ANNUAL REPORT
2014 - 15

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

ANNUAL REPORT

2014-15

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

ICAR-Directorate of Rapeseed-Mustard Research
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ICAR-DIRECTORATE OF RAPESEED-MUSTARD RESEARCH
SEWAR, BHARATPUR- 321 303 (RAAJSTHAN), INDIA

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

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Brassica Science for oil and nutritional security

MISSION

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

Preface

It's a matter of pride and satisfaction to present 22nd annual report comprising salient research achievements and development programmes of the ICAR-Directorate of Rapeseed-Mustard Research, carried out during the year 2014-15. In continuation to previous efforts to develop high yielding varieties, five strains including two of double low quality were promoted for advance stage testing under different AICRPRM trials. Simultaneously, promising strains were identified against different abiotic and biotic stresses including drought, heat, aphid infestation, white rust and alternaria blight. Intergeneric hybridization and resynthesis of *B. juncea* were followed to broaden the gene pool. *Brassica carinata* lines developed through interspecific hybridization/population improvement registered significant improvement for maturity duration, plant height, seed yield, oil content and seed size. A core set of 146 *B. juncea* accessions and one trait specific set comprising 135 accessions for different component traits were developed which are expected to facilitate the better utilization of available genetic resources. Two thousand one hundred fifty two accessions comprising 600 from national gene bank and 1552 from Rothamsted Research, UK were evaluated and 1074 accessions were deposited in national gene bank for long term conservation. Molecular characterization of the putative transgenic plants of *B. juncea* var. NRCDR-2 for antifungal defensin gene confirmed three events to be PCR positive for TvD1 gene integration. 47,962,057 high quality expressed sequence reads were generated using Illumina MiSeq paired-end sequencing technology. These reads were assembled into 45,280 unigene contigs and a total of 4,108 perfect SSR loci of $\geq$ 10 bp were identified.

Crop management studies focused upon standardization of RCTs, and enhancing water and nutrient use efficiency. In a study on economic feasibility and sustainability of Indian mustard (*Brassica juncea*) productivity through organics Sesbania green manuring significantly increased mustard seed yield. FIRB was found most promising among various RCTs. The seed treatment with Titanium oxide @1000 ppm was found effective in enhancing nutrient use efficiency. Strategies were suggested to enhance rapeseed mustard production on the basis of land utilization types. Dimethoate 30 EC@ 300 g *a.i.* and imidacloprid 17.8 SL @ 20g *a.i.* per ha, were found effective against aphid and painted bug, respectively. Carbendazim ST+ FS was most effective for management of sclerotinia rot. 25 advanced breeding lines were screened against *Alternaria brassicae* under artificially created conditions and promising tolerant lines including 22 recombinant inbred lines were identified. Major constraints in mustard production were prioritized with the farmers' participation and web-based application software for rapeseed-mustard information management was developed. Twenty two training programmes of 2-5 days, two model training courses, 5 exhibitions were organized and 100 FLDs were conducted. During Beej Pakhwara 418 q quality seed of mustard varieties was sold to farmers. A total of 24 instructional episodes were broadcasted through 10 All India Radio stations.

ICAR-Directorate of Rapeseed Mustard Research was conferred with first prize of prestigious Mahindra Samriddhi Krishi Sansthan 2015 in recognition of its contributions for betterment of rapeseed mustard cultivation. Nine scientists of directorate were awarded/recognised by different societies/organisations for their meritorious contributions.

With the sense of humility and gratitude, I convey my sincere thanks to Prof. S. Ayyappan, Secretary DARE, Government of India and Director General, ICAR; Dr. J.S.Sandhu, Deputy Director General (Crop Science) and Dr. B.B. Singh, Assistant Director General (Oilseeds & Pulses) of the Council for their meticulous direction, support and encouragement.

I place on record my sincere thanks to all the scientific, technical, administrative and supporting staff for their admirable contributions to this report and also bringing recognition to the Directorate. My sincere appreciation and thanks are due to the editors, Drs. K.H. Singh, O.P. Premi, Kapila Shekhawat and M.S. Sujith Kumar for their conscientious and determined efforts in compiling the programmes and achievements of the Directorate in the present form.

