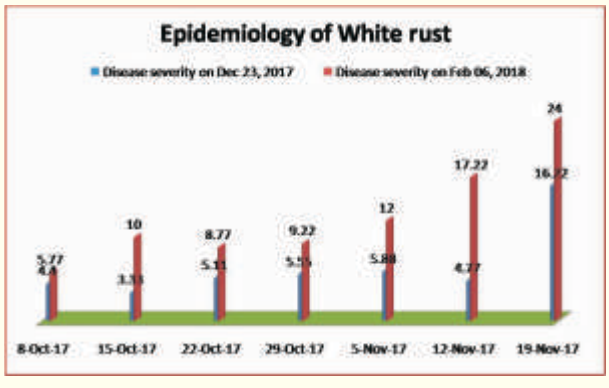


Fig. 2.18 Epidemiology of White rust

Management of white rust

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

seventreatments involving PGPR and new generation fungicides alone and in different combinations viz., seed treatment with metalaxyl 35@ 6g/kg seed+ foliar spray of metalaxyl 8%+ mancozeb64% @ 0.2% (T1); seed treatment with mancozeb @ 3 g/ kg seed+ foliar spray of metalaxyl-M @ 0.2% (T2); seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of Folicur @ 0.1% (T3); seed treatment with metalaxyl 35@ 6g/kg seed+ foliar spray of metalaxyl-M @ 0.2% (T4); seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of Bacillus subtilis (109 cfu) (T5); seed treatment with metalaxyl 35@ 6g/kg seed + foliar spray of P. fluorescence (109cfu) (T6) and control (T7)were tested under filed conditions. Data on WR incidence were recorded(Fig. 2.18).The maximum reduction in disease severity was observed in T1 (Seed treatment with metalaxyl 35@ 6g/kg seed+ foliar spray of metalaxyl 8%+ mancozeb 64% @ 0.2%) followed by T2 (seed treatment with mancozeb @ 3 g/ kg seed+ foliar spray of metalaxyl-M @ 0.2%).

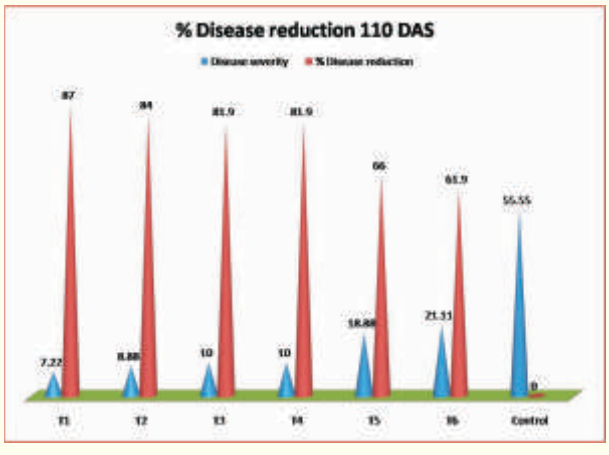


Fig. 2.19 Management of white rust

Effect of soil/ seed infestation and flower bud inoculation

Experiment was laid out to see the effect of soil/ seed infestation and flower bud inoculation on systemic infection of WR on mustard with different treatments viz., Oospore infested seeds, oospore infested plots, Bud inoculation (50 DAS) with seed treatment and Bud inoculation without seed treatment (50 DAS) Observations on disease index, number of infected leaves/plant, total number of pustules on all infected leaves on 20 randomly selected plants were recorded. Maximum (9.56) pustules/plant was recorded in bud inoculated without seed treated plants followed by 9.31 pustules/plant in bud inoculated + seed treated plants. Minimum (6.7) pustules/ plant was recorded in oospore infested seeds followed by oospore infested soil (Fig 2.19).The maximum (17.77%) white rust severity was recorded in oospore infested soil followed by bud inoculation without seed treatment (17.0%). The minimum (13.3%) white rust severity was recorded in bud inoculated + seed treated plants (Fig 2.20)

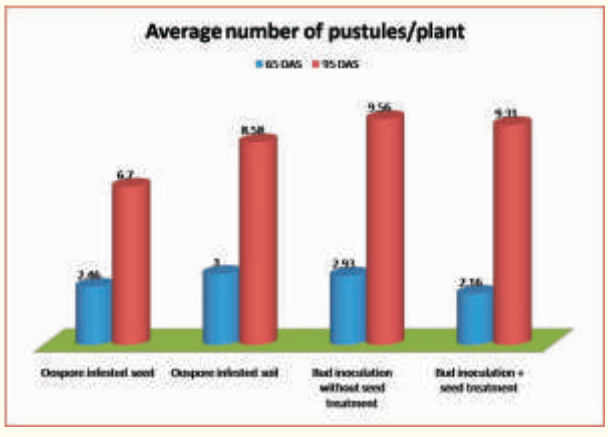


Fig. 2.20 Effect of soil/ seed infestation and flower bud inoculation on WR

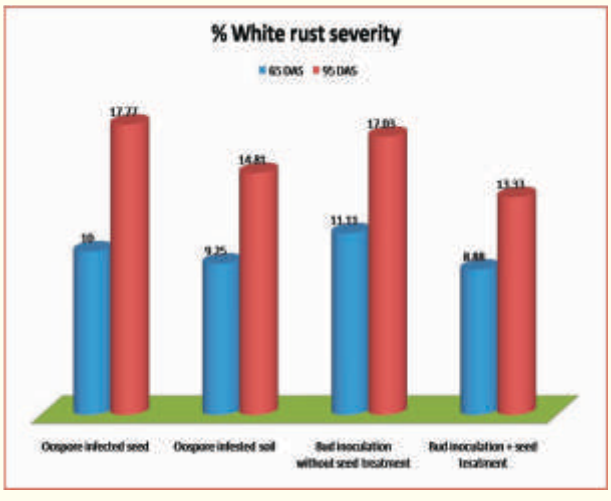


Fig.2.21 White rust severity

2.8 Technology Assessment and Dissemination

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

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

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

Constraints faced by KVKs personnel in transfer of technology

A study was conducted for identification of major constraints faced by them in implementation of transfer of technology programmes based on data collected from 107 KVKs personnel from Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Punjab, Delhi and Haryana who participated in training programmes organized by ICAR-DRMR during September-October 2016. Respondents were asked to give the responses on five point continuum from Very important to not important. On the basis of mean per cent score (MPS), ranking was done on the basis of importance of the constraints.

The study (Table 2.15) revealed that no mechanism of regular updating of research advancement through ICAR institutes, as a nodal centre of technology development, was perceived as most important constraint and it was assigned first rank with 85.98 MPS by the respondents. “Lack of resources and transport facilities leading to ineffective programme implementation” was accorded second rank by the respondents with 80.37 MPS. The respondents assigned third rank to “Large number of activities assigned to KVKs in comparison to staff” with 76.63 MPS.

However "Lack of incentives and recognition to the SMSs” was relatively least important constraint as it was assigned lowest MPS (40.18) with fourteenth rank followed by Govt. rules or guidelines developed politically do not in conformity with the guidelines of the programme. This affects the effective implementation of extension programmes. Therefore, this constraint was accorded thirteenth rank by the respondents with 43.92 MPS.

Table 2.15: Constraints faced by KVKs personnel in implementation of transfer of technology programmes (n=107)

Constraints	MPS	Rank
No mechanism of regular updating of research advancement through ICAR institutes as a nodal centre of technology development	85.98	1
Lack of resources and transport facilities leading to ineffective programme implementation.	80.37	2
A large number of activities assigned to KVKs in comparison to staff	76.63	3
Non-cooperation and lack of interest of farmers to participate in extension activities	74.76	4
More emphasis on implementation of university recommendations only	71.02	5
Lack of strong linkages and co-ordination among KVKs, line departments and research institutions	70.19	6
Lack of suitable technologies to address the problems of the farmers effectively	67.28	7
Budget of extension activities are very low	63.55	8
Lack of technical staff and clerical assistants for helping in implementation of the programmes and administrative procedure.	60.74	9
Lack of refresher courses suitable for KVKs	56.07	10
Poor infrastructure facility at KVKs for using ICT technology	54.20	11
Political interference in KVKs activities	48.59	12
Govt. rules not in conformity with the guidelines of the programme/ FLDs implementation	43.92	13
Lack of incentives and recognition to the SMSs	40.18	14

Training need assessment of KVK personnel

A study was also conducted for identification of major aspects of training needs in rapeseed-mustard production based on data collected from 107 KVK's personnel

The study (Table 2.16) reported that selection of improved varieties, proper seed rate and sowing method was the top most priority of the training perceived by the KVKs personnel. It was accorded first rank by 85.59 % respondents. The Insect-pest and disease management was the second most important area of training reported by the 80.37 % respondents. The management and use of fertilizers found third place in order of priority as reported by 74.76 % respondents.

The weed management was another important area of training as needed by 70.09 % respondents with fourth rank priority. The management of abiotic stress and natural calamities also play important role in mustard production and training need of this aspect was perceived important by 67.28 % respondents with fifth rank. The 60.74 % respondents perceived seed and soil treatment, land preparation or field management sixth rank important areas of training need.

Table 2.16: Training needs of the participants

Aspects	Training needs (n=107)	
	(%)	Rank
Selection of improved varieties, proper seed rate and sowing method	85.6	I
Insect-pest and disease management	80.4	II
Management and use of fertilizers	74.8	III
Weed management	70.1	IV
Management of abiotic stress and natural calamities	67.3	V
Seed and soil treatment, land preparation or field management	60.7	VI

Impact of training in terms of increase in knowledge of KVK participants

To study the impact of trainings in terms of enhancing the knowledge level of the KVKs participants after training, the data on pre and post knowledge of the participants were collected from 107 KVK's personnel participated in training programmes organized by ICAR-DRMR.

The study (Table 2.17) showed that maximum increase of 48.6% in knowledge of the respondents was in the field of varietal and seed production followed by disease management with 47.7% increase. There was 35.5% increase in the knowledge of participants about pest management aspects. Regarding fertilizer and irrigation management, 28.55% knowledge increment was observed. There was minimum per cent knowledge enhancement in case of weed management and crop management practices.

Table 2.17 Impact of training in terms of increase in knowledge of KVK participants

Aspects	Pre knowledge	Post knowledge	Increase
	Score (%)	Score (%)	%
Varietal and seed production	46.7	95.3	48.6
Crop Management practices	62.6	81.3	18.7
Fertilizer and irrigation management	66.3	94.9	28.5
Weed management	42.5	68.8	26.3
Pest management	48.6	84.1	35.5
Disease management	38.3	85.9	47.7

Identification of major constraints perceived by farmers in mustard cultivation

A study was carried out to identify major constraints perceived by farmers in mustard cultivation. For the purpose of the study, data were collected from 250 mustard growing farmers who participated in training and other extension programmes of ICAR-DRMR during 2016-17 belong to different districts of Rajasthan, Madhya Pradesh and Uttar Pradesh. Respondents identified many constraints. Out of them, seven major constraints related to mustard production system were ranked as per the intensity.

The study (Table 2.18) revealed that lack of knowledge about improved technology like new variety/balance fertilizers/ micronutrients/weed management, etc. and resources to access the required knowledge was most important constraint as reported by 85.2% farmer respondents. The respondents did not have the knowledge of research development in mustard production technology. It was felt that respondents were using imbalance dose of fertilizers particularly urea and DAP and were not aware about importance of micronutrients for the crop. The majority of the farmers felt that they were not able to have updated information timely due to lack of resources. Another most important constraint in enhancing adoption of recommended technologies reported by 82% respondents was non availability and inferior quality of required inputs (seeds, fertilizers, pesticides, insecticides, etc.) in time especially at local level.

The price fluctuation of the produce was also a serious concern of the farmers. The 80.4% respondents reported lack of assured price as third most important constraint that caused the lack of motivation among the farmers to increase investment in adoption of scientific technology. The increasing cost of cultivation (inputs, labourers, etc.) also bothered the farmers as 72% respondents reported this as an important constraint.

The low rainfall and lack of irrigation facility resulting in lack of soil moisture were perceived fifth most important constraint reported by 66% respondent. As a result, poor germination, early or delaying sowing, untimely irrigation, etc. were responsible for low productivity of mustard.

The problems of insect-pest and diseases (especially painted bug, aphid, Sclerotinia, white rust, termite) were affecting productivity of mustard adversely as reported by 60% respondents with sixth rank in order of importance.

The problem of saline water and problematic soil was also reported by 58% respondents as an important constraint in increasing the mustard production.

Table 2.18: Major Constraints perceived by farmers in mustard cultivation (n=250)

Constraints	% Respondents	Rank
Lack of knowledge about improved technology (New variety/balance fertilizers/ micro-nutrients/weed management, *etc*. and resources to access the required knowledge	85.2	I
Non availability and inferior quality of required inputs in time (seeds, fertilizers, pesticides, insecticides, *etc*.)	82.0	II
Lack of assured price	80.4	III
Increasing cost of cultivation (inputs, labourers, *etc*.)	72.0	IV
Lack of irrigation facility/rainfall	66.0	V
Problems of insect-pest and diseases (Painted bug, Aphid, Sclerotinia, White rust, Termite,)	60.0	VI
Problematic soil and water	58.0	VII

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 online web based tool developed for rapeseed-mustard information management and disseminations have been updated. Online database of Rapeseed-mustard area, production and yield containing the information of 54 years data of 72 rapeseed-mustard producing countries worldwide, 48 years data of 26 rapeseed-mustard producing states in India and 17 years data of all districts of rapeseed-mustard producing states updated.

Updation and maintenance of web site

The website of DRMR developed and regularly being updated as per guidelines of ICAR. The URL of website of DRMR is *www.drmr.res.in*

Externally Funded Projects

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

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

A total of 38 farmer's varieties, 01 new variety/hybrid for 1st year and 01 new variety/hybrid for 2st year of different species of rapeseed-mustard have been tested for 24 DUS characters as per the DUS guideline for rapeseed-mustard. Out of 40 farmer's varieties, 30 varieties were characterized for 1st year, while 8 farmer's varieties were tested for DUS characters for 2nd year along with 16 reference varieties of *B. juncea, B. carinata, B. napus, B. rapa* var. yellow sarson and *B. rapa* var. toria. In addition, 135 Rapeseed-mustard varieties including 94 varieties of Indian mustard (*B. juncea*), 02 varieties of brown sarson (*B. rapa* var. brown sarson), 07 varieties of gobhi sarson (*B. napus*), 05 varieties of karan rai (*B. carinata*) 12 varieties of yellow sarson (*B. rapa* var. yellow sarson) and 15 varieties of Toria (*B. rapa* var. toria) including 01 variety of Taramira (*E. sativa*) were maintained through appropriate mating systems.

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

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

Co-Investigator: Pankaj Sharma, Pr. Scientist (Plant Pathology), A.K.Sharma, Pr. Scientist (Ag. Extension)

A total 1682.97 q TL seeds of rapeseed-mustard varieties were produced during *rabi* 2016-17. The improved varieties of Rapeseed-mustard *i.e.* DRMRIJ31, NRCHB101, NRCDR02, RH406, RH749, NRCYS05-02 and YSH401 were included in the seed production programme. Quality seed production programme was conducted at different locations *viz*. KVK, Kumher, Madhurikund (DUVASU) Farm, and ICAR-IIMR, Ludhiana in participatory mode and ICAR-DRMR, Bharatpur.

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

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

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

Under Pre-breeding project, 80 germplasm/ inbred lines, 71 progeny rows and 52 F_1 Crosses were evaluated in three different experiments; Evaluation of inbred/germplasm lines, Evaluation of progeny rows, Evaluation of F_1 crosses. Sixty six new F_1 crosses were attempted in *B. carinata.* Mean and range observed in different experiments for agronomic traits are presented in ensuing table 2.22.

Table 2.22: Mean and range for agronomic traits in different experiments

Descriptive statistics	DFI	DFS	D/M	Seed yield (kg/plot)	1000 SW (g)	Seeds/ siliqua	OC (%)	PH (cm)	MSL (cm)
Progeny Rows of *B. napus*									
Mean	67.7	112.7	141	0.283	3.6	21.1	42.8	191.0	71.8
Range	25	19	10	0.457	3.4	13.6	2.6	45	34
Minimum	54	102	133	0.083	2.90	14.4	41.7	166	56
Maximum	79	121	143	0.54	4.3	28	44.3	211	90
Progeny Rows of *B. carinata*									
Mean	61.3	107.1	140.2	256.0	4.1	14.9	41.1	166.5	43.5
Range	39	42	32	439	3.14	9.3	5.4	147	69
Minimum	47	89	123	79	2.76	10.8	38.3	98	26
Maximum	86	131	155	518	5.90	20.1	43.7	245	95
Germplasm/ Inbred *B. carinata*									
Mean	83.0	120.7	151.2	0.2	3.9	15.7	41.3	189.4	39.6
Range	67	54	40	0.952	3.63	15.9	10.4	196	71
Minimum	52	85	127	0.01	2.17	6.2	34.2	83	16
Maximum	119	139	167	0.962	5.80	22.2	44.5	279	87
Evaluation of F_1 Crosses of *B. carinata*									
Mean	59.2	103.1	137.8	0.4	4.1	15.2	39.5	175.5	54.1
Range	22	33	26	0.72	4.23	13.9	13.7	74	43
Minimum	49	86	130	0.05	2.60	5.6	28.5	132	33
Maximum	71	119	156	0.77	6.83	19.6	42.2	206	76

Four F_1 crosses (K5xIPS20, K14xIPS20, K26xIPS-20, K1xIPS20) of *B. carinata* were found promising. Single plant selection was practiced from segregating populations of F_2 Generation (MCB 1-2-7-3 x Pusa Swarnim, MCB 1-4-2 x Kiran Selection, MCB 1-4-3 x Pusa Swarnim, MCB 1-2-7 x Kiran Selection, MCB 1-2-8 x Pusa Swarnim) and F_3 generation of *B.carinata* IPS-29.