ICAR-DRMR, Bharatpur
May 23, 2015

(Dhiraj Singh)

Abbreviations

AAII	Average Aphid Infestation Index
AAU	Assam Agricultural University
ADG	Assistant Director General
AICRP	All India Coordinated Research Project
AICRP-RM	All India Coordinated Research Project on Rapeseed-Mustard
ANMR	Additional Net Monitory Return
ATMA	Agricultural Technology Management Agency
AVT	Advance Varietal Trial
BARC	Bhabha Atomic Research Center
BAU	Birsa Agricultural University
CACP	Commission on Agriculture Cost and Pricing
CAZRI	Central Arid Zone Research Institute
CMS	Cytoplasmic Male Sterility
CIAH	Central Institute of Arid Horticulture
CRRI	Central Rice Research Institute
CV	Coefficient of Varieties
DAC	Department of Agriculture and Cooperation
DARE	Department of Agricultural Research and Education
DAS	Days After Sowing
DDG	Deputy Director General
DM	Dry matter/Downey Mildew
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
FIGs	Farmer Interest Groups
FIRB	Furrow Irrigated Raised Bed System
FLD	Front Line Demonstration
FYM	Farm Yard Mannure
GCV	Genotype Coefficient of Varieties
IAA	Indole Acetic Acid
IARI	Indian Agricultural Research Institute
IBCR	Incremental Benefit Cost Ratio
ICAR	Indian Council of Agricultural Research
IHT	Initial Hybrid Trial
IJSC	Institute Joint Staff Council
IMC	Institute Management Council
IPR	Intellectual Property Right
IVT	Initial Varietal Trial
LT	Latest Release
LAMP	Linux, Apache, MySQL and PHP Technology
KVK	Krishi Vigyan Kendra
MBC	Microbial Biomass Carbon
MEY	Mustard Equivalent Yield
MoU	Memorandum of Understanding

MPUAT	Maharana Pratap University of Agriculture and Technology
MS	Murashage Skoof
MSI	Membrane Stability Index
MSI	Mustard Straw Incorporate
MSL	Mean Sea Level
MTC	Model Training Course
MUFA	Mono Unsaturated Fatty Acid
NAARM	National Academy of Agricultural Research and Management
NAAS	National Academy of Agricultural Sciences
NBPGR	National Bureau of Plant Genetic Resources
NC	National Check
NCD	North Carolina Design
NDN	National Disease Nursery
NGO	Non-Government Organization
NPTC	Network Project on Transgenics in Crops
PAU	Punjab Agriculture University
PCR	Poly Cyclic Chain Reaction
PCV	Phenotypic Coefficient of Varieties
PPV&FRA	Protection of Plant Varieties & Farmers Rights Authority
PMC	Pollen Mother Cells
PRWC	Percent Relative Water Content
PSB	Phosphorus Solubilizing Rhizobacteria
PUFA	Poly Unsaturated Fatty Acid
RAC	Research Advisory Committee
RCBD	Randomized Complete Block Design
RDF	Recommended Dose of Fertilizers
RCT	Resource Conservation Technology
RFD	Results-Framework Document
R&M	Rapeseed & Mustard
RRS	Regional Research Station
RVSKVV	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 Dantiwarh Agricultural University
SGM	Sesbania Green Mannure
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SOC	Soil Organic Carbon
SPS	Single Plant Selection
SSG	Supporting Staff Grade
STMS	Sequence Tagged Microsatellites
TSP	Tribal Sub Plan
UAS	University of Agriculture Sciences
WHO	World Health Organization
WP	Wettable Powder/ Whole Pacakge
WSC	Wide Spaced Crop
WUE	Water Use Efficiency
ZC	Zonal Check