Table 2.23: Species-wise characterization of promising genotypes

Genotype	Source	PH	MSL	S/S	1000 SW	O.C.	DFI	DFS	D/M	Specific trait
B. juncea										
IPS-F5-10-9	IPS	145	85	15.8	4.7	45.1	-	-	-	OC
B. napus										
F3 2-2	PRT	168	59	15.4	4.8	42.2	71	105	143	SW
IPS-F5-9-10	IPS	142	80	20.3	4.7	43.6	-	-	-	SW
IPS-F5-9-13	IPS	185	85	30.8	2.97	44.6	-	-	-	OC
IPS-F5-9-9	IPS	140	75	23.7	3.05	44.6	-	-	-	OC
IPS-F5-10-9	IPS	145	85	15.8	4.75	45.0	-	-	-	OC
B. carinata										
MCB 1-2-3-13-5	Inbred	83	37	21.3	4.4	40.7	55	104	139	PH
MCB 1-2-3-4	Inbred	107	35	16.4	4.8	39.2	53	86	139	PH
K 40	Germplasm	107	25	9.3	4.3	37.7	93	132	167	PH
MCB 1-1-5-1	Inbred	138	40	19.3	5.0	39.8	59	99	138	DM
F2 11-2	Inbred	178	84	16.0	4.4	40.1	52	102	129	DM
MCB 1-2-3-12	Inbred	153	26	15.4	4.7	39.8	58	92	136	DM
F2 4-2	PRT car	118	35	14.0	3.7	39.9	60	100	114	DM
MCB 1-2-3-2-5	Inbred	163	46	13.9	4.0	40.0	57	100	138	SW
MCB 1-2-3-14-1	Inbred	136	38	14.2	4.6	39.1	55	92	139	SW
IPS 1 (Block 1)	PRT car	145	32	14.3	4.5	43.4	63	107	142	SW
ST5 IPS 6-2 R3	PRT car	168	37	12.7	4.7	41.3	55	105	140	SW
F2 6-2	Inbred	239	39	17.8	3.6	43.7	88	128	155	OC
K41	Germplasm	263	39	16.6	4.3	43.5	92	129	159	OC
F2 9-4	PRT car	189	60	13.7	4.5	43.7	60	91	124	DM, OC
F2 1-1 MCB1-1-4 / P.SWARNIM	PRT car	210	33	17.4	3.3	43.5	82	126	151	OC

DRMR EA-14: Incentivizing research in agriculture - Indian mustard

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

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

Co-Investigators: Ibandalin Mawlong, Scientist (Plant Biochemistry), Pankaj Sharma, Pr. Scientist (Plant Pathology), R.S. Jat, Pr. Scientist, (Agronomy), A.K. Thakur, Sr. Scientist (Biotechnology)

Morphological characterization of heat tolerant breeding lines and germplasm

Observations were recorded on 13 morphological characters of 15 selected advance breeding and 20 germplasm lines. Breeding lines RH-555 (33.8g), NPJ-124 (32.4g), DRMR-1616-47 (30.8g), BPR549-9 (28.4g), RH-119 (25.6g) and DRMR1165-40 (23.6g) were selected for seed yield /plant in comparison to check BPR541-4 (20.3g) under normal sown conditions.

RH-555 (22.8g), NPJ-124 (22.3g), HPLM0625 (20.6g), BPR 549-9 (20.3g), RH-119 (18.2g) and DRMR 1165-40 (17.2g) were found superior in comparison to check BPR-541-4 (15.3g) under early sown conditions while germplasm DRMR

1231 (25.5g), DRMR 2489 (25.3g), DRMRIJ-31 (23.9g), DRMR 2546 (22.4g), DRMR 2291 (21.6g), DRMR 1693 (21.6g), DRMR-C-III-1 (19.9g), DRMR 1469 (19.8g), DRMR 2062 (19.5g) and DRMR 2059 (19.5g) recorded significantly higher seed yield/plant in comparison to check BPR541-4 (16.9g) under same conditions.

Seed yield per plant had positively and significantly correlated with secondary branches per plant (0.45), biological yield (0.63) and test weight (0.68) under normal sown condition while under early sown condition seed yield per plant had positively and significantly correlated with secondary branches per plant (0.37), siliquae length (0.40) and test weight (0.51).

Advancement of RILs

Heat tolerance

From variable F_2 population of crosses NRCDR 02 x BPR 541-4 and NRCHB 101x BPR 543-2, individual plants were advanced through single seed descent method for developing RIL population for high temperature tolerance.

Stem rot

From F_2 population of the cross, NRCHB 101 (*B. juncea*) x DRMR 261 (*B. carinata*), individual plants were advanced through single seed descent method for developing RIL population for stem rot resistance. In another F_2 population (EC 597328 x RH 749) individual plants were inoculated (257 plants) with stem inoculation technique. More than 80% plants showed fair degree of resistance. All plants advanced for developing RILs.

Genetics of heat tolerance

F1s generated from the 10 x10 diallel involving parents BPR 543-2, Urvashi, BPR 549-9, DRMR 1165-40, UP II-73, EC 511664, NRCDR 02, NRCHB 101, Rohini, DRMRIJ 31 were grown in RBD with three replications along with parents. Data were recorded on biochemical and physiological (Proline, chlorophyll content, excised leaf water loss, relative water content, chlorophyll stability index) and morphological traits (Plant height, primary branches, secondary branches, fruiting zone length, main shoot length, siliquae on main shoot, siliquae per plant, siliquae length, seeds per siliquae) on sampled plant of each F1 and parents.

Physiological and Biochemical characterization of selected heat tolerant lines (IInd year)

Based upon two years data (2016-17 and 2017-18) under different developmental stages a comparison was made between two sowing seasons- early sown and late sown. The following was observed by taking the mean over two years.

Total chlorophyll content: At bud stage under early sown, total chlorophyll content ranged did not vary much among the four genotypes. Under late sown it ranged from 1.68 mg/g FW (BPR-549-9) to 2.07 mg/g FW (DRMR1165-40). It was observed the increase to vary from 6.41 % (DRMR-11912) to 15.95% (BPR-5499) over that of late sown condition. At flowering stage under early sown, total chlorophyll content ranged from 2.09 mg/g FW (DRMR1165-40) to 2.75 mg/g FW (NPJ-124). Under Late sown it ranged from 1.86 mg/g FW (NPJ-124) to 2.15 mg/g FW (BPR-5499). It was observed the increase to vary from 1.65% (DRMR1165-40) to 32.11% (NPJ-124) over that of late sown condition. Under early sown at pod stage, total chlorophyll content ranged from 1.82 mg/g FW (NPJ-124) to 2.37 mg/g FW (DRMR1165-40). Under late sown it ranged from 1.72 mg/g FW (DRMR-11912) to 2.20 mg/g FW (BPR-5499). It was observed the increase to vary from 9.22% (DRMR-1165-40) to 17.68% (DRMR-11912) over that of late sown condition

Total carotenoid content: At bud stage under early sown, total carotenoid content ranged from 5.32 mg/g FW (NPJ-124) to 5.96 mg/g FW (BPR-5499). Under late sown it ranged from 4.73 mg/g FW (BPR-5499) to 5.33 mg/g FW (DRMR-11912). It was observed the increase to vary from 5.80% (NPJ-124) to 20.62% (BPR-5499) over that of late sown condition. At flowering stage, under early sown, total carotenoid content ranged from 5.70 mg/g FW (DRMR-1165-40) to 6.34 mg/g FW (DRMR-11912). Under late sown it ranged from 4.83 mg/g FW (DRMR-11912) to 6.02 mg/g FW (BPR-5499). It was observed the increase to vary from 19.47% (NPJ-124) to 23.77% (DRMR-11912) over that of late sown condition. At pod stage, under early sown, total carotenoid content ranged from 5.47 mg/g FW (NPJ-124) to 6.45 mg/g FW (DRMR11912). Under late sown it ranged from 5.12 mg/g FW (NPJ-124) to 6.12 mg/g FW (DRMR-1165-40). It was observed the increase to vary from 1.16% (DRMR-1165-40) to 11.21% (DRMR-11912) over that of late sown condition.

Relative water content (RWC): At bud stage under early sown, RWC ranged from 80.75 (NPJ-124) to 90.64 (DRMR-116540). Under late sown it ranged from 79.06 (NPJ-124) to 90.45 (DRMR 1165-40). It was observed the increase to vary from 0.22% (DRMR-1165-40) to 4.98 % (BPR-5499) over that of late sown condition while at flowering stage under early sown, RWC ranged from 71.55 (BPR-5499) to 87.99 (DRMR1165-40). Under late sown it ranged from 70.41 (BPR-5499) to 82.05 (DRMR-1165-40). It was observed the increase to vary from 1.60% (BPR-5499) to 14.61% (NPJ-124) over that of late sown condition. At pod stage, under early sown, RWC ranged from 81.0 (NPJ-124) to 87.85 (BPR-5499). Under late sown it ranged from 76.56 (NPJ-124) to 83.04 (DRMR-1165-40). It was observed the increase to vary from 2.98% (DRMR-11912) to 6.03% (BPR-5499) over that of late sown condition.

Chlorophyll Stability Index (CSI): At bud stage, under early sown, CSI ranged from 67.66% (NPJ-124) to 82.04% (BPR-5499). Under Late sown it ranged from 70.36% (DRMR-11912) to 81.74% (NPJ-124). It was observed the increase to vary from 1.69% (DRMR1165-40) to 9.81% (DRMR-11912) over that of late sown condition. At flowering stage, under early sown CSI ranged from 80.81% (BPR-5499) to 90.60% (DRMR11912). Under Late sown it ranged from 73.33% (BPR-5499) to 84.84% (DRMR1165-40). It was observed the increase to vary from 3.80% (NPJ-124) to 7.86% (DRMR-11912) over that of late sown condition. Under early sown, at pod stage CSI ranged from 83.47% (BPR-5499) to 90.22% (DRMR-11912). Under late sown it ranged from 82.18% (NPJ-124) to 88.22% (DRMR-1165-40). It was observed the increase to vary from 2.50% (DRMR-1165-40) to 8.13% (DRMR-11912) over that of late sown condition.

Proline content: At bud stage under early sown, proline content ranged from 0.93 µmole/g FW (DRMR-11912) to 2.91 µmole/g FW (DRMR1165-40). Under late sown it ranged from 0.14 µmole/g FW (NPJ-124) to 0.86 µmole/g FW (BPR-5499). It was observed the increase to vary from 62.35% (BPR-5499) to 90.33% (DRMR-11650) over that of late sown condition. At flowering stage, under early sown, proline content ranged from 2 µmole/g FW (NPJ-124) to 4.21 µmole/g FW (BPR-5499). Under Late sown it ranged from 1.51µmole/g FW (NPJ-124) to 2.83 µmole/g FW (BPR-5499). It was observed the increase to vary from 32.73 % (BPR-5499) to 44.22 % (DRMR-11912) over that of late sown condition. At pod stage under early sown proline content ranged from 0.86 µmole/g FW (DRMR-116540) to 4.46 µmole/g FW (BPR-5499). Under late sown it ranged from 0.28 µmole/g FW (DRMR-116540) to 4.33 µmole/g FW (BPR-5499). It was observed the increase to vary from 0.72 % (DRMR-11912) to 67.09% (DRMR-116540) over that of late sown condition.

From investigation, the tolerance was found to be in the following order; DRMR-11912> DRMR-1165-40, NPJ-124 >BPR-549-9. Eight genotypes, JN 32, DRMR 1192-2, NPJ 124 and BPR 549-9 were found highly tolerant whereas

DRMR 1165-40, BPR 543-2 showed tolerant, DRMR 1616-47 and UP II-73 were moderately tolerant at IARI, New Delhi under phytotron conditions.

DRMR EA-15: CRP on molecular breeding: Molecular breeding for improvement of tolerance to biotic (white rust/stem rot) and quality traits (low erucic acid and glucosinolates) in mustard

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

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

Glucosinolate estimation using UV-spectrophotometer

Glucosinolate estimation was done using standardized protocol at absorbance 425.Glucosinolate estimation of 610 samples was done which includes samples from F2, BC2 and BC3 generation. Glucosinolate content was estimated in F2 generation derived from the crosses; NRCHB-101 x PDZ-1,NRCHB101 x RLC-3,NRCHB101 x HEERA,DRMR150-35 x PDZ-1,DRMR150-35 x RLC-3,DRMR150-35 x HEERA,DRMRIJ-31 x PDZ-1,DRMRIJ-31 x RLC-3,DRMRIJ-31 x HEERA,NRCDR-02 x PDZ-1,NRCDR-02 x RLC-3,NRCDR-02 x HEERA. These F_2 populations showed the frequency of distribution of total glucosinolate to range from18 µmol/g to 168 µmol/g. Clustering of all the progenies derived from the crosses showed considerable diversity in their total glucosinolate content. 8 Lines derived from crosses DRMR150-35×PDZ-1 and NRCHB101× RLC-3 having total glucosinolate content less than 30 µmol/g were reconfirmed by molecular markers. In F2 generation, glucosinolate content was found in variable ranges i.e. < 30 µmol/g (14 plants), 30-50 µmol/g (87 plants), 50-80 µmol/g (172 plants),> 80µmol/g (289 plants) respectively. In case of BC2F1 and BC3 generation the glucosinolate content was found in a range of 64.10 µmol/g to 144.67 µmol/g.

Erucic acid estimation of F_2 using gas chromatography

The selfed seeds of F2 generation were harvested separately for erucic acid estimation using gas chromatography. Erucic acid (%) content among parents is shown in table 2.24. Only those samples having glucosinolate content below 60 µmole/g seed were subjected to Erucic acid estimation using GC.

Table 2.24: Erucic acid content in segregating F_2 generation

F_2 generation	Erucic acid (%) content in F_2						
	<2	2-10	11-20	21-30	31-40	>40%	No. of samples analysed
NRCHB101 x PDZ-1	0	0	0	3	3	0	6
NRCHB101 x RLC-3	0	0	4	9	6	1	20
NRCHB101 x Heera	0	2	2	6	5	0	15
DRMR150-35 x PDZ-1	0	0	3	14	16	1	34
DRMR150-35 x RLC-3	0	0	0	2	14	1	17
DRMR150-35 x Heera	Erucic acid (%) content not done as all samples were having glucosinolate content greater than 60 µmole/g seed						

Validation of samples using low glucosinolate markers

The samples which were found to have glucosinolate content below 30 µmol/g in F2 generation and below 80 µmol/g in BC2 seeds and BC3 seeds were validated using low glucosinolate molecular marker i.e. GER-1MRPR + IP3GER-1F(Q1) and GER-5FPF+GER-5MRPR(Q5).

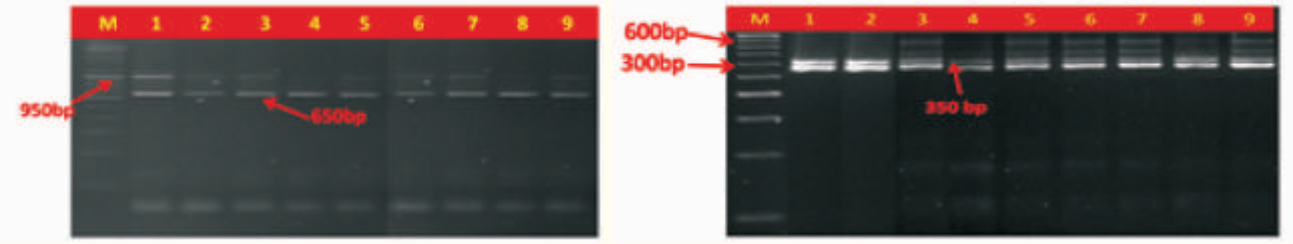


Fig. 2.22: Agarose gel showing validation of markers linked to quality (glucosinolate); (A) GER-1MRPR+ IP3GER-1F (Q1), (B) GER-5FPF + GER-5MRPR (Q5) M-100bp BC2 seed samples 1-6 and BC3 seed samples 8 and 9. 1: NRCHB101 x (NRCHB101 x PDZ-1), 2: NRCHB101 x (NRCHB101 x RLC-3), 3: NRCHB101 x (NRCHB101 x HEERA), 4: NRCHB101 x (NRCHB101 x PDZ-1), 5: DRMR150-35 x (DRMR150-35 x PDZ-1), 6: NRCHB101 x (NRCHB101 x HEERA), 7: DRMR150-35 x (DRMR150-35 x RLC-3), 8: NRCDR-02 x (NRCDR-02 x PDZ-1), 9: DRMRIJ-31 x (DRMRIJ-31x RLC-3)

White rust screening at off-season nursery Wellington

Twenty Five F3 plant progenies derived from cross NRCHB101 x BEC-144 and 27 BC2 F1 seeds samples of the crosses DRMR150-35 x (DRMR 150-35 x PDZ-1), DRMR 150-35 x (DRMR 150-35 x RLC-3), DRMR 150-35 x (DRMR 150-35 x Heera), NRCHB101 x (NRCHB101 x PDZ-1), NRCHB101 x (NRCHB101 x RLC-3), NRCHB101 x (NRCHB101 x Heera), DRMR150-35 x (DRMR150-35 x BioYSR), DRMR150 -35 x (DRMR150-35 x BEC-144), NRCHB101 x (NRCHB101 x BioYSR) and 32 BC3F1 derived from crosses DRMRIJ-31 x (DRMRIJ-31 x HEERA), DRMRIJ-31 x (DRMRIJ-31 x Donskaja) along with parents were grown at off-season nursery Wellington for generation advancement and white rust screening.

Foreground selection of BC_2F_1 using markers linked to glucosinolate loci and CAPS markers for erucic acid loci and glucosinolate estimation

Total 350 plants of BC_2F_1crosses (DRMR150-35xPDZ-1), (DRMR150-35 x RLC-3), (NRCHB101xPDZ-1), (NRCHB101xHeera) were screened for quality trait (low glucosinolate and low erucic acid). A total of 53 plants were found to be low for glucosinolate using markers linked to glucosinolate loci. These 53 plants which were low for glucosinolate were then screened for the erucic acid using CAPS marker. Out of these 18 plants were found low for both (low glucosinolate and low erucic acid) traits. These 18 plants were backcrossed with their recurrent parent for generation advancement.

Total glucosinolate estimation of selected plants was performed in wet lab. Out of total selected plants (BC_2F_1 generation) undertaken for glucosinolate estimation plants derived from cross NRCHB101 x PDZ-1 and NRCHB101xHeera were found to have glucosinolate content falling in range of 50-70 µmol/g seed. Similarly plants derived from cross DRMR150-35 x RLC-3 and from NRCHB101 x Heera were found to have glucosinolate content falling in range of 70-80 µmol/g seed. The parents *i.e.* NRCHB101, DRMR150-35, PDZ-1, RLC-3 and Heera were found to have glucosinolate content of 131.2, 122.84, 26.73, 14.07 and 33.19. Plants of BC_3F_1 generation were estimated for glucosinolate content. Plants were found to have glucosinolate content in range 50-80 µmol/g (55.92, 71.55, 72.51, 74.92, 77.44 and 69.02 µmol/g seed).

Phenotyping of backcrossed generations for white rust at DRMR

BC_2F_2 and BC_3F_3 generation seed samples screened from wellington were sown at experimental field for screening of white rust resistance. Out of total 48 plants 13 plants were found to be resistant to white rust. Foreground selection of BC_2F_1 generation for white rust resistance was done using molecular markers i.e. At5g41560 (AcB1-A4.1) and At2g36360 (AcB1-A5.1). Out of total 160 plants, 20 white rust resistant plants were found.

Table 2.25: Screening of BC_2 generation for white rust in field (Wellington)

BC_2 Generation	No. of plants screened using marker	At5g41560 (AcB1-A4.1)	At2g36360 (AcB1-A5.1)	Resistant to white rust
BC_2 (DRMR150-35 x BioYSR)	77	+	–	6
BC_2 (DRMR150-35 x BEC-144)	51	+	+	6
BC_2 (NRCHB101 x BioYSR)	32	+	+	8

Background selection of BC_2F_1 using SSR markers

A subset of 45 out of 139 polymorphic marker used for background selection among BC_2F_1crosses (DRMR-150-35x BioYSR), (DRMR-150-35 x BEC-144), (NRCHB101 x BioYSR) and (DRMR-150-35 x BEC-144) for white rust and (DRMR150-35 x PDZ-1), (DRMR-150-35 x RLC-3), (NRCHB101 x PDZ-1), (NRCHB101 x Heera) for quality trait is in 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-Investigator: Ajay Kumar Thakur, Sr. Scientist (Biotechnology), Har Vir Singh, Scientist (Agronomy)

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

SB/YS/LS-86/2014 (DST-SERB): Development of a core set of SSR markers for characterization of *Brassica juncea* varieties and germplasm

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

A total of 1000 SSR markers derived from four Brassica species viz. *B. nigra*, B. *rapa*, *B. oleracea* and *B. napus* (available in the public domain) were evaluated for their cross-transferability and polymorphic potential in a representative set (mini-core) of *B. juncea* germplasm and varieties. Overall, 700 SSRs out of 1000 SSR markers produced PCR amplicons of expected size, out of them, 379 (54.14%) of SSRs resulted into polymorphic amplicons across the genotypes under investigation, while 321 (45.86%) SSRs exhibited monomorphic nature of amplicons (Table 2.20). The highest frequency of cross-species amplification and transferability had been obtained for *B. nigra*-derived SSR markers, where a total of 168 SSRs (84%) out of 200 markers tested showed cross-amplification in *B. juncea* genotypes. A total of 104 (64.28%) markers resulted into polymorphic amplicons and monomorphic amplification products were produced by 60 (35.72%) SSRs. Among *B. rapa*-derived SSR markers, 486 (69.42%) of the 700 markers showed successful cross-amplification in *B. juncea* genotypes, where 249 (51.24%) markers produced polymorphic amplicons. Among *B. oleracea* and *B. napus*-derived SSR markers (50 each), only 56% and 36% of the markers could respond positively for cross-species amplification, respectively. The number of alleles detected at each locus ranged from 1 to 6 with DNA fragment size from 50-500 bp.

Table 2.26 : Transferability and polymorphic potential of *Brassica species*-derived SSR markers in *B. juncea* reference set

Name of the species	No. of SSRs evaluated	No. of SSRs amplified	Polymorphic SSRs	Monomorphic SSRs
B. nigra (BB)	200	168 (84.0%)	108 (64.3%)	60 (35.7%)
B. rapa (AA)	700	486 (69.4%)	249 (51.2%)	237 (48.7%)
B. oleracea (CC)	50	28 (56.0%)	13 (46.4%)	15 (53.6%)
B. napus (AACC)	50	18 (36.0%)	9 (50.0%)	9 (50.0%)
Total	1000	700 (70.0%)	379 (54.1%)	321 (45.9%)

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

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

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

A total of 700 mutants were evaluated for different traits during 2017-18. Among 136 mutants selected for Alternaria blight including 118 at Bharatpur and 19 at Pantnagar were screened for confirmation under artificially created epiphytotic conditions at Bharatpur as well as Pantnagar. Experiment was sowed on 26 Oct 2017 in two rows of each mutant with 3 m row length taking 45 row to row spacing. Among 118, BRNS-M-17-41, BRNS-M-17-44 were observed promising. Among 19, two promising mutants (BRNS-M-17-162, and BRNS-M-17-175) were selected with < 20% Alternaria blight disease severity both on leaves and siliquae. Laboratory screening at cotyeldonary stage and true leaf stage for Alternaria blight tolerance under controlled conditions was done. Out of 94 mutants, only one mutant BRNS-M-17-48 (RH-119 G 100Kr) was found tolerant to Alternaria blight under detached leaf inoculation experiment. While under seedling stage experiments, non-significant results were observed.

Among 140 mutants, M_3 generation advanced to M_4 generation of 24 (BRNS–M-17-180 to BRNS-M-17-204) mutants promising for white rust resistant under severe disease pressure at Wallington (TN) in off season nursery. A total of 700 mutants were inoculated for screening against Sclerotinia rot disease using stem inoculation method. Out of 200 mutants showed scorable lesion length, 19 mutants found tolerant to SR disease were BRNS-M-17-44, BRNS-M-17-46, BRNS-M-17-75, BRNS-M-17-87, BRNS-M-17-96, BRNS-M-17-112, BRNS-M-17-122, BRNS-M-17-139, BRNS-M-17-140, BRNS-M-17-157, BRNS-M-17-160, BRNS-M-17-182, BRNS-M-17-186, BRNS-M-17-190, BRNS-M-17-194, BRNS-M-17-203, BRNS-M-17-205, BRNS-M-17-206, BRNS-M-17-216. Sclerotinia rot lesion length was recorded on check Kranti (8.66 cm), RH 749 (3.9cm) and Rohini (3.0 cm).

Selections from mutant progenies

Four M_3 mutant progenies of RH 749 (Gamma 100kr), 5 M_5 and 7 M_6 WR free progenies of RH 749 & Kranti were planted in field for further selections and advancement. Two white flower advance mutants lines (one yellow seeded & appressed, DRMR-WFYSM 15 and one brown seeded & open, DRMR-WFBSM 15-1) of *B. juncea*, one white flower mutant progeny of of Toria and one purple M_6 mutant progeny (DRMR-PMJ 17) were planted in the field during 2017-18 for further advancement, maintenance and evaluation. SPS from M_4(4), M_5 (5) & M_6 (5) were selected and other lines/

progenies were advanced and maintained. The data were recorded on different traits for white flower and purple mutants. Plant height (cm), number of primary branches, main shoot length (cm), number of siliquae on main shoot, siliqua length (cm), seeds/ siliqua, 1000-SW (g), oil content (%), seed yield/plant (g) in WFYSM 15, WFBSM 15-1and PMJ 17 were (175.2, 161.2, 216.8), (5.8, 7.2, 5.8), (69.8, 81.2, 95.4), (40.6, 56.2, 72.2), (4.34, 4.38, 4.64), (16.6, 16.2, 18.4), (4.39, 4.67, 4.83), (42.09, 42.93, 40.93), (21.47, 22.4, 18.71), respectively. Similarly, in white flowered toria the1000-SW was 3.68g and oil content 42.73%.

On the basis of per cent oil content, total 30 lines selected were having more than 43% oil content and promising mutants were BRNS-M-17-1 (43.66%), BRNS-M-17-5 (43.68%), BRNS-M-17-7 (43.66%), BRNS-M-17-12 (43.46%), BRNS-M-17-22 (43.77%). Out of them, two promising mutants namely BRNS-M-17-14 (44.90%) and BRNS-M-17-16 (43.68%) were selected for high oil content having yellow seed coat, seeds per siliqua (>18) and white rust resistant. Total five Alternaria blight tolerant mutants were used for diallel crosses attempted with high yielding variety NRCHB 101. High yielding mutants were selected including BRNS-17-423; 47g/plant of RH-749 G+E, 100Kr+1.0%, BRNS-17-488; 45g/plant, BRNS-17-490; 54g/plant of Kranti G 100 Kr and BRNS-17-507; 44.6g/plant, BRNS-17-525; 41g/plant of Pusa Bold G 100Kr with long siliquae, long main shoot, more number of siliquae on main shoot and higher per plant yield. The mutants showed several other variable traits.

Total phenol, total antioxidant, total soluble sugar, and radical scavenging activity were estimated and biochemical analysis was carried out using 19 Alternaria blight tolerant mutants of M_4 generation and 24 white rust resistant mutants with 8 resistant/ susceptible check genotypes. The resistant mutants/ checks revealed that increasing trend for all estimated biochemical parameters and vice versa. Based on biochemical analysis, mutant BRNS–M-17-182, BRNS–M-17-190 and BRNS–M-17-201 were showed highly resistant against white rust among 24 promising white rust resistant mutants (BRNS–M-17-180 to BRNS-M-17-203). Similarly, three promising mutants were BRNS-M-17-162, BRNS-M-17-168 and BRNS-M-17-175 selected against Alternaria blight which also matched with the phenotypic response of disease.

Fig. 2.23 Mutant of yellow seeded high oil content (BRNS-M-17-16)

Fig. 2.24 Mutants of variable leaf

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

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

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

Two low erucic acid varieties namely, PM-21 and PM-30 were selected for mutagen treatment. Seeds were irradiated with 1000 Gy and 1200 Gy doses of gamma ray. Three doses *viz*. 0.25, 0.50 and 0.75% of EMS was used to treat the seeds of same varieties. Combined treatment of gamma ray and EMS was also given to these varieties.

M_1 generation mutagen was raised dose wise also with control in the experimental field of DRMR. Seeds were sown in ten rows of 5 m each (70cm spacing row and 5 cm inter plant spacing). The sowing was done in Sept and Oct 2017. Single plants from all treatments were harvested. Numbers of plants in each dose were counted to determine the dose effect on germination.

PM-21 Control

PM-21, 1200Gy

PM-21, 1500Gy

PM-30, 1500Gy

PM-30 Control

Fig. 2.25: Field view showing effect of mutagen plant population of treated varieties

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: A.K. Sharma, Pr. Scientist (Ag. Extension)

ITMU has been involved in protection, management and commercialization of intellectual property generated by the ICAR-DRMR and the institutes under AICRP-RM project. During the period, the 23 rapeseed-mustard varieties registered by ICAR-DRMR with PPV&FRA were renewed. The annual registration renewal charge/fee for these 23 rapeseed-mustard varieties worth Rs. 1,22,000 were submitted to PPV&FRA for renewal of these varieties.

An MoU was signed between M/s BASF India Limited, Mumbai and ICAR-DRMR for evaluation of herbicide for two seasons at ICAR-DRMR, Bharatpur. A sum of Rs 12, 79, 200 was generated as testing fee by signing the MoU.

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

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

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

During 2017-18, 1750 FLDs on rapeseed-mustard and 12 trainings of extension personnel were approved by Department of Cooperation, Ministry of Agriculture, Govt. of India for ICAR-DRMR. These FLDs were conducted through different AICRP-RM centers across the country.

Training programmes

For upgrading the knowledge and skills of grass root extension workers of State Department of Agriculture about research developments in the field of rapeseed-mustard, 10 training programmes for extension workers of two days each were organized by ICAR-DRMR and AICRP-RM centres. Two training programmes simultaneously by ICAR-DRMR (19-20 Feb. 2018 for 37 participants) and one each by Sriganganagar (27-28 Feb. 2018 for 20 participants) and Navgaon (14-15 Feb. 2018 for 20 participants) in Rajasthan; Ludhiana (26-27 Feb. 2018 for 18 participants) in Punjab; Chhata (27-28 Feb. 2018 for 20 participants) in Jammu & Kashmir; Varansi (3-4 Feb. 2018 for 20 participants) and Kanpur (16-17 March 2018 for 20 participants) in Uttar Pradesh; Morena (1-2 Feb. 2018 for 21 participants) in Madhya Pradesh and SK Nagar (23-24 Jan 2018 for 20 participants) in Gujarat were organized during 2017-18. In these training programmes a total of 196 extension workers of respective districts/states participated and they were made aware of the new technologies advances in rapeseed-mustard cultivation.

3 Transfer of Technology

20th Beej Pakhwada

ICAR-DRMR's popular endeavour, 20th Beej Pakhwada was organized during September 15-October 10, 2017 at DRMR to sale the quality seeds of improved varieties namely DRMR IJ-31, RH 749, RH 406, NRCDR 02, NRCHB 506, DRMR 150-35, NRCHB 101 of Indian mustard, and NRCYS 5-2, YSH 401 of yellow sarson to the rapeseed-mustard farmers. The seeds were sold to the farmers on first-come-first serve

basis. A record number of farmers from different states visited the Directorate during this *Pakhwada* and purchased seeds of different improved varieties. Farmers were also provided counselling for situation specific varietal selection along with advise on scientific cultivation of rapeseed-mustard. A large quantity of seeds of different varieties were also procured by a number of Krishi Vigyan Kendras and Agricultural Universities this year for conducting frontline demonstrations in their respective districts/states across the country so that production potential of improved varieties can be shown to large number of farmers that will lead to their wide adoption in different agro climatic situations of the country. Shri Gajendra Singh Shekhawat, Hon'ble Minister of State for Agriculture & Farmer Welfare visited ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur on September 24, 2017. Shri Shekhawat visited farm section and participated in *Beej Pakhwada* where he interacted and apprised farmers about the use of soil health card and neem coated urea. 580.8 q TL seeds of improved verities of Indian mustard were sold during *Beej Pakhwada*.

Training programmes

ICAR-DRMR organized a total of 7 training

programmes of 2-5 days duration for farmers (211 participants) on various aspects like scientific production technology of mustard and agricultural management, bee-keeping and seed production technology in mustard sponsored by PD, ATMA, Gwalior district of Madhya Pradesh and Dholpur and Tonk district of Rajasthan, BIAF, Ajmer, Rajasthan and under ICAR seed project.

ICAR-DRMR also organized 4 training programmes of 2-5 days duration for extension

workers/ATM / BTM/TA (100 participants) from different districts of Uttar Pradesh and Rajasthan on Scientific production technology of rapeseed-

mustard sponsored by State Institute of Agriculture Management Rehamankheda, Lucknow (UP) and under FLDs, NMOOP by DAC, MoA, Govt. of India (Annexure I&II).

3 days TSP training programme on "Rapeseed-mustard seed production technologies" was organized at ICAR-DRMR, Bharatpur under TSP fund of ICAR seed project benefitting 35 tribal farmers from Pratapgarh district of Rajasthan. The farmer were learnt by theory and practical sessions/exposures on introduction of Rapeseed-mustard crops and seed production techniques.

Sarson Vigyan Mela

ICAR-DRMR organized 24th Sarson Vigyan Mela on February 03, 2018. The mela was

inaugurated by Dr. Anand Kumar Singh, Deputy Director General (Crop Science), ICAR, New Delhi. Addressing the farmers, he urged them to have regular talk with the scientists for enhancing their knowledge about new improved varieties and other technologies. He emphasized the need of working in groups for marketing of their products. He further suggested the farmers to make the post harvest value addition of agriculture produce before selling in the market so that they can get higher price and farming can become profitable. He said that government is planning to enhance the price of farm produce upto 1.5 times for benefitting the farmers. He told to farmers that they should collect information about of various government schemes from agriculture departments and research institutions. He appreciated various initiatives of DRMR for mustard farmers.

On the occasion, Dr. Anupam Barik, Additional Commissioner (Oilseed), Agriculture Cooperation and Farmer's Welfare Department, New Delhi, said that rapeseed-mustard is an important oilseed crop with maximum contribution in edible oil production. He also said that various oilseed fairs are organizing in the country to motivate the farmers to use improved farm techniques. He also suggested for bee-keeping and added that government is providing Rs. 2000 to purchase one bee hive box. He emphasized that bee-keeping will provide extra income to the farmers along with increased crop production. He said that it is also necessary

to aware the people about judicious use of edible oil in their food. He appreciated the works done by DRMR and urged to the farmers to be in touch with the Directorate.

Dr. P. K. Rai, Director, ICAR-DRMR welcome all the dignitaries and addressed the farmers. He said that Rapeseed-mustard is important oilseed crop contributing significantly in agriculture economy of the country. He also highlighted the programmes and activities of the Directorate being undertaken for the benefit of the farmers.

Addressing the farmers, Sh. Yogesh Sharma, Joint Director (oilseeds), Bharatpur division, Department of Agriculture, said that land holdings were decreasing day by day, therefore, integrated farming model should be adopted by

the farmers to increase the income from farming. He urged the farmers to visit the research institutes and take the advantage of different govt. Programmes.