Executive Summary

- Five strains; DRMR 150-35, DRMR 1153-12, DRMRIJ 13-38, DRMR 1-5 (double low strain) and DRMR 2-11(double low strain) were promoted for advance stage evaluation under AICRPRM
- A core set of Indian mustard with 146 accessions (~8 % of total accessions)and one trait specific set (with 135 accessions) for component traits were developed
- Eight independent putative transgenic events of *B. juncea* var. NRCDR-2 were developed with TvD1 gene via Agrobacterium tumefaciens-mediated gene transfer technique
- 47,962,057 high quality expressed sequence reads were generated using Illumina MiSeq paired-end sequencing technology. These reads were assembled into 45,280 unigene contigs from which a total of 4,108 perfect SSR loci of $\geq$ 10 bp were identified
- In long term experiment on Economic feasibility and sustainability of Indian mustard (*Brassica juncea*) productivity through organics, Sesbania Green Manuring (SGM) significantly increased mustard seed yield by 32.6% over control. Mustard Straw Incorporation in addition to Sesbania Green Manuring (MSI + SGM) further augmented the seed yield by 9.4% over SGM alone and by 45.0% over control
- An increase of 14.3 % seed yield was obtained under furrow irrigated raised beds over conventional tillage during five year experimentation on resource conservation technologies
- Out of various combinations used for enhancing resource use efficiency through nano particles, the seed treatment with Titanium oxide @1000 ppm resulted in maximum increase in seed yield, harvest index, oil productivity, profitable efficiency and economics.
- Seventeen entries *i.e.* DRMRHJ 4109, RSPN 29 (*B. juncea*), NUDB 26-11 (*B. napus*), DLSC 1 (*B. carinata*), RTM 1351, RTM 1359, RTM 314, RTM 1415, RTM 1375, RTM 1355, RTM 2002, RTM 1212, TMB 2030, TMB 29, TMB 2031, TMB 2032 and T 27 (*E. sativa*) were found resistant against aphid infestation having the AAII less than 1
- Breeding lines DRMR-14-2800 (8.3%), DRMR-14-2805 (8.7%), DRMR-14-2806 (9.0%) and DRMR-14-2807 (10.0%) were found at par with tolerant check EC-399299 (9.7%) for disease reaction against alternaria blight
- Forecasting models for sclerotinia infestation were developed, which indicated soil moisture as an important variable in SR infestation.
- Based on reaction of 11 rapeseed-mustard genotypes to HSR and BPR isolates of *A. candida;* Rohini, Basanti and RH-30 were categorized as primary differential. PBC-9221 (*B. carinata*) and GSL-1 (*B. napus*) showed resistant reaction to both the isolates.
- 0.21, 0.90, 1.30, 1.30, 0.025 and 0.25 q breeder seed of MJA 5 (parental line of hybrid NRCHB 506), NRCHB 101, NRCDR 02, Giriraj, DRMR 601 and NRCYS 05-2, respectively, was produced during 2013-14.
- ICAR-Directorate of Rapeseed Mustard Research was conferred with first prize of prestigious Mahindra Samriddhi Krishi Sansthan 2015 in recognition of its contributions for betterment of rapeseed mustard cultivation. Nine scientists of directorate were awarded/recognised by different societies/organisations for their meritorious contributions.
- Winter school was organized on "Strategies to enhance oilseed Brassica production under climate and resource constraint scenario".
- 418 q quality seed of mustard varieties was produced.
- A total of 24 instructional episodes were broadcasted through 10 All India Radio stations. Twenty two training programmes of 2-5 days, two model training courses, 5 exhibitions were organized and 100 FLDs were conducted
- A total of 36 research papers, 13 technical bulletins and 4 book chapters were published.
- Resources worth Rs 3429448 were generated.

1 ICAR-DRMR: *An Overview*

All India Coordinated Research Project on Oilseeds (AICRPO) was established at IARI, New Delhi in April 1967 for the improvement of oilseeds in the country. Setting up separate Project Coordinating Units for various crops during V Plan (1974-79) and on Jan. 28, 1981 for Rapeseed-Mustard at Haryana Agricultural University, Hisar, the research programme on oilseeds, especially rapeseed-mustard was further strengthened. The ICAR established the National Research Centre on Rapeseed-Mustard (NRCRM) on Oct. 20, 1993 to carry out basic, strategic and applied research on rapeseed-mustard at Adaptive Trial Centre, Sewar, Bharatpur (77° 27'18.8"E Long.; 27°12'8.9"N Lat. and 170 m above MSL) of the State Department of Agriculture, Govt. of Rajasthan on the recommendation of the Task Force constituted in 1990. The centre was upgraded as Directorate of Rapeseed-Mustard Research (DRMR) in the XI Plan (2007-12) on Feb. 24, 2009. Besides, generating basic knowledge and materials, it also engages in developing ecologically sound and economically viable production and protection technologies. The Directorate also has the responsibility to plan, coordinate and execute the research programme through a wide network of 11- main and 12 sub-centres across the country in addition to need based verification centres under the umbrella of AICRP-RM to augment the production and productivity of rapeseed-mustard. The Directorate is located 7 and 3 km away from the Bharatpur railway station and roadways bus station, respectively on Mathura-Jaipur national highway. Bharatpur, internationally known for Keoladeo National Bird Sanctuary, is on the Delhi-Bombay main railway track just 35 km ahead of Mathura 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. The ICAR-DRMR functions as a fulcrum to support the production system research through different research and support units (*see Organogram*) and develop basic technologies and breeding materials for rapeseed (yellow sarson, toria, taramira, gobhi sarson) and mustard (Indian mustard and Ethiopian mustard) crops.