Five technical folders/bulletins were also released by the dignitaries during the *Mela*. The mustard crop competition, kisan gosthi, visit of experimental field, exhibitions, *etc*. were main feature on the day. About 20 exhibition stalls were organized by different departments/ research institutes, input dealers. involved in transferring information on improved farming techniques. ICAR-DRMR honoured Viresh Multipurpose Farmer's Producers Company Limited, Bharatpur and Utthan Mustard Producer Company Limited, Bharatpur by providing Citation for their appreciable contribution in extension of improved technologies of Rapeseed-mustard.

The winners of crop competition, kisan Prashnotharies, progressive farmers, NGOs that contributed significantly towards development and dissemination of improved farming techniques of rapeseed- mustard were honoured in the *mela*. About 1500 farmers, farm women, extension workers and students actively participated in the *mela*.

Mera Gaon Mera Gaurav

"Mera Gaon Mera Gaurav" programme was actively taken up by ICAR-DRMR during 2017-18 to provide information on various production and protection technologies and advisories on regular basis in 25 adopted villages by the five teams of Inter-disciplinary members comprising of scientific and technical staff. The team members visited their respective adopted villages during different stages of farming

operations to give necessary instructions. A total of 6134 farmers were benefitted from different programmes like awareness programmes, FLDs, interaction meetings, kisan gosthies, agro advisory services organized by Directorate.

Awareness programmes: Several awareness programmes for soil fertility improvement, preparation of soil health card, importance of vermi-compost; biogas plant; summer ploughing and use of gypsum, suitable varieties of guar for *kharif* sowing, cleanliness in village, scientific cultivation practices of crops, sowing technique and seed rate in mustard, thinning and weeding in mustard, fertilizer, irrigation management, organic farming, sanitization and cleaning, Pradhanmantri Fasal Beema Yojana (PMFBY), farm mechanization, insect-pest and disease management, harvesting, threshing and storage practices in mustard, frost management, etc. were organized during village visit and interface meeting with farmers. Soil samples were taken from selected farmers and analyzed for judicious use of fertilizers. A two days farmer's training programme on "Mustard seed production technologies" was also organized at ICAR-

DRMR, Bharatpur under ICAR seed project for 30 farmers from 20 adopted villages of Bharatpur and Mathura districts of Rajasthan.

FLDs : Under the programme, 285 farmers were selected from 25 adopted villages of Bharatpur district for conducting 285 FLDs (280 FLDs on mustard and 5 FLDs on wheat) to

show the production potential of improved varieties along with other technological interventions like Sulphur and Zinc application, seed treatment, proper spacing at farmers' field. ICAR-DRMR provided 6.20 quintal seed of improved varieties of Indian mustard viz. RH 749, DRMRIJ 31, RH 406, NRCHB 101and wheat viz. HD 2967, HD 3086 along with 280 quintal of Single Super Phosphate, 196 quintal of Urea and 14 quintal of Zinc Sulphate as well as relevant literature. A number of farmers were taken to visit the FLDs sites to the production potential of new varieties and benefits of technological interventions.

Sarson Field days : Four Sarson field days were also organized in Jaicholi, Habibpur, Dehra and Maharajsar villages adopted under MGMG to show performance and production potential of improved varieties of Indian mustard to farmers and extension personnel at the farmer's field. More than 1000 farmers and extension personnels participated in these Sarson field days.

Scientist made regular visits to the adopted villages by the scientists were done for interaction meeting/ kisan gosthies, monitoring of FLDs, providing first hand solution of the problems faced by the farmers. The farmers of adopted villages were also provided the opportunity to participate in ICAR-DRMR programmes, like kisan mela, exhibitions, visitors' advisory services, trainings, etc. A total 51 Kisan gosthies were organized to motivate the farmers to adopt the scientific cultivation of mustard. The relevant literature in the form of leaflets/folders were also distributed to the participating farmers in gosthies and interaction meetings. A total of 79 agro advisories were issued to the farmers.

Front line demonstrations (FLDs)

A total 337 frontline demonstrations (FLDs) under whole package with four improved varieties Giriraj (DRMRIJ 31), RH 749, RH 406, and NRCHB 101 were laid out in different villages of Bharatpur district of Rajasthan during 2017-18 to show the impact and

production potential of these varieties on farmers' field. The average yield of demonstrated varieties Giriraj, RH 749, RH 406, and NRCHB 101 was 2400, , 2338, and kg/ha with yield improvement of 11.6, 11.3, 6.8, and 3.78%, respectively over prevailing varieties. The average cost of cultivation under all FLDs was Rs. 33400 against Rs. 34600 in farmers' plot. On an average, the improved varieties fetched additional net monetary return (ANMR) of Rs 9440 /ha in response to less cost of Rs. 1200/ha.

Sarson School on AIR

Sarson School on AIR (Radio Krishi Shiksha Programme) covered two major mustard

producing states Rajasthan and Uttar Pradesh during 2017-18. ICAR-DRMR's scientists communicated the scientific technology to the farmers and extension personnel of these states through weekly radio programmes, which was being broadcasted through 10 All India Radio stations viz. Jaipur, Alwar, Kota, Swai Madhopur and Suratgarh of Rajasthan; Lucknow, Mathura, Varanasi, Jhansi and Agra of Uttar Pradesh during Sept., 2017 to Feb., 2018. ICAR-DRMR also broadcasted technology delivery modules through 24 radio talks from each of the selected AIR stations during the crop season 2017-18 to provide timely advice about various advanced production practices of rapeseed-mustard that enhanced the knowledge and created confidence for adoption of improved technology among the farmers.

Visitors Advisory Services

Under Visitors Advisory Services, successfully organized/ coordinated interaction meetings and counselling sessions on rapeseed-mustard cultivation for 92 visiting groups of farmers and 33 groups of students from Rajasthan, Uttar Pradesh, Gujarat, Haryana, Himachal Pradesh and Madhya Pradesh consisting of 4342 stakeholders including 2969 farmers, 197 farm women, 175 extension personnel, 890 students and 111 teachers. The visiting groups were educated/ trained through lectures, visit to technology park, experimental fields, museum and were also provided literature.

4 Training and Capacity Building

4.1 TRAININGS

4.1.1 Scientist

Topic	Venue	Period	Participants
Winter school on Harnessing NGS data for genetic enhancement in crops	ICAR-DWBR, Karnal	October 2-12, 2017	H.K. Sharma
Advances in simulation modeling and climate change research towards knowledge based agriculture	ICAR-IARI, New Delhi	November 16-December 6, 2017	Harvir Singh
New extension approaches for inclusion of rural youth, small holder farmers and integration of MGMG activities with ongoing extension programmes	IIRR, Hyderabad	November 21-30, 2017	A.K. Sharma
Short course on Sustainable intensification of Brassica production system (SIBPS)	ICAR-DRMR, Bharatpur	January10-19, 2018	H.K. Sharma, M.D. Meena
CAFT training on Recent techniques and tools for nutritional quality assessment and enhancement of food crops	ICAR-IARI, New Delhi	January 23-February 12, 2018	M.S. Sujith Kumar
Genomics–assisted breeding for crop improvement	ICAR-IARI, New Delhi.	March 1-21, 2018	B.L. Meena
Management development programme on building and leading teams	IIM, Indore	March 7-9, 2018	Pankaj Sharma
Certified farm Advisor	ICAR-IIPR, Kanpur	October 3-17, 2017	B.S. Rathore

4.1.2 Technical staff

Topic	Venue	Period	Participants
Automobile maintenance, road safety and behavioral skills	ICAR-CIAE, Bhopal	July 18-22, 2017	Govind Prasad
Promotion of public-private partnership in agriculture reforms	SKNAU, Jobner	August 1-4, 2017	A.K. Verma, B.L. Ola
Selection, adjustment, operation and maintenance of agricultural implements for field and horticultural crops	ICAR-CIAE, Bhopal	August 1-10, 2017	H.P. Meena

Quality seed production technology of oilseeds and pulses	NSRTC, Varanasi	September 11-15, 2017	H.P. Meena
Motivation and positive thinking	ICAR-NAARM, Hyderabad	September 13-22, 2017	M.L. Meena, Karnal Singh
Seed health testing	NSRTC, Varanasi	November 13-17, 2017	H.P. Meena
Use and maintenance of instruments in soil and plant analysis	ICAR-IISS, Bhopal	November 13-18, 2017	R.N. Meena
New extension approaches for inclusion of rural youth, small holder farmers and integration of MGMG activities with ongoing extension programme	IIRR, Hyderabad	November 21-30, 2017	Sandeep Rastogi
Enhancing nutrient use efficiency through next generation fertilizers in field crops	ICAR-IIPR, Kanpur	November 21-30, 2017	B.L. Ola
Training program on layout and maintenance of field implements and recording observations	ICAR-IARI, New Delhi	December 3-12, 2017	K.N. Meena
Good agriculture practices (GAPS) for enhancing resources use efficiency and farm productivity	ICAR-IARI, New Delhi	December 5-18, 2017	R.C. Meena, K.N. Meena
Sustainable intensification of Brassica production system (SIBPS)	ICAR-DRMR, Bharatpur, Rajasthan	January10-19, 2018	Sandeep Rastogi, B.L. Ola
Communication skills and scientific writing for technical officers	ICAR-NAARM, Hyderabad	January 3-9, 2018	Sanjay Kumar
KOHA for library staff of ICAR	NAARM, Hyderbad	February 5-9, 2018	Rakesh Goyal
Workshop on participatory extension management skills in agriculture and allied fields	EEI, Anand	June 27-July 1, 2017	Sandeep Rastogi

4.1.3 Administrative staff

Topic	Venue	Period	Participants
Public financial management system (PFMS)	ICAR-DRMR, Bharatpur	July 7, 2017	All administrative staff
Training on e-Procurement system	ICAR-DRMR, Bharatpur	July 19, 2017	All administrative staff
Management development programme on public procurement	NIFM, Faridabad	July 10-15, 2017	A.K. Tondon
Workshop on pay fixation	ISTM, Delhi	July 12-14, 2017	R.S. Meena, Poonam Keshri
Workshop on e-Procurement	New Delhi	August 21-22, 2017	P.K. Tiwari

4.2 Participation in Seminars, Symposia, Conferences, Meetings

Event	Venue	Duration	Participants
State coordination committee meeting for doubling farmers' income in Rajasthan by 2022	MPUAT, Udaipur	April 4-6, 2017	P.K. Rai Pankaj Sharma
Krishi Mela	Motihari, Bihar	April 14, 2017	P.K. Rai Pankaj Sharma
Meeting with DDG (CS) regarding on carry over liability towards salary etc of XII plan period	Delhi	April 17, 2017	P.K. Rai
ICAR review committee meeting with (Crop Science Division) regarding social impacts, resources, consolidation on	IARI, New Delhi.	April 29, 2017	P.K. Rai
National conference on Biotechnology: Resource management for sustainable nature in 21st century	Dr. BRAU, Agra	April 22-23, 2017	P.K. Rai Arun Kumar Anubhuti Sharma Ajay Thakur H.S. Meena Priyamedha
Meeting of NASF project on Creating a fully characterized genetic resource pipeline for mustard improvement programme in India	PAU, Ludhiana	May 2, 2017	K.H. Singh
GCIRC Technical meeting	SLU, Alnarp, Sweden	May 8-11, 2017	Pankaj Sharma
GCIRC General Assembly meeting	SLU, Alnarp, Sweden	May 10, 2017	Pankaj Sharma
6th TSP workshop on Augmenting rapeseed-mustard production of tribal farmers for sustainable livelihood security under tribal sub plan	AAU, Jorhat	June 22-23, 2017	P.K. Rai A.K. Sharma
ICAR foundation day, award ceremony 2017 and Directors conference	NASC, New Delhi.	July 15-16, 2017	P.K. Rai
12th Annual review meeting of ICAR seed project	MPKV, Rahuri	July 29-30, 2017	Bhagirath Ram
24th Annual Group Meeting of AICRP-RM	RARI, Durgapura, Jaipur	August 3-5, 2017	P.K. Rai, V.V. Singh, K.H. Singh, Pankaj Sharma, P.D. Meena, O.P. Premi, R.S. Jat, Bhagirath Ram, H.S. Meena, Arun Kumar, Anubhuti Sharma, Ajay Kumar, Priyamedha, Ibandalin Mowlong, M.S. Sujith Kumar, M.L. Meena, Karnal Singh, Sanjay Sharma, R.C. Sachan

Scientific Advisory Committee Meeting of KVK, Dholpur	KVK, Dholpur	August 10, 2017	P.K. Rai
National workshop on IPRs: A potential tool of technological development in agriculture	RBS Engineering Technical Campus, Bichpuri, Agra	August 21-22, 2017	K.H. Singh
Farmer awareness programme- cum-*Kisan Gosthi* on improved mustard production technology	BHU, Varanasi	August 22, 2017	P.K. Rai
International conference on Advances in potassium research for efficient soil and crop management	NASC, New Delhi	August 28-29, 2017	R.S. Jat
Review meeting of Consortia research platform on hybrid technology- Mustard	ICAR-DRMR, Bharatpur	September 7, 2017	K.H. Singh
Zonal Research Extension Advisory Committee (ZREAC) meeting	ARS, Navgaon, Alwar	September 11, 2017	V.V. Singh R.S. Jat
SFC meeting on Oilseed for consideration of schemes of DARE/ICAR for the period (2017-2020)	ICAR, New Delhi	September 14, 2017	P.K. Rai
Meeting of mid-term review– ICAR regional committee no. VI	ICAR-CAZRI, Jodhpur	September 22, 2017	P.K. Rai
Kisan mela and farmers' innovation day	ICAR-CAZRI, Jodhpur	September 23, 2017	P.K. Rai
Brain storming session-cum-workshop on Strategies for area expansion and productivity enhancement of oilseeds and oil palm	ICAR-IIOR, Hyderabad	September 26, 2017	Pankaj Sharma
KVK Scientific Advisory Committee meeting	KVK, Bichpuri, Agra	October 13, 2017	Pankaj Sharma R.S. Jat
ISMPP International conference on Plant health for human welfare	University of Rajasthan, Jaipur,	November 1-4, 2017	Pankaj Sharma P.D. Meena
International conference on Conservation and management of agricultural and natural resources: Strategies for food security in developing countries	Career Point University, Kota	November 8-9, 2017	Ajay Thakur
3rd International conference on Bio-resources and stress management"	SIAM, Jaipur	November 8-11, 2017	R.S. Jat H.S. Meena Mukesh Meena M.D. Meena
Indo-Canada 5th joint working group meeting at DAC	New Delhi	November 14-15, 2017	P.K. Rai Pankaj Sharma
71st Annual conference on Statistics and informatics for farmers welfare organized by ISAS	ICAR-DRMR, Bharatpur	November 25-27, 2017	ICAR-DRMR Scientists

International conference on global research initiatives for sustainable agriculture and allied sciences	MPUAT, Udaipur	December 2-4, 2017	P.K. Rai V.V. Singh Pankaj Sharma Arun Kumar H.S. Meena Priyamedha
National sheep and wool fair	ICAR-CSWRI, Avikanagar	December 8, 2017	P.K. Rai
12th DUS review meeting	ICAR-IISR, Lucknow	January 15-17, 2018	Priyamedha
International symposium on Global futuristic trends in life sciences	Rajiv Gandhi Biotechnology Centre, Nagpur	January 16, 2018	Anubhuti Sharma
Review meeting of DBT-UDSC partnership centre on Genetic manipulation of Brassicas	New Delhi	February 2, 2018	P.K. Rai
Meeting on Priority areas of research in Indian mustard (*Brassica juncea*)	NRCPB, New Delhi	February 3, 2018	K.H. Singh
20th congress on Recent need based eco-friendly technologies for doubling farmers income	Bioved, Allahabad	February, 17-18, 2018	P.K. Rai
National agronomy congress on Redesigning agronomy for nature conservation and economic empowerment	GBPUAT, Pantnagar	February, 20-22, 2018	O.P. Premi H.K. Sharma Harvir Singh
Scientific Advisory Committee of KVK, Gunta Bansur	KVK, Bansur, Alwar	February 21, 2018	P.K. Rai Pankaj Sharma
Germplasm field day on Rapeseed-mustard and linseed	ICAR-NBPGR, New Delhi	February 22, 2018	H.K. Sharma
12th meeting of Oil and Oilseeds Sectional Committee, FAD 13	Manak Bhavan, New Delhi	February 23, 2018	Anubhuti Sharma
Brain storming session-cum-interaction meet on Engineering interventions for production and processing of different crops	ICAR-CIAE, Bhopal	February 26-27, 2018	R.S. Jat
International conference on Science, technology and social humanities	Dr. BRAU, Agra	February 26-28, 2018	Anubhuti Sharma
International conference on Innovative technologies towards energy, environment, food and sustainable agriculture	RBS Engineering Technical Campus, Bichpuri, Agra	February, 26-28, 2018	Ajay Thakur H.S. Meena Mukesh Meena M.D. Meena B.L. Meena
Director's conference	ICAR, New Delhi	March 8-9, 2018	P.K. Rai
Kisan mela	KVK, Bansur, Alwar	March 17, 2018	P.K. Rai Pankaj Sharma Bhagirath Ram Ajay Thakur H.K. Sharma
21st Annual breeder seed review meeting	ICAR-NBPGR, New Delhi	March 26, 2018	Bhagirath Ram

5 Awards and Recognition

Dr. P.K. Rai, Director (Acting), received Bioved-Honorary Fellowship Award-2018 by Bioved, Allahabad; SRMR-Fellowship-2017 by Society for Rapeseed-Mustard Research, Bharatpur; Life Time Award-2017 by Indian Society of Genetics, Biotechnology Research and Development, Agra and Life time achievement award-2017 by Astha Foundation, Meerut.