Objectives

? Utilizing frontier research for better exploitation of genetic resources.

? Development and identification of appropriate production-protection technologies.

? Capacity building and knowledge management through technology assessment, refinement and dissemination.

Functions

? National repository for rapeseed-mustard genetic resources and information.

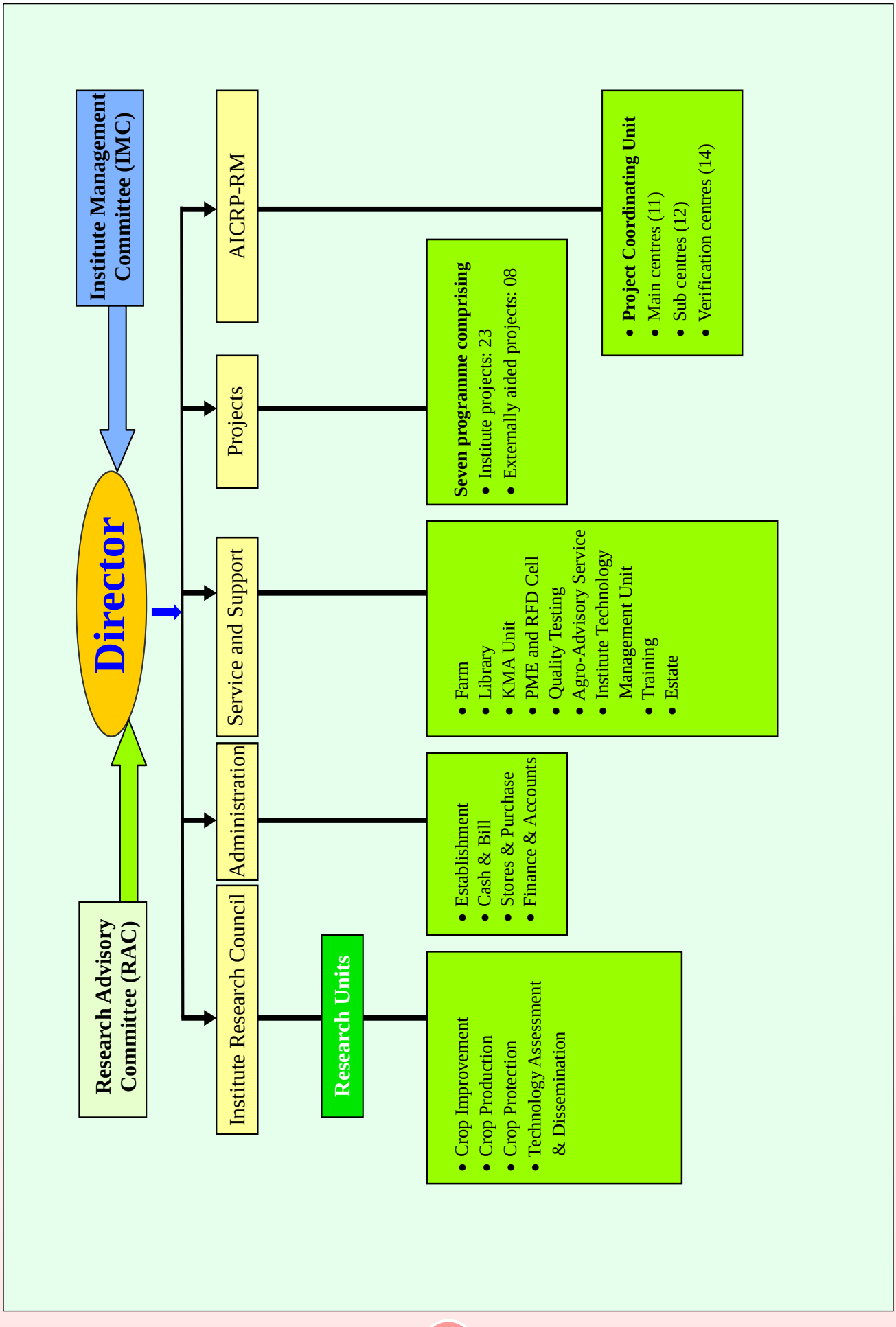
? Basic, strategic and applied research to improve the productivity and quality of oil and seed-meal.

? Development of ecologically sound and economically viable production and protection technologies for different situations.

? Generation of location specific interdisciplinary information based on multi-location testing and coordination.

? Establishment of linkages and promotion of cooperation with national and international agencies to achieve above objectives.

? To extend technical expertise and consultancies.


Institute Management Committee (IMC)
Research Advisory Committee (RAC)
Director
Institute Research Council
Administration
Service and Support
Projects
AICRP-RM
Research Units
• Crop Improvement
• Crop Production
• Crop Protection
• Technology Assessment & Dissemination
• Establishment
• Cash & Bill
• Stores & Purchase
• Finance & Accounts
• Farm
• Library
• KMA Unit
• PME and RFD Cell
• Quality Testing
• Agro-Advisory Service
• Institute Technology Management Unit
• Training
• Estate
Seven programme comprising
• Institute projects: 23
• Externally aided projects: 08
• Project Coordinating Unit
• Main centres (11)
• Sub centres (12)
• Verification centres (14)

2 Research Achievements

2.1 Genetic enhancement for stress tolerance in Indian mustard

DRMR C1-10 : Population improvement for higher productivity and oil content in Indian mustard under normal and water stress conditions

Project Leader : V.V. Singh, Principal Scientist (Genetics & Plant Breeding)

Associates: P. K. Rai, Principal Scientist (Plant Pathology), S. S. Rathore, Senior Scientist (Agronomy) and Bhagirath Ram, Senior Scientist (Genetics & Plant Breeding)

Performance and contribution of entries in AICRP-RM trials

Entry DRMR 150-35 was promoted to AVT II (early rainfed mustard trial zone V). Entry DRMR 1153-12 was promoted to AVT I (Timely sown, rainfed mustard, Zone V). DRMR 10-40, DRMR 1153-12 and DRMR 675-39 of *B. juncea* were characterized as drought tolerant at 02 or more locations. DRMR 541-44 has been identified promising for low light stress tolerance. DRMR-100, DRMR-312, DRMR-316 of *B. carinata* showed resistance/ tolerance to more than one disease in AICRP-RM trials.

Six promising entries *viz*; DRMR 683-21 (timely sown irrigated mustard), DRMR 1165-40, 1187-55, DRMR 1191-2 (timely sown rainfed mustard), DRMR 131 (late sown mustard), DRMR 1617-45 (early mustard trial) have been inducted in different coordinated trials for multi location testing during 2014-15 under AICRP- RM.

Evaluation of promising entries in station/ advanced trials

During 2013-14, strain DRMR 683-21 (1881 kg/ha) out yielded best check RGN 73 (1599 kg/ha) by a margin of >10% in station Trial II, DRMR 131 (2449 kg/ha) out yielded best check RH 819 (2200 kg/ha). In station trial under rain fed conditions, entries DRMR 1165-40 (2802 kg/ha) and DRMR 1191-2 (2679 kg/ha) recorded more yield than the check RH 819 (2464 kg/ha). During 2014-15, 64 entries were evaluated in 04 station trials for selection of promising entries for varied situations.