Dr. V.V. Singh, Principal Scientist (Genetics and Plant Breeding), received Outstanding Achievement Award during International conference on GRISAAS at MPUAT, Udaipur (Dec 2-3, 2017).

Dr. Pankaj Sharma, Principal Scientist (Plant Pathology), was honored with Best Oral Research Paper Presentation Award in ISMPP International Conference on Plant health for human welfare, University of Rajasthan, Jaipur during Nov. 1-4, 2017. He was also conferred Distinguished Scientist Award by Society for Scientific Development in Agriculture and Technology during International Conference at MPUAT, Udaipur during Dec 2-4, 2017.

Dr. Bhagirath Ram, Principal Scientist (Genetics and Plant Breeding), received Best Presentation Award in International Conference on Novel Applications of Biotechnology in Agricultural Sectors: Towards Achieving Sustainable Development Goal-2018 (INABASDG-2018), organized at Banaras Hindu University, Varanasi (U.P.) India during March 20-21, 2018.

Dr. Anubhuti Sharma, Senior Scientist (Biochemistry), received Best Paper Presentation Award and Innovative Scientist Award in National conference on 'Biotechnology: resource Management for sustainable Nature in 21st Century', organized by Indian Society of Genetics, Biotechnology Research & Development, Agra, from April 22-23, 2017.

Dr. H.S. Meena, Senior Scientist (Genetics and Plant Breeding), received Young Scientist Award in International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2017), at MPUAT, Udaipur, Rajasthan during Dec. 2-4, 2017.

Dr. M.K. Meena, Scientist (Soil Science), received Young Scientist Award from Society of Genesis, Urban and Rural Development in International Conference on "Advances in Agriculture and Allied Science Technologies for Sustainable Development", held at Osmania University, Hyderabad, during February 10-11, 2018.

Dr. A.K. Thakur, Senior Scientist (Biotechnology), received Young Scientist Award from Indian society of Genetics, Biotechnology Research & Development in National Conference on "Biotechnology: Resource Management for Sustainable Nature in 21st Century" at Dr. B.R.A. University, Agra on April 22-23, 2017. He was also conferred Young Scientist Award from Samagra Vikas Welfare Society (SVWS), Lucknow on October 16, 2017.

Dr. H.K Sharma, Scientist (Senior Scale) Genetics and Plant Breeding, received Young Scientist Award from Society for Agriculture Innovation and Development (SAID), Ranchi in May, 2017. He also received Outstanding Scientist in Plant Breeding Award from Venus International Foundation, Chennai in November, 2017 and also got inducted in the Editorial Board of Journal of Genetics, Genomics and Plant Breeding as Associate Editor.

Dr. B.L. Meena, Scientist (Genetics and Plant Breeding), received Young Scientist Award from Society of Genesis, Urban and Rural Development in International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development, held at Osmania University, Hyderabad, during February 10-11, 2018.

Dr. Priyamedha, Scientist (Senior Scale) Genetics and Plant Breeding, received Young Scientist Award from Indian society of Genetics, Biotechnology Research & Development in National Conference on Biotechnology: Resource Management for Sustainable Nature in 21st Century at Dr. B.R.A. University, Agra on April 22-23, 2017. She was also honored with Young Scientist Award in International Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2017), organized at MPUAT, Udaipur, Rajasthan during Dec. 2-4, 2017.

Dr. M.D. Meena, Scientist (Senior Scale) Soil Science, received Young Scientist Award from Society of Genesis, Urban and Rural Development in International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development, held at Osmania University, Hyderabad, during February 10-11, 2018.

Mr. Harvir Singh, Scientist (Agronomy), received Young Scientist Award from Society of Genesis, Urban and Rural Development in International Conference on Advances in Agriculture and Allied Science Technologies for Sustainable Development, held at Osmania University, Hyderabad, during February 10-11, 2018.

6 Linkages and Coordination

Short Course on 'Sustainable intensification of Brassica Production System'

ICAR-DRMR, Bharatpur organized a short course on 'Sustainable intensification of Brassica Production System (SIBPS)' sponsored by ICAR during January 10-19, 2018 to create better understanding on temporal and spatial intensification of the rapeseed-mustard

production and to enhance the production vis-à-vis resource use under changing climates. The short course was attended by 18 participants including Scientists, Assistant Professors, Senior Scientists/ Associate Professor and SMS.

Lectures on production systems, brassica gene pools, sustainable intensification, conservation agricultural practices, disease and insect pest management and mechanization of brassica production system were delivered by eminent speakers. The course was steered by the Course Director, Dr. R.S. Jat and Coordinator, Dr. Pankaj Sharma. At the outset, Dr. P.K. Rai, Director, ICAR-DRMR in the inaugural function highlighted the importance of such thematic trainings for the young researchers in the present context of climate change and resource crunch production scenario. The participants were exposed hands on practicals and field visits besides class room lectures.

Participation in GCIRC Technical Meeting

Dr. Pankaj Sharma, Principal Scientist, DRMR attended International Consultative Group of Research on Rapeseed (GCIRC) Technical Meeting 2017 in Swedish University of Agricultural Sciences Alnarp, Sweden during May 8-11, 2017. During meeting four scientific programme were on economy, breeding and genetics, agronomy and management and analysis and use of rapeseed. General assembly meeting during the technical meeting also discussed about the next International Rapeseed Congress going to be held in Berlin during 2019.

Quality oils in alternative oil crops such as *Crambe* and *Lepidium* were another significant highlight of the congress. The GCIRC technical meeting was organized by GCIRC, Paris, France and Sveriges Frö- och Oljeväxtodlare (SFO), Alnarp, Sweden. Dr. Pankaj Sharma presented his findings on Epidemiology and recent advances in Sclerotinia rot management in *Brassica juncea*. 125 participants from 15 countries attended the technical meeting.

Interaction with AAFC, Saskatoon

Dr. Ranjana Sharma, Associate Director, Research Development Technology (RDT) for Agriculture and Agri-Food (AAFC) Canada, visited ICAR-DRMR, Bharatpur on November 18, 2017. Scientific staff of DRMR attended the interaction meeting. Dr. P.K. Rai, Director (Acting), ICAR-DRMR, briefed about the research activities being carried out at ICAR-DRMR. During meeting Dr. Ranjana Sharma presented the highlights of research projects being handled at Saskatoon Research and Development Centre, Saskatchewan, Canada. She also discussed about the collaborative projects that may be taken in future in Brassica research and development of both the countries. Dr. Sharma also visited experimental farm of ICAR-DRMR.

71st Annual Conference of Indian Society of Agricultural Statistics

71st Annual Conference of Indian Society of Agricultural Statistics was organized at ICAR-DRMR, Bharatpur during 25-27 November, 2017. Main theme of the conference was "Statistics and Information Science for Farmer's Welfare". The conference was inaugurated by chief guest Padam Bhushan Dr. R. B. Singh, Chancellor, CAU, Imphal. Dr. Arvind Kumar, Vice Chancellor, Rani Laxmi Bai Central Agricultural University, Jhansi, Dr, D. P. Mondol, Director General, NSSO, Dr. T Haq, Director, Special cell on Land Policy, Niti Ayog, Dr. Padam Singh, Ex-Member, National Statistics Commission and Ex-Director, IASRI, Dr. Devendra Verma, Director General, Central Statistical Office, Statistics and Programme Implementation Ministry, Dr. Mukesh Srivastava, World Food Organization, Bankok were also present during inaugural session. Dr. P. K. Rai, Director, ICAR-DRMR, formally welcomed all the distinguished guests and stated the achievements, different research projects and programmes of the Directorate. On this occasion Dr. U. C. Sud, Ex-Director IASRI and Secretary of ISAS presented annual report of the society.

All the dignitaries emphasized the importance of statistics, recording of correct data, and practical use of agricultural statistics in development of agriculture in the country. They also emphasized the role of agricultural statistics in doubling the farmer's income. During inaugural session Dr. P. R. Kumar, Ex-Director, NRCRM was honored for his excellent contribution in rapeseed-mustard research. Chief guest Dr. R. B. Singh

also released two publications of the Directorate. Dr. Vinod Kumar, Senior Scientist and organizing secretary presented vote of thanks. During three days conference delegates discussed different aspects of use of agricultural research and information technology in doubling the farmer's income and presented their research papers. Around 200 scientists and students from different states of the country participated in the conference.

7 All India Coordinated Research Project on Rapeseed-Mustard

ICAR-DRMR successfully organized 24th Annual Group Meeting of AICRP-RM during August 3-5, 2017 at Rajasthan Agricultural Research Institute (SKNAU, Jobner), Durgapura, Jaipur (Rajasthan). Dr. P.S. Rathore, Vice-Chancellor, SKNAU, Jobner presided over the inaugural session. Dr. S.K. Chaturvedi, ADG (O & P), ICAR, New Delhi was the Chief Guest of the function. Dr. V.K. Yadav, Director Research, SKNAU, Jobner and Dr. S.J. Singh, Director, RARI, Durgapura, Jaipur also graced the occasion. Dr. V.K. Yadav, Director Research, SKNAU extended heartiest welcome to Dr. S.K. Chaturvedi, ADG (OP), Dr. P.S. Rathore, Vice Chancellor, Dr. P.K. Rai, Director, DRMR, all the distinguished delegates, faculty members, Dean, Directors of SKNAU and media persons. He mentioned that there is scope of expansion of area of rapeseed mustard in non-traditional areas of the country and also emphasized about the achievements, technologies developed and facilities available in the area of research and teaching in SKNAU, Jobner.

Dr. P.K. Rai, Director (Acting), DRMR, Bharatpur presented the research highlights and total scenario of Rapeseed–mustard production, productivity and acreage in the different state of the country and global level as well. He informed that the overall weather was good for rapeseed-mustard cultivation in the country during the cropping season. The varietal improvement programme was conducted in 13 centres across the country in toria, yellow sarson, Indian mustard, karan rai and taramira. The performance evaluation trials were conducted at 44 centres including 20 voluntary centres/ private organizations. A total of 5695 accessions comprising toria, yellow sarson, Indian mustard, karan rai and taramira were maintained at different centres of AICRP. About 108 stains of toria, 53 strains of yellow serson, 1033 strains of Indian mustard, 10 strains of gobhi sarson and 10 strains of taramira were evaluated at the different centres. Regarding breeder seed production, 212.67q breeder seed was produced of 74 rapeseed–mustard varieties against the indent of 101.07q indicating surplus availability of 158.62q. In his inaugural address, Dr. S.K. Chaturvedi, ADG (O&P) emphasized on the importance of varietal stability over the years and expressed his concern about the increasing number of Rapeseed-mustard varieties released by different centres, with a very little gain in yield potential so far over the years. He further asserted to identify the varieties performing better under disease pressure, environmental fluctuation and fertility levels. He was on the view that effective pre-breeding efforts should be made so that newer genes can be brought from wild species to cultivated species. IPM and FLDs should be revisited so that technologies could be translated to the farmer's field successfully. Dr. Rajandra Prasad, CSAUT emphasized the vertical increase in production of rapeseed-mustard and pointed out insect-pest infestation, diseases incidence and poor technology transfer as the major hurdles of oil seed production. He also suggested that the extension workers and KVK peoples should discuss to evolve appropriate mechanism for technology transfer.

The Chairman of the Session, Dr. P.S. Rathore, Vice Chancellor, SKNAU, Jobner in his address expressed that it is a great pride for Rajasthan to occupy the first position in area as well as production of rapeseed-mustard in the country. He also emphasized the scope for enhancing the production and productivity of rapeseed-mustard and pointed out major constraints such as salt, poor water quality, changing climate, high temperature during maturity and erratic rainfall. He pointed out that during 90's only one nutrient was deficient in our soil and now, more than 10 nutrients are deficient. The balanced fertilization is the need of hours. He appreciated the varieties and production, protection technologies developed by ICAR-DRMR, Bharatpur. Nutritional factors such as omega fatty acids and level of erucic acids and glucosionolates are now the major concerns. ICAR-IARI, New Delhi and BHU, Varansi centers were conferred with best main and sub-centre AICRP award respectively, for 2016-17.

Twelve sessions were held during the meeting. Technical programmes for the year 2017 -18 were formulated and finalized for various disciplines. Dr. K.H. Singh, PI, Genetics and Plant Breeding presented the highlights of the programme. A total of 5,695 accessions comprising toria (513), Indian mustard (4,105), yellow sarson (357), gobhi sarson (115), brown sarson (46), karan rai (186), taramira (262), *Brassica tournefortii* (4), *Sinapis alba* (1), *B. caudatus* (2), *R. caudatus* (5), *B. nigra* (15), *B. oleracea* (06), *B. rugosa* ((3), *Raphanus sativa* (1), *Crambe spp.* (1*), Lepidium spp.* (2), *Camellina spp* (1) and other wild species (25) were maintained through appropriate mating system. Eighty six new accessions comprising Indian mustard (22), taramira (61) and toria (3) were collected. Further, 837 accessions consisting of 415 Indian mustard, 84 toria, 174 yellow sarson, 17 gobhi sarson, 41 brown sarson, 06 Karan rai and 100 taramira accessions were evaluated. On the basis of germplasm evaluation, promising donors were identified for earliness, tolerance to aphid and drought. With a view to improve seed yield, earliness, seed size, disease/pest resistance, high temperature tolerance, quality and high oil content, in total 1084 crosses were attempted with various objectives and 8,624 single plants and 687 bulks were selected from segregating and advanced generations. On the basis of evaluation of advanced breeding lines, strains with yield superiority over checks were identified by different centers. 145 strains including 13 of toria, 5 of yellow sarson and 127 of Indian mustard, was tested in twenty four performance evaluation trials consisting of toria (3) yellow sarson (2) and Indian mustard (19) at 47 locations across the 6 agro-climatic zones of the country.

Dr. R.S. Jat, PI, Agronomy presented highlights of the programme. Six experiments on various crop production aspects of rapeseed-mustard were conducted at 26 cooperating centres across 5 zones. In long term fertility experiments in 6th year of experiment, crop responded up to 100% NP in Zone I, II & III and balanced fertilizer application in zone IV. In agronomic evaluation of latest released varieties, maximum seed yield of RH 749 was obtained in zone II by sowing in mid October sown crop with narrow spacing 30x10 or 30x20. Higher seed yield of GM-3 was obtained in first fortnight of October sown crop at Jobner and second fortnight of October at Nagpur and S.K. Nagar. In Zone V, NRCHB-101 gave maximum seed yield in first week of November sown crop with normal planting geometry. Varietal performance under rainfed early mustard entry, RH 725 produced 20.9% and 4.3% higher seed yield than the best check at Hisar and Ludhiana. Yield maximization of latest released varieties under pearl millet/rice-mustard cropping system, the maximum seed yield of NRCHB-101 was obtained when sown in the first fortnight of November at narrow spacing (30 x 10 cm) along with 125% RDF at Imphal. The chairman suggested to make joint programme of agronomy and physiology for technical programme formulation.

Dr. Pushp Sharma, PI, Plant Physiology reported that five experiments were conducted to evaluate mustard genotypes from different agro-climatic zones to abiotic stresses. Forty six genotypes of Indian mustard (*B. juncea*) were tested for high temperature tolerance at seedling stage both,

under field and laboratory conditions. Selection criteria of low seedling mortality (<20%) and high dry matter i.e. > 40mg was recorded only in one genotype KMR(E)15-1 at Hisar, Ludhiana and Mumbai under laboratory and also under field condition at Hisar and Ludhiana. The chairman suggested to some observations which can be utilized by breeders in crop improvement programme like pollen germination, pollen fertility, stigma receptivity etc.

Dr. P.D. Meena, PI, Plant Pathology presented the results of experiments and informed that disease pressure was moderate to severe during the season. He also reported promising resistant/ tolerant sources against various diseases. In Screening of *Brassica* germplasm and breeding materials, PDZ-5 of *B. juncea* was found resistant to WR at four locations. Under Uniform Disease Nursery for major diseases, PDZ 1, DRMR 1-5, DRMR 2-11 of *B. juncea* and DRMR-316, DRMR-312, DRMR-100 of *B. carinata* showed resistance to WR. DRMR 1-5 of *B. juncea* at JAG and SKN. DRMR-316 and DRMR-100 of *B. carinata* showed resistance to PM at 4 and 3 locations, respectively. In National Disease Nursery (NDN) for Alternaria blight DRMRAB 7-158, RH 1235 and RMWR 09-05 of *B. juncea* showed tolerant reaction to WR Basanti, DRMR 2019, DRMRIJ 12-40 and RLC-3 showed resistant reaction against Hisar, Ludhiana and Berhampore isolates of *A. candida* at Hisar. The chairman suggested that donors for different disease tolerance /resistance may be submitted to NBPGR and sharing with other centres.

Dr. Sarwan Kumar, PI, Entomology presented the highlights and reported that weather conditions were favourable for the development of insect-pests. He also reported some promising entries, which showed resistance/ tolerance to mustard aphid. Moderate to heavy population of mustard aphid was reported from most of the centres from 3rd SMW to 11th standard week with peak during 5th to 8th week. Very high population of cabbage aphid was reported at Ludhiana centre with activity from 48th-11th standard week. Low population of painted bug was found active from 45th to 49th standard week at Hisar while at Kanke and Navgaon centres, it was active from 10th to 13th and 5th to 12th standard weeks, respectively. The chairman suggested that compilation of data should not be done on centre wise.