Evaluation of Half sib progenies for high oil content and Alternaria blight tolerance (III selection cycle)

Observations were recorded on oil content (%) from a set of 253 half sib progenies developed for 3rd cycle of selection. Over all mean of progenies was slightly higher (40.6%) in comparison to check mean (40.3 %). The mean (41.9%) of 10 best progenies showed an increase over check varieties. Ten high oil content progenies were OHS 68 (42.5%), OHS 76 (42.3%), OHS 253 (42.2 %), OHS 86 (42.1%), OHS 61 (42.1%), OHS 115 (42.0%) OHS 243 (41.9%), OHS 246 (41.9%), OHS 247 (41.83%), OHS 194 (41.82%). From a set of 45 half sib progenies, seven half sibs, AHS 14, AHS 15, AHS 16, AHS 18, AHS 21, AHS 44, AHS 45 were selected from 3rd selection cycle on the basis of relative tolerance against alternaria blight in comparison to checks (PHR 2, JMM 915, PAB 9534, EC 399301).

Observation nursery

Out of 50 advanced progenies grown in observation nursery along with checks (NRCHB 101, RGN 73, Maya and NRCDR 2), progenies BPR-1160-74 (2837 kg/ha), DRMR 46 (2600 kg/ha), BPR-1480-8 (2482 kg/ha), BPR-1566-28 (2482 Kg/ha) and DRMR 42 (2423 Kg/ha), recorded more than 10% higher plot yield than the best check NRCHB 101 (2245 kg/ha).

Generation of breeding material

Fresh inter varietal crosses were attempted between RH749/DRMR150-35, NRCDR 02/NRCHB101, NRCDR02/DRMRIJ31, RH749/DRMRIJ31, RH406/NRCHB101, RH819/RH749, RB50/RH819, RH119/NRCDR02, DRMRIJ31/Heera, DRMR IJ31/Donskaja, NRCDR02/Heera, NRCDR

02/Donskaja. Six F_{1s} were advanced to F_2 generation

Evaluation and selection from segregating generations

Single plants selected from [F_3,150 SPS (06 crosses), F_4, 100 SPS (03 crosses), F_5 80 (8 crosses), observation nursery 80 (18 crosses)] were grown in augmented blocks with standard checks (RH 749, RGN 73, NRCDR-02, NRCHB 101) under irrigated conditions. Under rainfed conditions, [F_3 165 SPS (10 crosses), F_4 88 SPS (10 crosses), observation nursery (80 bulk from 18 crosses), were grown along with checks (RB 50, RH-819, RGN 48, RGN 229) for evaluation. Individual plant as well as promising lines were selected. One hundred germplasm lines under rainfed conditions and 120 half sibs for yield components under irrigated conditions were evaluated.

Rain fed

Evaluation of full sib and half sib progenies under rain fed conditions

Analysis of variance showed significant differences among full sib progenies for plant height, primary branches/plant, fruiting zone length, siliquae/plant, main shoot length, seeds/ siliqua, 1000-seed weight, oil content (%) and , seed yield /plant, indicating adequate variability for these traits in the material after 03 cycles of full sib progeny selection. Heritability estimates ranged from 47.8% (plant height) to 92% (seed yield /plant). Full sib progenies, DFS 74 (41.2 g), DFS 76 (33 g), DFS 70 (31.9 g), DFS 99 (25.8 g), DFS 2 (24.2 g), DFS 81 (23.6 g), DFS 82 (22.1g), DFS 83 (21.1g), DFS 40 (2.9g) and DFS 41 (20.4) showed significantly higher seed yield/plant over best check RB50. It was observed that mean of full sib families increased in each cycle of selection in comparison to checks. In first cycle, mean of families was 9.7g and it increased up to 13 .1g in third cycle of selection indicating effectiveness of full sib progeny selection in Indian mustard.

Evaluation of 140 half sibs revealed significant differences among progeny for plant height, primary branches /plant, fruiting zone length, main shoot length, siliqua length, 1000-seed weight, oil content (%) and , seed yield /plant, indicating adequate variability for these traits in the material after 03 cycles of half sib progeny selection. Heritability estimates ranged from 54.5% (plant height) to 81.0% (main shoot length). Genetic advance expressed as percent of mean was highest for seed yield /plant (32.2%). Half sib progenies DHS 23 (16.5 g), DHS 24 (14.8 g), DHS 30 (17.6 g), DHS 34 (16.3g), DHS 36 (19.6g), DHS 116 (16.3g), DHS 119 (16.5g) and DHS 134 (16.3g) showed significant superiority in terms of seed yield /plant over best check (RB 50). After 3rd cycle of selection mean of families in terms of seed yield/ plant increased from 7.6g to 9.6g.

Observation Nursery

Advanced (50) progenies were grown under rainfed conditions and promising entries BPR-1566-29-2, BPR -1566-35-1, BPR -1616-71-3, BPR-1360-74-1, BPR-1360-74-2, BPR-16-8-81-2, BPR-3-2-1-83-2 were selected on the basis of drought tolerant parameters. Correlations of these indices with grain yield under drought (Ys) and irrigated conditions (Yp) were determined. Significant positive correlation was found between grain yield in the stress condition (Ys) with criteria Mean productivity (MP), geometric mean productivity (GMP), Stress tolerance index (STI), Yield stability Index (YSI), Modified stress tolerance index (K1STI, K2STI) indicating that these parameters would be reliable in discrimination of drought tolerant genotypes.

On the basis of plot yield, progenies BPR 1360 - 74 (2600 kg/ha), BPR 1617-49 (2305 kg/ha), BPR 1566-29 (2246 kg/ha), BPR 1480-15 (2305 kg/ha) and BPR 1345-67 (2245 kg/ha) were selected in comparison to best check (2127 kg/ha).

Five progenies; BPR 1679-10 (2688 kg/ha), BPR 1686-19 (2645 kg/ha), BPR 1686-29 (2737 kg/ha) and BPR 1686-31 (2436 kg/ha) were selected in comparison to best check Kranti (2347 kg/ha) and RH 819 (2145 kg/ha) from F_5 generation.

Maintenance of unique lines of karan rai

12 lines of *Brassica carinata* having dwarf stature, early maturity long shoot and bolder seed were maintained.

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

Project Leader: Arun Kumar, Senior Scientist (Genetics-Cytogenetics)

Associate: H.S. Meena, Scientist, Sr. Scale (Genetics)

Cytogenetical investigations in colchicine-induced tetraploids of *Brassica fruticulosa*

Efficiency of colchicine treatment

B. fruticulosa seedlings at cotyledonary leaves stage were treated with aqueous colchicine (0.1% and 0.2% v/v) for 2-3 days for 3-5 hours per day. The highest induction percentage (15.8%) of putative polyploids was recovered with 0.2% aqueous colchicine (Counted as the number of colchicine – induced tetraploids recovered from total number of seedlings treated with aqueous colchicine). A total of four colchicine-induced putative polyploids were synthesized from 0.2% (50 seedling treated) and one in 0.1% (50 seedling treated). These plants were numbered as P_1, P_2, P_3, P_4 and P_5 while, diploid plants numbered as P.

Morphology

All the five colchicine-induced plants were robust from the initial stage of development and it was maintained till maturity, although different responses to colchicine were evident in all the five plants (Fig. 2.1). All the colchicine-induced tetraploid plants showed reduction in plant height except one (P_2), when compared with diploids. Secondary branches per plant, length of petiole, length and width of leaflet, corolla length and width and siliqua length showed considerable increase in comparison to corresponding diploids. Primary branches per plant in three tetraploid, plants (P_3, P_4 and P_5) showed reduction whereas; two plants (P_1 and P_2) were found similar to diploids. The number of seeds per siliqua decreased in all the synthesized colchicine-induced polyploid plants. Among the five colchicine-induced tetraploid plants, P_2 showed considerable increase in all the morphological attributes except seeds per siliqua which were less and primary branches per plant which was equal to the diploid plants.

Cytology of diploid and colchicine-induced tetraploids

Meiotic data of diploid and colchicine - induced tetraploid plants are summarized below and some representative cells are illustrated in Fig. 2.2. In diploid *B. fruticulosa* (P) majority of Pollen Mother Cells (PMCs) analyzed at diakinesis/metaphase I showed normal bivalent formation and few univalents were encountered however, their number never exceeded four per cell. The average number of chromosome associations was 7.60 II + 0.80 I. The equal distribution of chromosomes (8:8) was observed in all the cells analyzed at anaphase I.

Cytologically, colchicine - induced tetraploid plants (P_1-P_5) showed quadrivalent frequency ranging from 2.3 to 3.1 and univalent frequency ranging from 3.4 to 4.1. Among all the associations, bivalent chromosome associations were observed more frequently (7.2 to 8.8). The number of chiasmata ranged from 12-16 and 20-36 with an average number of 21.3 and 23.6 and their terminalization coefficient ranged between 0.73and 0.86. 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 of synthesized autotetraploids leading to a good seed set may

ultimately result more variability for brassica crop improvement.