Dr. Anubhuti Sharma, PI, Biochemistry, presented the highlights of Biochemistry and reported that important breeding materials and IVT/AVT quality trials were evaluated at different centres. Among the 24 genotypes analyzed, the oil content ranged from 30.2 % in LES-55 (Ludhiana) to > 40% in PDZ-4 and RL-1359. Oil stability index which is the ratio of MUFA: PUFA ranged from 0.72 (LES-54) to 1.31 (RL-1359). Total flavonoid content ranged from 0.70 (PDZ-8) to 1.19 (PM-21) mg/g QE. Total phenol content ranged from 1.00 (PDZ-8) to 1.53 (RLC-3) %. O-dihydroxyphenol content ranged from 0.51(LES-54) to 1.16 (RLC-3). CJRB-1661, PDZ-8, PDZ-4, PDZ-1, PDZ-5, RLC-3 had Total Glucosinolate content < 30 µmol/g. < 2% Phytic acid content was reported only in LES-55. LES-54, NRCHB-101, PM-30, Kranti, PDZ-7, RLC-2, PDZ-6 recorded > 5 ppm β-carotene content.

The Variety Identification Committee meeting of AICRP on Rapeseed-Mustard was held on August 3, 2017 under the Chairmanship of Dr. S.K. Chaturvedi, ADG (OP), New Delhi. A total of 6 proposals of Indian mustard PRO 5111, Albeli 1, RH 0725, CS 2800-1-2-3-5-1, DRMR 1165-40, and PDZ-1 were considered for identification. The committee identified three strains of Indian mustard RH 0725, CS 2800-1-2-3-5-1 and PDZ-1 for release under different agro-ecological conditions. More than 170 scientists/personnel associated with rapeseed-mustard research and development in the country participated in this meeting. With the plenary session chaired by Dr. S.K. Chaturvedi, ADG (OP), ICAR, the meeting was successfully concluded on 5th August, 2017.

The following action points were suggested for timely implementation:

- Effective pre-breeding efforts should be made so that newer genes can be brought from wild species to cultivated species. IPM

and FLDs should be revisited so that technologies could be translated to the farmer's field successfully.

- Joint technical programme of agronomy and physiology must be planned.
- In plant physiology experiment, some observations which can be utilized by breeders in crop improvement programme like pollen germination, pollen fertility, stigma receptivity etc. must be recorded.
- Donors identified for different disease tolerance /resistance may be submitted to NBPGR and shared with other centres.

The following recommendations were made on the basis of multi-location experimentation at various centres:

- Application of 150% NPK under rice-mustard in Zone I, Zone II, Zone III and Zone V resulted in maximum seed yield in Rice/Maize/Pearlmillet-mustard cropping systems, respectively.
- The variety NRCHB 101 gave maximum seed yield when sown on 10 November at 30x10 cm spacing and with 150% RDF (N:P:K:S:B:Zn:FYM @ 60:32:30:24:1:15 kg/ha: 5 t/ha) at Imphal.
- Seven white rust donors DRMR-1-5, DRMR 2035, DRMRMJA 35, DRMRIJ 12-40, DRMRIJ 12-26, DRMR 2019, DRMRIJ 12-28 identified.
- Dimethoate 30EC @300 g a.i./ha/ ml per litre of water was found effective with higher IBCR for painted bug management.
- Foliar spray of brassinolide @20 ppm and salicylic acid @100ppm improved seed yield under rainfed conditions.

Strains of Indian mustard *(B. juncea)* identified for release during XXIX Annual Group Meeting of AICRP-RM

Variety	Organization	Average seed yield (kg/ha)	Maturity duration (days)	Mean oil content (%)	Salient feature	Recommended for the states
RH 0725	CCS HAU Hisar	**2642(2366-2811)**	141	42.2	Timely sown rainfed condition	**Zone II-** Rajasthan, Punjab, Haryana, Delhi, Jammu and Western UP
CS 2800-1-2-3-5-1	ICAR-CSSRI Karnal	**1792(1714-2081)**	134	39.4	Salinity/Alkalinity conditions	**Zone II-** Rajasthan, Punjab, Haryana, Delhi, Jammu and Western UP
PDZ-1	IARI, New Delhi	**2234(2019-2499)**	142	40.7	Quality mustard	**Zone II-** Rajasthan, Punjab, Haryana, Delhi, Jammu and Western UP

8 Publications

8.1 Research Papers

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- Priyamedha, KH Singh, HK Sharma, BL Meena, Anubhuti Sharma and PK Rai. 2017. Rapeseed-Mustard: Plant Variety Protection at a glance. ICAR-DRMR, Sewar, Bharatpur 321 303.
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- प्रेमचन्द गढ़वाल, भगवत सिंह राठौड, पंकज शर्मा, रामस्वरूप जाट, पी.के.राय। 2017। बेल वाली सब्जियों की वैज्ञानिक खेती. कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:3
- प्रेमचन्द गढ़वाल, सुनील कुमार, भगवत सिंह राठौड़, पंकज शर्मा, पी.के.राय एवं बजरंग लाल ओला। 2017। टमाटर के दैहिक विकार कीट तथा रोग. कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:4
- बजरंग लाल ओला. भगवत सिंह राठौड़, सुनील कुमार, पंकज शर्मा, रामस्वरूप जाट एवं पी.के.राय। 2017। गेहूँ में खरपतवार प्रबंधन. कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:5
- सुनील कुमार, भगवत सिंह राठौड़, प्रेमचन्द गढ़वाल, पंकज शर्मा, पी.के.राय एवं रामस्वरूप जाट। 2017। प्रमुख उद्यानिकी फसलों में समेकित रोग प्रबंधन. कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:6
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- सुनील कुमार, भगवत सिंह राठौड़, बजरंग लाल ओला., अरविन्द कुमार वर्मा,पंकज शर्मा एवं पी.के.राय। 2018। फसलों में कीटनाशकों का सुरक्षित इस्तेमाल एवं सावधानियां। कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:11
- सुनील कुमार, भगवत सिंह राठौड़, संदीप कुमार रस्तोगी,पंकज शर्मा, पी.के.राय एवं प्रेमचन्द गढ़वाल। 2018। फसलों में टीकाकरण—बीजोपचार। कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:12
- बजरंग लाल ओला, भगवत सिंह राठौड़, सुनील कुमार, अरविन्द कुमार वर्मा,पंकज शर्मा एवं पी.के. राय। 2018। मूँगफली की वैज्ञानिक खेती एक लाभकारी खेती। कृषि विज्ञान केन्द्र, भा.कृ.अनु.प.—स.अनु.नि., गूंता—बानसूर। तकनीक प्रसार पत्रक:13

8.3 Books

- विनोद कुमार, पंकज शर्मा,, अरूण कुमार, प्रियामेधा एवं हरीओम शर्मा। 2017। सिद्धार्थः सरसों संदेश। भा.कृ.अनु.प.—स.अनु.नि.,भरतपुर 321 303। पृष्ठ संख्या 76।

8.4 Book Chapters

- Ibandalin Mawlong, Lianthanzauva and M.S. Sujith Kumar. 2017. Post Harvest Value Addition of Mustard. Biomolecules Reports. ISSN: 2456-8759. pp
- Meena PD, Meena HS, Sujithkumar M, Sheera A and Sharma P. 2018. Detection and management of Rapeseed-mustard disease. In: Das S, Dutta S, Chakraborty BN and Singh D (Eds.). Recent approaches for management of plant diseases. Today and Tomorrow publishers, N. Delhi. Pp. 448-481.
- Thakur AK, Singh KH, Sharma D, Singh L, Parmar N, Nanjundan J and Khan YJ. 2018. Transgenic development for biotic and abiotic stress management in horticultural crops. In: Rout G.R. and Peter KV (Eds.), Genetic Engineering of Horticultural Crops. Academic Press, Elsevier. pp. 353-386.

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**
Enhancing the level of resistance/tolerance against Alternaria blight in Indian mustard (*Brassica juncea* L) using biotechnological approaches	DRMR BT-1	Ajay Thakur
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
Growth and yield response to plant density and stage of transplanting in Indian mustard	DRMR CP-18	Harvir Singh

Nutrient transformation in soil as influenced by enriched composts and their effect on yield and quality of mustard	DRMR CP-19	M.D. Meena
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
Programmed 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
Development of a core set of SSR markers for characterization of *Brassica juncea* varieties and germplasm	SB/YS/LS-86/2014	A.K. Thakur
Garmin Krishi Mausam Sewa	DRMR EA-8	O.P. Premi
Induced mutagenesis for isolation of Alternaria blight resistant mutant in *Brassica juncea*	DRMR EA-9	P.D. Meena
Development of low glucosinolates and low phytic acid mutations for improving nutritional value of low erucic acid genotypes in Indian mustard	DERMR EA-10	Anubhuti Sharma
XII plan scheme national agriculture innovation fund/intellectual property management and technology transfer commercialization of agriculture technology	DRMR EA-13	Vinod Kumar
Frontline demonstration and other related activities of oilseeds	DRMR NMOOP-1	A.K. Sharma

10 IRC, RAC and IMC

Institute Research Council (IRC)

ICAR-DRMR organized its 27th Institute Research Council (IRC) meeting during September 28-29, 2017 under the Chairmanship of the Director, ICAR-DRMR. A second meeting of IRC was also organized on December 15, 2017 for remaining presentations. The individual scientist presented progress of project work done during 2016-17 and proposed technical program for the year 2017-18.

The chairman called on all the scientists for working on the development of the technology practically applicable in field situation. He said that there is almost 50% gap in requirement and domestic production of the edible oil in the country that lead to import the oil by incurring a huge exchequer. There is a need to develop high yielding varieties and more farmer friendly technology suitable for small and marginal farmers. The efforts should be directed towards making the country self-sufficient in edible oilseed.

He said that programme or project should be discussed within scientists group for further improvement. The aim of the project should be benefit of the farmers and they should be the target group for technology development. He stressed that technical programme should be devised keeping in view of resources and budget availability. The work of the Co-PI of the project should be clearly defined. He emphasized on team work of inter-disciplinary scientists for better research output. He stressed that programme should be in the light of RAC and QRT recommendations.

IRC also suggested to submit the report as per new proforma. The IRC expressed satisfaction with the progress made under various projects during 2016-17 and approved the technical program for 2017-18.

Research Advisory Committee (RAC)

20th Research Advisory Committee meeting was held on 18-19 December, 2017 under the Chairmanship of Dr. J.B. Chowdhury at ICAR-DRMR, Bharatpur. The other members were: Dr. S.R. Bhat, Emeritus Scientist, ICAR-NRCPB, New Delhi; Dr. B.S. Mahapatra, Prof Agronomy, GBPUAT, Pantnagar; Dr. K.P. Singh, Ex Professor and Head, Mycology and Plant Pathology, BHU, Varanasi; Dr. V.K. Yadav, Director Research, SKNAU, Jobner; Dr. R.P. Singh Ratan, Director, Extension Education, BAU, Ranchi; Dr. P.K. Rai, Director, ICAR-DRMR, Bharatpur and Dr. K.H. Singh, Principal Scientist, ICAR-DRMR, Bharatpur. Additional Director General (Oilseeds & Pulses) could not attend the meeting due to his official engagement in some other important assignment. At the outset, Dr. P.K. Rai, Director, DRMR extended warm welcome to Chairman and members of RAC. Session started with introductory remarks by Dr. J. B. Chowdhury, Chairman, RAC, who cited his long association with oilseed Brassica Research and with the Directorate of Rapeseed-Mustard Research, since its inception. He emphasized on importing germplasm from abroad particularly from east European countries and Australia to enhance variability and heterosis. He also desired to have information on issues like GM Mustard and canola quality and asked to follow focused approach to meet the objectives of proposed programmes. Dr. K.H. Singh, Member-Secretary RAC presented Action Taken Report on recommendations of 19th RAC Meeting, which were confirmed by the RAC.

Director, ICAR-DRMR Bharatpur presented the DRMR activities and then presentations were continued by PIs of different disciplines *i.e.* Crop Improvement, Agronomy, Plant Protection, Technology Assessment & Dissemination and Biochemistry & Biotechnology. RAC appreciated the efforts and achievements made by the scientists of Directorate since the last RAC meeting. Discussions were held after each presentation and members gave their comments/ observations/suggestions. Dr. S.R. Bhat asked the scientists to go for wide hybridization using wild species to develop and stabilize amphidiploids. Embryo rescue technique may be

used to get more seeds in wide hybridization. Allelic relationship of white rust resistant genes in different resistant lines should be studied. Dr. B.S. Mahapatra asked to bring recommendation on use of weedicide/herbicide in form of a technical bulletin to farmers. He also emphasized that *Orobanche* management strategies should be strengthened involving

DWR, Jabalpur and CCS HAU Hisar. Dr. K.P. Singh asked to conduct large scale survey on Collar rot disease; its incidence, severity of damage in mustard growing regions to prepare status report before initiating a project on this aspect. He also stressed to explore colonization of *Trichoderma* at large scale on mustard residue. Dr. V.K. Yadav suggested to conduct studies on the effect of oil extraction methods on quality parameters such as fatty acid composition, glucosinolate content and phytates in oil and

seed meal. Dr. R.P. Singh expressed the need of broadening linkages by DRMR with other state departments and Krishi Vigyan Kendra to develop strategies for ensuring the availability of package of practices mustard seed and other inputs at the right time and for rapid dissemination of technology. He also asked to promote seed villages through farmer participation to ensure easy availability of seed of improved rapeseed mustard varieties to farmers. It was also suggested to integrate all management practices such as Agronomy, Entomology and Plant Pathology.

Committee visited various laboratories and field experiments and interacted with scientists. During interaction with farmers, problems of high temperature, weed management, implements for weed management, price of the produce and management of diseases were highlighted. After in-depth discussion and interaction, suitable recommendations were made to improve the ongoing research programmes to meet the targeted objectives well in the outlined timeframe.

Institute Management Committee (IMC)

19th Institute Management Committee (IMC) meeting was held on March 21, 2018 under the Chairmanship of Dr. P.K. Rai, Director, ICAR-DRMR, Bharatpur. Other IMC members, Dr. S.J. Singh, Director, RARI, Durgapura, Jaipur; Dr. Rajbir Yadav, Principal Scientist, ICAR-IARI, New Delhi; Dr. B.D. Sharma, Principal Scientist, ICAR-CIAH, Bikaner; Dr. R.C. Bhattacharya, Principal Scientist, ICAR-NRCPB, New Delhi; Sh. Yogesh Sharma, Joint Director of Agriculture, Department of Agriculture, Bharatpur; Sh. S.K. Sharma, F&AO, ICAR-NRCPB, New Delhi; Dr. Pankaj Sharma, Principal Scientist, ICAR-DRMR, Sh. P.K. Tiwari, F&AO, ICAR-DRMR and Sh. R.C. Meena, SAO, ICAR-DRMR as Member Secretary. Dr. O.P. Premi, Principal Scientist, ICAR-DRMR presented an invited lecture. Sh. R.C. Meena, Member –Secretary welcomed all the guests and briefed the house about the achievements in the last year. Various agenda points were discussed thoroughly. The committee granted approval for new civil work to be started in SFC (2017-2020). The committee also asked for purchase of various items/equipments approved in SFC subject to completion of all the codal formalities and availability of funds. The meeting ended with vote of thanks to the chair.

11 Tribal Sub-Plan

ICAR-DRMR, Bharatpur implemented Tribal Sub-Plan during 2017-18 in collaboration with AAU, Jorhat (Assam); CAU, Imphal (Manipur) and BAU, Ranchi (Jharkhand) in selected tribal dominated districts of jurisdiction area of respective universities for the sustainable livelihood security of tribal farmers through on and off-campus trainings, kisan mela, exposure visits, and field days/scientists-farmers interaction meetings. FLDs were also conducted at tribal farmer's field.

6th TSP Workshop

6th TSP workshop was organized by ICAR-Directorate of Rapeseed- Mustard Research, Bharatpur in collaboration with Directorate of Research (Agri), AAU, Jorhat, Assam, during June 22-23, 2017. The workshop was inaugurated by Prof. M. Premjit Singh, Hon'ble Vice-Chancellor, Central Agricultural University, Imphal, Manipur and chaired by Dr. P.K. Rai, Director, ICAR-DRMR, Bharatpur.

Prof. M. Premjit Singh stated the importance of integration of bee-keeping with mustard cultivation to enhance farmers' income. He emphasized that bee-keeping should be included in package of practices for Rapeseed-mustard cultivation as a component to increase the yield of rapeseed-mustard and to provide additional income to farmers. He mentioned that ICAR-DRMR started project in the state during 2011 is now boon to the state of Manipur in particular and NEH region in general so far the area and production of rapeseed and mustard is concerned. He also emphasised some of the constraints for cultivation of rapeseed-mustard crop in NEH region during the project implementation period.

Dr. P.K Rai, Director, ICAR-DRMR highlighted the objectives and importance of the workshop. He briefly discussed the prospects for Rapeseed-Mustard cultivation in NE States under Tribal Sub Plan. He emphasised importance of the crop in the light of the problem of low production and productivity of rapeseed-mustard crop in NEH region. He stressed for participatory seed production programme to meet the demand of farmers for quality seed in future.

Dr. Ashok Kumar Sharma, Pr. Scientist, ICAR-DRMR and Nodal Officer, TSP presented a brief account on the role of ICAR and collaborating universities in Tribal Sub Plan. He highlighted the area and production trends and constraints in the participating states. The progress reports of TSP of 2016-17 was presented by Nodal Officers/Team leaders of the collaborative universities.

Dr. G.N. Hazarika, Director of Research (Agri.), AAU, highlighted that 4.5 lakh ha area in Assam can be utilized successfully for Rapeseed-mustard cultivation after Sali paddy. Large scale demonstration with oil exploration should be promoted with mini type oil expeller machines. For horizontal expansion of new varieties and also to meet the requirement of quality seeds, farmers in tribal area should be motivated to reserve some quantity of their produce for seed purpose for the next season.

The annual plan for TSP 2018-19 was presented by respective universities and after thorough discussions, MoUs with participating universities were finalized for implementation of TSP programme for 2018-19. All the participants visited research farm of AAU, Jorhat, Assam. The workshop was attended by Dr. Niva Bara, Deputy Director of Extension, BAU, Ranchi; Dr. Robindro, from CAU, Imphal; Dr. Vinay Singh, SMS, KVK, Jhabua, RVSKVV, Gwalior along with other team members working in TSP programme of respective universities, besides AAU scientists and staff.