Utilization of *B. fruticulosa* (tetraploid) in hybridization with *B. juncea*

Colchicine-induced tetraploid plants of *B. fruticulosa* obtained from the above experiment were crossed with different varieties of *B. juncea viz*. Pusa Bold, Bio-902, Varuna, Laxmi, Rohini, NRCDR-2, Maya and Vasundhra through sexual hybridization using *B. fruticulosa* as pollen donor. Few seeds were obtained in crosses with five varieties except NRCDR-2, Maya and Vasundhra.

Selection from segregating generations of F_4 progenies of inter-specific crosses:

Thirty F_4 single plant progenies of inter-specific cross between NRCDR-2 (*B.juncea*) x NRCKR-304 (*B.carinata*) were planted during rabi 2014-15 and more than 70 single plants were selected on the basis of phenotypic traits *viz*. plant type, height, earliness, seed weight, white rust resistence *etc*. Similarly, 30 single plant progenies of cross Kranti (*B. juncea*) x GCS-6 (*B. napus*) were planted and more than 85 single plants were selected on the basis of siliqua density, siliqua angle, plant height, seed size and other agro-morphological characteristics. Single plant progenies from selected plants from both the crosses will be advanced to F_5 generation in next season.

Fig. 2.1. Comparison of morphological attributes in diploid and colchicine – induced tetraploids of *B. fruticulosa*, 1. Leaf, 2. Flower, 3. Siliquae (Pods).

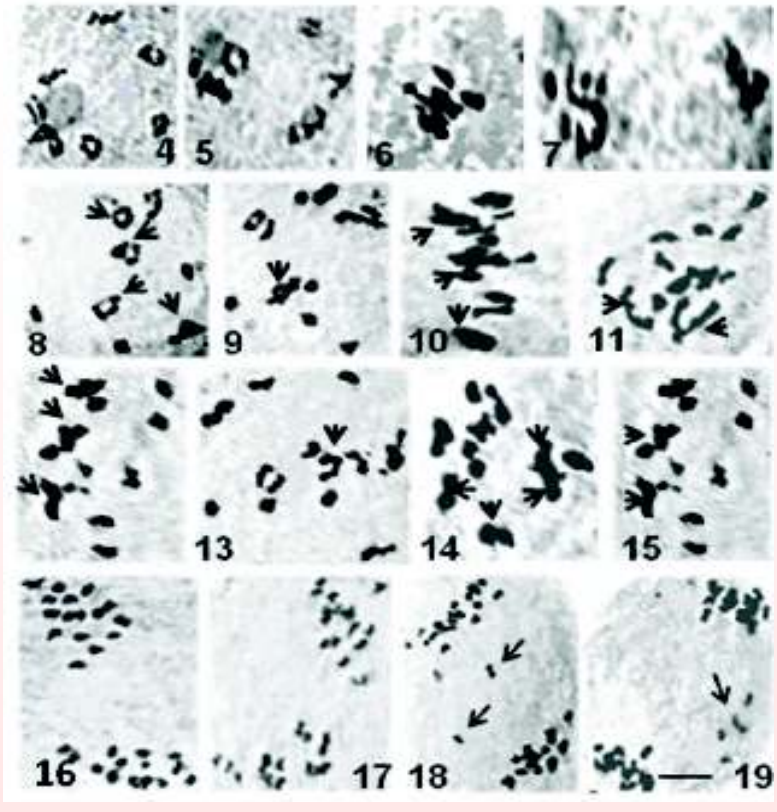


Fig. 2.2. Documentation of cytological examinations in diploid and colchicine – induced tetraploids of *B. fruticulosa*, 4-7. *B. fruticulosa* diploid, Diakinesis 4. 8II, 5. 7II + 2I, 6. Metaphase I 8II, 7. Anaphase I 8:8. 8 - 19 *B. fruticulosa* tetraploids, 8-9. Diakinesis, 8. 4 IV+8I, 9. 2 IV+10 II+4 I, 10,15. Metaphase I 10. 3 IV+8 II + 4I, 11. 3 IV