CAU, Imphal (Manipur)

In Manipur TSP was implemented in Imphal West, Imphal East, Kakching, Thoubal, Kangpokpi and Bishnupur districts of Manipur; East Siang district of Arunachal Pradesh and East Khasi Hills, West Jaintia Hills and Ri Bhoi of Meghalaya. Six on-farm training on scientific production technology of rapeseed-mustard, 1 field day and 2 scientists-farmers interactions were organized that benefitted 447 tribal farmers. A 3 days training-cum-exposure visit programme for capacity building of 10 tribal farmers and 2 research/extension staff was organized at ICAR-DRMR, Bharatpur jointly with CAU, Imphal.

AAU, Jorhat (Assam)

TSP was implemented in Karbi Anglong and Dhemaji districts of Assam. Five on-farm trainings on scientific production technology of rapeseed-mustard, 2 field days and 3 scientists-farmers interactions were organized that benefitted 423 tribal farmers. A 3 days training-cum-exposure visit programmes for capacity building of 14 tribal farmers and 2 research/ extension staff was organized at ICAR-DRMR jointly with AAU, Jorhat.

BAU, Ranchi (Jharkhand)

TSP was implemented in Ranchi and Lohardaga districts of Jharkhand. Five training programmes on scientific production technology of rapeseed-mustard, 4 field days and 6 scientists-farmers interactions were organized that benefitted 1520 tribal farmers. Besides, 3 kisan diwas/ mela were also organized wherein 930 tribal farmers participated.

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

On Farm Trials

Seven technologies were assessed for different agricultural problems, *viz*., 02 OFTs on Agronomy for irrigation management in mustard. Irrigation at 35-40 and 85-90 DAS with sprinkler, resulted 20.8% increase in yield as compared to farmer practice with the B:C ratio of 2.99. Another OFT was on integrated nutrient management in mustard with the problem of imbalance use of fertilizers. Nutrients application on soil health card basis (N, P, K, S, Zn, B), resulted 27.3% increase in yield over farmer practices with B:C ratio of 2.93.

Assessment of plant spacing on growth and yield of cauliflower was carried out by paired row which resulted in 18.4% increase of yield as compared to farmer practices with the B:C ratio

of 3.19. Another was on assessment of boron on growth and yield of bottle gourd. Use of boric acid 25 ppm + 0.5 % urea as adjuvant at 30, 45 and 60 DAS, resulted 21.3 % increment in the yield over farmer practices with B:C ratio of 5.53. Two OFTs were carried on Animal science, first on effect of mineral mixture on the age of puberty of cross bred cow heifers to overcome the problem of late puberty in heifers due to deficiency of minerals in ration. Improvement of fertility through estrus synchronization in buffaloes to overcome the problem of long inter calving period due to anestrous and repeat breeding. Treated by "OVSYNCH" protocol as per NDRI Karnal with the result of decrease in duration about 3.5 months from the farmer practices, with B:C ratio of 1:16.7. One OFT conducted on plant protection

Front Line Demonstrations

Total 387 FLDs were conducted in 152 hectare area in different villages of Bansur tehsil of Alwar district. During kharif season, 41 FLDs were conducted in 15.5 hectare area and benefited 4 villages of Bansur tehsil on cluster bean, green gram and bajra fodder crops for varietal evaluation and integrated disease management. In *rabi* season, 348 FLDs were conducted in mustard, wheat and oat in 136 hectare area in different villages of Bansur tehsil of Alwar district.

Animal Health Camps

Two Animal health camps were organized in the villages of Loiti and Nangal Bhau Singh with the help of Veterinary Officer. In the camp, 181 animals including cow, buffalo and goats were treated for different ailments. The main ailments were infertility, prolapse, diarrhea, worm infestation etc. The livestock farmers were also made aware about the importance of timely

vaccination, deworming and balance feeding for maximum milk production.

Kisan Mela

District level Kisan Mela was organized at KVK, Gunta-Bansur on March 17, 2018. Chief Guest of the function was Dr. Anshdeep, CEO, Zila Parishad, Alwar and chaired by Dr P. K. Rai, Director, ICAR-DRMR, Bharatpur. In his address, Dr. Anshdeep advised the farmers to take the benefit for KVK and adopt improved technology for higher production of crops, fruits and vegetables in the area. Dr. P.K. Rai also

addressed the farmers for adopting new technologies with integrated approach. He said that the establishment of this KVK is improving the farmers and farm women livelihood, production and productivity of different crops as

well as new technologies are reaching to the farmers. He urged the farmers for their participation in training programmes, adoption of improved package and practices of cultivation. Dr. Rai also appealed the farmers to join the hands with different agricultural agencies to double the farmer's income by 2022.

On this occasion, live telecast of Hon'ble Prime minister Sh. Narendra Modi addressing farmers during Krishi Unnati Mela 2018 at IARI, New Delhi was shown to farmers. Kisan gosthi and Scientist-farmers interaction was also conducted and scientists from DRMR and line departments provided valuable information on production and protection technologies, different schemes of Central Government viz, soil health card, per drop more crop, bee-keeping, organic farming, MGMG, PMFBY, KCC etc. Progressive farmers were also felicitated by chief guest. The attraction of the fair was more than 25 exhibition stall representing Govt. Departments, ARS, KVK, NGOs, fertilizer, seed, pesticide, tractor companies and mobile soil testing laboratory etc. depicting various facets of agriculture. Over 1450 farmers, farm women from different villages of Alwar district of Rajasthan attended the Mela.

Trainings

Krishi Vigyan Kendra conducted 18 on-campus, 30 off-campus trainings and 6 sponsored trainings for practicing farmers including farm women and rural youth on improved technologies in the field of agriculture, horticulture, animal husbandry and other allied enterprises and total 1540 farmers were benefited. The trainings were conducted on different topics such as integrated crop management in kharif and rabi crops, integrated weed management in wheat and mustard crop, importance of organic farming, integrated disease management in rabi and kharif crops,

integrated crop management in horticultural crops, importance of balance feeding in milch animals, control of ecto-endo-parasites in animals and prevention and control of infectious diseases in animals.

Publications

Eight extension folders were published on groundnut, chilli, seed treatment, safe use of pesticides, goat farming, important information for livestock farmers, schemes for the benefit of the farmers and importance of mustard oil for human food. Eighteen popular hindi articles were published in different magazines. All

extension activities were covered in print media (26) and eleven radio and TV talks were delivered.

Other Extension Activities

101 lectures were delivered in different farmers trainings, 38 film shows were organized for trainee farmers. Four exposure visits for warehouse, mushroom production, farmers producer organization and visit to Krishi Unnati Mela at New Delhi were organized in which 126

farmers participated. Nine Special days viz. World Honey Bee Day, World Soil day, International Yoga Day, Swachhata Pakhwada, Vigilance awareness weekand Parthenium eradication week were celebrated in which 789 farmers participated. Conducted 12 diagnostic visits at farmers field and benefitted 52 farmers. Six field days, 7 group discussion meetings with 150 farmers and 15 extension personals, 17 kisan gosthies with 720 farmers and 43 extension personals, 98 scientists visits on farmers field benefitted 719 farmers and 58 extension personals. Organized 02 animal health camps with 181 farmers and 4 extension personals, 02 method demonstrations with 10 farmers and 03 extension personals.

M-Kisan Advisory

Through M-Kisan Portal, KVK, Gunta-Bansur send 58 messages in Hindi on different topics such as improved seed varieties, nutrient management, disease management, weed management, foliar spray in crops and vegetables, management of diseases such as FMD, HS,BQ, PPR etc and benefited 3,51,284 farmers.

Mustard Production

A total 20.30 quintal seed of mustard variety RH-406 was produced at KVK farm generating Rs. 65,975 under revolving fund.

13 Distinguished visitors

Name	Designation & address	Date
Sh. Gajendra Singh Shekhawat	Minister of state for Agril. & FW, Govt. of India	September 24, 2017
Dr. T. Mohapatra	Secretary, DARE & DG, ICAR, New Delhi	September 25-26, 2017
Dr. Ranjana Sharma	Associate Director, RDT for Agriculture and Agri-Food, Canada	November 18, 2017
Dr. R.B. Singh	Chancellor, CAU, Imphal	November 25, 2017
Dr. Arvind Kumar	Vice-chancellor, RLB CAU, Jhansi	November 25, 2017
Dr, D. P. Mondol	Director General, NSSO	November 25, 2017
Dr. T Haq	Director, Special cell on Land Policy, Niti Ayog	November 25, 2017
Dr. Padam Singh	Ex-Member, National Statistics Commission and Ex- Director, IASRI	November 25, 2017
Dr. Devendra Verma	Director General, Central Statistical Office, Statistics and Programme Implementation Ministry	November 25, 2017
Dr. Mukesh Srivastava	World Food Organization, Bankok	November 25, 2017
Dr. U. C. Sud	Ex-Director, IASRI	November 25, 2017
Sh. Kalyan Singh	Hon'ble Governor, Bharatpur	January 25, 2018
Sh. Gulab Chand Kataria	Home minister, Govt. of Rajasthan	January 25, 2018
Dr. A.K. Singh	DDG (CS), ICAR, New Delhi	February 3, 2018
Dr. Anupam Barik	Additional Commissioner (Oilseed), AC&FW, New Delhi,	February 3, 2018

14 Personnel

Personal

Director's office

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

Scientific Staff

Crop Improvement

Dr. V.V.Singh, Principal Scientist (Genetics & Plant Breeding)
Dr. Bhagirath Ram, Principal Scientist (Genetics & Plant Breeding)
Dr. Arun Kumar, Senior Scientist (Cytogenetics)
Dr. H.S. Meena, Senior Scientist (Genetics & Plant Breeding)
Dr. Hariom Kumar Sharma, Scientist SS (Genetics & Plant Breeding)#
Dr. B. L. Meena, Scientist SS (Genetics & Plant Breeding)##
Dr. Priya Medha, Scientist, SS (Genetics & Plant Breeding)

AICRP-RM Unit

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

Natural Resource Management (NRM)

Dr. O.P. Premi, Principal Scientist (Agronomy)
Dr. R.S. Jat, Principal Scientist (Agronomy)
Dr. M.D. Meena, Scientist, SS (Soil Science)###
Dr. M.K. Meena, Scientist (Soil Science)
Sh. Harvir Singh, Scientist (Agronomy)

Plant Protection

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

Plant Biotechnology

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

Plant Biochemistry

Dr. Anubhuti Sharma, Senior Scientist (Plant Biochemistry)
Dr. Ibandalin Mawlong, Scientist (Plant Biochemistry)
Dr. M.S. Sujith Kumar, Scientist (Plant Biochemistry)

Technology Assessment & Dissemination

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. Sh. U.S. Rana, Chief Technical Officer (CTO)***
2. Dr. R.C. Sachan, Chief Technical Officer (CTO)
3. Sh. M.L. Meena, Assistant Chief Technical Officer (ACTO)
4. Sh. H.P. Meena, Assistant Chief Technical Officer (ACTO)

5. Sh. Ram Narayan, Assistant Chief Technical Officer (ACTO)
6. Sh. Karnal Singh, Assistant Chief Technical Officer (ACTO)
7. Dr. Kailash Narayan, Senior Technical Officer (STO)
8. Sh. Sanjay Sharma, Senior Technical Officer (STO)
9. Sh. Govind Prasad, Technical Officer (Driver)
10. Sh. R.C. Meena, Technical Officer (TO)
11. Sh. Ram Singh, Senior Technical Assistant (STA)
12. Sh. Rakesh Goyal, Senior Technical Assistant (STA)
13. Sh. Bachu Singh, Senior Technical Assistant (STA)
14. Sh. Radha Charan Rajpoot, Technical Assistant (TA)

Administration

1. Sh. R. C. Meena, Senior Administrative Officer (SAO)
2. Sh. U.C. Sharma, Assistant Administrative Officer (AAO)****
3. Sh. Ram Sahay Meena, Assistant Administrative Officer (AAO)
4. Sh. Mukesh Kumar, Assistant
5. Smt. Poonam Keshri ^
6. Sh. Anurag Bharat, Assitant $
7. Sh. G.L. Meena, Senior Clerk
8. Sh. Pankaj Pathak, Senior Clerk

Audit and Accounts Unit

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

Supporting

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

Krishi Vigyan Kendra, Gunta-Bansur

1. Dr. Bhagwant Singh Rathore, Senior Scientist & Head
2. Dr. 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

* Director (Acting) Since January01, 2017

** On study leave

*** Retired on October 31, 2017

**** Retired on January 31, 2018

Transferred from ICAR-CRIJAF, Barrackpore, Kolkatta and Joined DRMR on July 10, 2017

Transferred from ICAR Research complex for NEH Region, Umaiam and joined DRMR on July 01, 2017

Transferred from ICAR-CSSRI, Karnal and joined DRMR on June 24, 2017

^Transferred to ICAR-NIRJAFT, Kolkata, relieved on March 28, 2018

$Fresh joining at ICAR-DRMR on August 11, 2017

Institute Committees

S. No.	Committee	Members
1	Priority Setting, Monitoring and Evaluation (PME Cell)	Dr. Pankaj Sharma, Pr. Scientist (In-charge), Drs. Vinod Kumar, , Ajay Thakur, Hariom Kumar Sharma, M.D. Meena, Sh. Sanjay Sharma, Mrs. Veena Sharma
2	Results- Framework Document (RFD)	Dr. Vinod Kumar, Pr. Scientist
3	Human Resource Development (HRD)	Dr. Pankaj Sharma, Pr. Scientist (Nodal Officer), Dr. R.S. Jat (Co-Nodal Officer)
4	Institute Foreign Deputation Committee (IFD)	Dr. Pankaj Sharma, Pr. Scientist; Drs. Bhagirath Ram, Arun Kumar, R.C. Meena (SAO)
5	Institute Technology management Unit (ITMU)	Director (Ex-office Chairman), Dr. Vinod Kumar (Member secretary) and Dr. Ajay Thakur
6	Institute Purchase committee (IPC)	Dr. Pankaj Sharma (In-charge), Drs. R.S. Jat, Dr. H.S. Meena, Sh. R.C. Meena (SAO & Member secretary), Sh. P.K. Tiwari (F&AO)
7	Institute Joint Staff Council (IJSC)	Director (Ex-office Chairman), Drs. Pankaj Sharma, Bhagirath Ram (Member secretary), Dr. Priyamedha, Harvir Singh, Sh. R.C. Meena (SAO), Sh. P.K. Tiwari (F&AO)
8	Institute Research Council (IRC)	Director (Chairman), Dr. Ashok Kumar Sharma (Member secretary)
9	Research Advisory Committee (RAC)	Dr. J.B. Chaudhary, (Chairman) Ex-Vice Chancellor (GBPUA&T, Pantnagar); Director, ICAR-DRMR, Dr. S.R. Bhatt, Ex- Pr. Scientist, ICAR-NRCPB, New Delhi; Dr. B.S. Mahapatra, Professor Agronomy, GBPUA&T, Pantnagar; Dr. K.P. Singh, Ex-Professor Mycology and Plant Pathology, BHU, Varanasi; Dr. V.K. Yadav, Director Research, SKNAU, Jobner; Dr. R.P. Singh Ratan, Director Extension Education, BAU, Ranchi; Assistant Dierctor General (O&P) ICAR, New Delhi and Dr. K.H. Singh, Pr. Scientist ICAR-DRMR, Bharatpur (Member Secretary)
10	Institute Germplasm Identification Committee (IGIC)	Director (Ex-office Chairman), Drs. K.H. Singh, (Member secretary), Pankaj Sharma, R.S. Jat, Arun Kumar, Priyamedha
11	Women Complaint Committee (WCC)	Drs. Priyamedha, Scientist (Chair person), Ibandalin Mowlong, Ms. Veena Sharma and Ms. Poonam Keshri

15 Panorama

International Yoga Day

International Yoga Day was celebrated on June 21, 2017 at the Directorate. The United Nations (UN) theme for this year was "Yoga for Health". Dr. P.K. Rai, Director (Acting) and DRMR staff participated in the event and performed various *Asanas* and *Pranayams*. At this occasion Dr. Rai

emphasized and advised to adopt yoga in our daily routine to remain healthy and happy in life. He further added that yoga rejuvenate us and can contribute in a holistic way to achieve an equilibrium between mind and body.

Sankalp to Siddhi

To commemorate the 75th year of "Quit India Movement" and 70th year of India's Independence ICAR-DRMR staff took "Sankalp Se Siddhi" pledge on August 9, 2017. Directorate took pledge for clean, poverty free, corruption free, terrorism free, communalism free and caste free India.

Independence Day

ICAR-DRMR celebrated 71st Independence Day on August 15, 2017. All the staff members of the Directorate actively participated in the event. Dr. P.K. Rai, Director (Acting), ICAR-DRMR unfurled the National flag (*Tiranga*) and addressed the staff member of the Directorate. During his address, he lauded the role of freedom fighters of the India. He emphasized that we all should remember the sacrifices of people who contributed directly or indirectly in securing freedom of our country. Furthermore, he urged all staff to contribute in the development of our country through strengthening of the rapeseed-mustard farmers.

Parthenium Awareness Week

12th Parthenium awareness week was observed in ICAR- DRMR from August 16-22, 2017. A parthenium awareness and parthenium up-rooting/ cleanliness drive was conducted on August 16, 2017 in the office premises of the Directorate. All scientists, technical, supporting and administrative staff members actively

participated in eradication of parthenium plants. The staff members were apprised about general features of parthenium besides harmful effects on human, cattle, crop and non crop plants.

Sadbhavana day

ICAR-DRMR, Bharatpur staff took Sadbhavana pledge on August 18, 2017 to commemorate the 73rd Anniversary of Shri Rajeev Gandhi, former Prime Minister of India. Staff taken pledge that they will work for the emotional oneness and

harmony of all the people of India regardless of caste, region, religion or language. They further pledged that they shall resolve all the differences among them through dialogue and constitutional means without resorting to violence.

राजभाषा कार्यक्रम

निदेशालय में दिनांक 14.09.2017, 26.012.2017 एवं 31.03.2018 को एक दिवसीय हिंदी कार्यशालाओं का आयोजन किया एवं दिनांक 14 से 29 सितम्बर 2017 तक हिंदी पखवाडा का आयोजन किया गया। हिंदी पखवाडा उदघाटन समारोह सितम्बर 14, 2017 को मनाया गया इस अवसर पर डॉ. चन्द्रलोचन त्रिपाठी व्याख्याता हिंदी, महारानी जया महाविद्यालय, भरतपुर ने अपने उद्बोधन में हिंदी को एक वैज्ञानिक भाषा बताते हुए कहा कि हम अपने विचारों एंव विषय ज्ञान को अपनी भाषा में अधिक प्रभावी ढंग से प्रस्तुत कर सकते है। उन्होने हर्ष जताया कि आज हिंदी का प्रयोग अनुसंधान संस्थानों में भी निरंतर बढ रहा है। इस अवसर पर हिंदी के पूर्व प्रवत्ता डॉ. रधुनाथ सिंह डागुर ने भी सरकारी काम काज में भी हिंदी प्रगामी प्रयोग पर अपने विचार व्यक्त किये।

दिनांक 29 सितम्बर 2017 को आयोजित पखवाडा समापन समारोह में निदेशालय के सभी वैज्ञानिक तकनीकी प्रशासनिक एवं सहायक वर्ग के कमचारियों ने भाग लिया इस अवसर पर निदेशालय के निदेशक डॉ. पी. के. राय ने अपने उद्बोदन में कहा कि हिंदी एक समद्ध भाषा है हमारे बहुभाषीय देश में, सम्पर्क भाषा

के रूप में हिंदी का महत्वपूर्ण योगदान है। उन्होने वैज्ञानिकों का आवाहन किया कि नई तकनीकों की जानकारी किसानों को उन्ही की भाषा में बताने के लिए सतत प्रयास करें ।

निदेशक ने इस अवसर पर निदेशालय में हिंदी के प्रगामी प्रयोग के लिए वर्ष के दौरान हिंदी में अधिकाधिक कार्य करने के लिए राजभाषा प्रोत्साहन पुरूस्कार योजना के तहत् श्री गुटेरी लाल मीना वरिष्ठ लिपिक, श्री मुकेश कुमार सहायक को प्रथम; श्री पंकज पाठक वरिष्ठ लिपिक, श्री रामसहाय मीना, सहायक श्री अजय कुमार टंडन कनिष्ट लेखा अधिकारी को द्वितीय एवं श्री पूनम केसरी, सहायक, श्रीमति वीना शर्मा, निजी सहायक, श्री तारा

सिंह, कुशल सहायक, श्री शीतल कुमार शर्मा कुशल सहायक तथा श्री लालाराम, कुशल सहायक को तृतीय पुरूस्कार से पुरूस्कृत किया। पुरूस्कार में निर्धारित राशि एवं प्रमाण पत्र प्रदान किया गये । डॉ विनोद कुमार प्रधान वैज्ञानिक एवं प्रभारी राजभाषा ने कार्यक्रम को संचालित किया एवं अंत में धन्यवाद ज्ञापित किया।

Swachha Bharat Mission

ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur actively carried out cleanliness round the year. Swachhta Pakhwada was also observed from September 15, 2017 to

October 02, 2017 to spread the message of cleanliness, not only among the staff but also to the resident of surrounding areas. Various events were organized under the supervision of Director Dr. P K Rai with a view to spread awareness and

sensitivity in virtues of sanitation and cleanliness which was a positive step towards the achievement of the Swachchh Bharat Abhiyan (Clean India Mission), launched on October 02, 2014 by Hon'ble Prime Minister, Shri. Narendra Modi. During Swachchh Bharat Abhiyan several events were organized, Sewa Diwas (September 17, 2017), Samagra Swachhta Diwas (September 24, 2017), Sarwatra Swachhta Diwas (September 25, 2017), Swachhta at Bird sanctuary Keoladeo National Park, Bharatpur (October 01, 2017) and public function/award ceremony (October 02, 2017).

Shri Gajendra Singh Shekhawat, MoS visited ICAR-DRMR

Shri Gajendra Singh Shekhawat, Hon'ble Minister of State for Agril. & FW, Govt. of India

visited ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur on September 24, 2017. Dr. P.K. Rai, Director (Acting), ICAR-DRMR welcomed Shri Shekhawat and briefed him about the research activities being carried out at Directorate during interaction with staff. Shri Gajendra Singh appraised the efforts made by Directorate in increasing the productivity of Rapeseed-mustard. Furthermore, he stressed upon the need of path breaking research to make country self sufficient in edible oil production. He emphasized to increase the oil content in the mustard varieties and urged scientist to work together for doubling the income of farmers by 2022. Shri Shekhawat took part in cleaning activity under *Swachh Bharat Mission* and also visited farm section and participated in *Beej Pakhwara* where he interacted and apprised farmers about the use of soil health card and

neem coated urea. He further added that present Central Government and ICAR is doing tireless efforts for doubling the income of farmers by 2022.

Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR visited ICAR-DRMR

Dr. Trilochan Mohapatra, Secretary, DARE, Govt. of India & DG, Indian Council of Agricultural Research, New Delhi visited ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur during September 25-26, 2017. Dr.

P.K. Rai, Director (Acting), ICAR-DRMR welcomed Dr. T. Mohapatra. During his visit Dr. T. Mohapatra actively participated in cleanliness drive carried out by ICAR-DRMR during Swachh Bharat Pakhwara celebrated under Swachh Bharat Mission. He also took part in tree plantation programme in front of administrative-cum-laboratory building. He visited basic science complex, experimental labs, museum and experimental farm of ICAR-DRMR, Bharatpur. In meeting with DRMR staff, he interacted with scientist, all technical, administrative, supporting staff and progressive rapeseed-mustard farmers. Dr. P.K. Rai, Director

(Acting), ICAR-DRMR briefly presented the research achievements and activities being carried out by ICAR-DRMR and AICRP-RM. Dr. T. Mohapatra appreciated the efforts made by the scientist. In his address, Dr. T. Mohapatra apprised the farmers about the Government schemes and new initiative by Ministry of Agriculture and efforts of ICAR for betterment of farmer and doubling of farmers income by 2022. He urged the scientist to put forward their best effort to enhance the production and productivity of rapeseed-mustard

Foundation day

ICAR-DRMR celebrated 24th Foundation on October 20, 2017. During the occasion Dr. P.K. Rai, Director, DRMR addressed all the staff and highlighted the important role played by rapeseed-mustard in the oilseed economy of the country. He expressed satisfaction over the achievements of the Directorate, and appreciated the efforts made by DRMR staff in overall development of the Directorate. Plantation of tree on the day was also organized.

Vigilance Awareness Week

As per the guidelines of Central Vigilance

Commission and ICAR, New Delhi, Directorate observed vigilance awareness week from October 30, 2017 to November 4, 2017. The week commenced on October 30, 2017 by administering of the Integrity Pledge to all the staff members of the Directorate. Interaction session with the scientists and staff was held where views of CVC on vigilance awareness were shared and various vigilance related issues were discussed on the theme "My vision: Corruption free India" on same day. During discussion, Director emphasized to enumerate the ethical standards by one and all to contribute in the nation building. A lecture was delivered by the Dr. P.K. Rai, Director, on the topic "*Preventive Vigilance as a tool of Good Governance*" and expressed his views on department's role on combating corruption. .

World Soil Day

ICAR-DRMR, celebrated the 'World Soil Day' on December 05, 2017. A total 50 farmers participated in the programme. The programme was coordinated by Dr. R. S. Jat. He briefed the importance of soil health and its impact on crop production. While speaking on the occasion, Dr. V.V. Singh highlighted the significance of 'World

Soil Days' and its impact on mustard as well as other production systems in the present context and distributed the soil health cards to the farmers. He urged farmers to follow the recommended nutrient management practices in the respective cropping systems to improve the soil health, optimize resources use and minimize the climate change effects.

AT HOME on Republic Day Eve

Government of Rajasthan selected ICAR-DRMR for organization of AT HOME programme of His Excellency Governor of Rajasthan on Republic Day eve (25 Jan 2018). His Excellency Governor of Rajasthan Sh. Kalyan Singh was Chief Guest of programme and other guests were Sh. Gulab Chand Kataria, Minister of Home, Govt of Rajasthan. Freedom fighters, public representatives, state level Govt officials and awardees participated in the programme. His Excellency Governor presented Presidents police medal and other medals and certificates to awardees.

Republic day

All the staff members of ICAR-DRMR family celebrated 69th Republic day. Dr. P.K. Rai,

Director (Acting) hoisted *Tiranga* and addressed the gathering. During his speech, he remembered the role of Dr. B.R. Ambedkar and other freedom fighters in formation of Constitution of India. Furthermore, he praised the contribution of ICAR-DRMR in enhancing the production and productivity of rapeseed-mustard in India. He urged ICAR-DRMR scientist to emphasize upon "Doubling the income of farmers by 2022" which is the dream of our honourable Prime Minister Shri Narendra Modi. He urged scientist to actively participate in "*Mera Gao Mera Gaurav*" and to apprise the farmers about the technologies developed by Directorate.

Basic Science Complex *Pujan*

Pujan of DRMR Basic Science complex was performed on February 01, 2018. All DRMR staff members were present on the occasion. During the occasion Director DRMR performed all rituals. After completion of *Havan* and *Pujan* all the staff visited the DRMR basic science complex.

International Women's Day

ICAR-DRMR women scientist celebrated International Women's day on March 8, 2018 at

Ludhawai village of Bharatpur. The theme of the Women's day this year was "Time is now: Rural and urban activists transforming women's lives". This programme was organized by Dr. Rupender Kaur along with Dr. Anubhuti Sharma. About 50 rural women participated in the programme. Lecture cum discussion session was conducted to aware them about this special day.

ICAR-DRMR on Print media

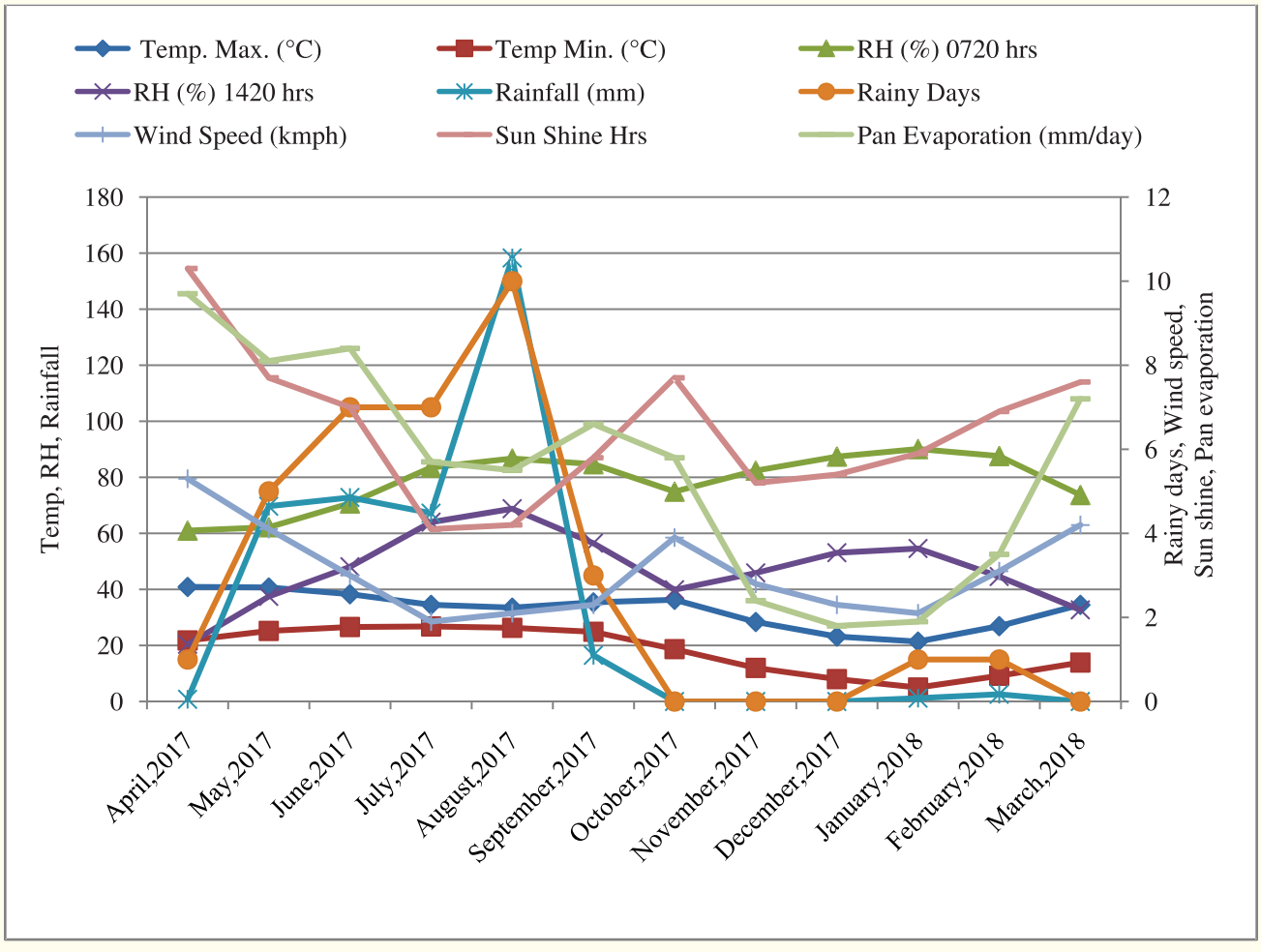
About 40 news items / stories/advice, etc. were published during the period in different daily and weekly hindi newspapers *viz*., Rajasthan Patrika, Dainik Bhaskar, Srusti Agro, Amar Ujala, Dainik Navjoyati, Rastradoot, Punjab Kesari, Haldhar Times, Krishi Goldline etc. to educate and make farmers, farmwomen, extension personnel aware about scientific rapeseed-mustard technology and programmes and activities of Directorate.

ICAR-DRMR on DD Kisan

An episode of farmers interaction with scientist of ICAR-DRMR was aired on March 16 and 19, 2018. In the episode Dr. P.K. Rai, Director, Dr. Ashok Sharma, Pr. Scientist (Extension), Dr. R.S. Jat, Pr. Scienstist (Agronomy) advised and interacted farmers on rapeseed-mustard production and protection technologies.

16 Meteorological Data

This year was deficient monsoon year with 431.1 mm rainfall in 37 rainy days. Monsoon started in last week of May and was remained active upto September. August month received maximum of 158.3 mm rainfall. Less rain in the month of September adversely affected the acreage of rapeseed-mustard. As a result, this year less area was sown under rapeseed-mustard. Average maximum temperature during the year recorded in April and May, 2017(40.7° C) while minimum was in January, 2018. The average sunshine varied from 5.2 to 10.3 hrs.



17 Budget and Resource Generation

Budget (Rs. in Lakhs)

Head	Sanctioned	Utilized
ICAR-DRMR	1076.77	1076.54
AICRP-RM	1462.77	1462.77

Resource Generation (Rs. in Lakhs)

Head of Account	Amount	Head of Account	Amount
Sale of farm produce	42,93,561	Training	50,000
Sale of tender form	71,000	Guest House	3,60,696
License fee	2,88,499	Transport charges	1,36,578
Analytical testing fee	1,25,043	DRMR	1,73,772
Sale of machine/ tools/ other items	4,94,300		
Total Income generated			**59,93,449**

Annexure-I

Training programmes organized for KVKs/extension personnel/farmers by ICAR-DRMR during 2017-18

Training programmes for farmers

Title	Period	Number and type of participants	Sponsored by
Scientific production technology of mustard and agriculture management	September 11-15, 2017	21, farmers	PD, ATMA, Gwalior, Madhya Pradesh
Scientific technology and recommendations of mustard	September 18-22, 2017	30, farmers	PD, ATMA, Dholpur, Rajasthan
Scientific production technology of mustard and agriculture management	September 23-24, 2017	38, farmers	BAIF, Ajmer, Rajasthan
Bee-keeping and agriculture management	December 11-15, 2017	27, farmers	PD ATMA, Tonk, Rajasthan
Bee-keeping and agriculture management	January 5-9, 2018	34, farmers	PD ATMA, Tonk, Rajasthan
Mustard seed production technologies	January 30-31, 2018	30, farmers	ICAR Seed Project
Scientific production technology of mustard and bee-keeping	February 23-27, 2018	31, farmers	PD ATMA, Dholpur, Rajasthan

Annexure-II

Training programmes for KVKs/extension personnel/ATM/BTM/TA

Title	Period	Number and type of participants	Sponsored by
Scientific production technology of mustard	September 4-8, 2017	32, ATM/BTM/TA of Uttar Pradesh	SIAM, Rehamankheda, Lucknow, Uttar Pradesh
Scientific production technology of mustard	September 25-29, 2017	31, ATM/BTM/TA working in different districts of Uttar Pradesh	SIAM, Rehamankheda, Lucknow, Uttar Pradesh
Scientific production technology of rapeseed-mustard	February 19-20, 2018	20, Field level extension functionaries of Sawai Madhopur district of Rajasthan	FLDs, NMOOP by DAC, MoA, Govt. of India
Scientific production technology of rapeseed-mustard	February 19-20, 2018	17, Field level extension functionaries of Sawai Madhopur district of Rajasthan	FLDs, NMOOP by DAC, MoA, Govt. of India


Dr.TRILOCHAN MOHAPATRA


हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch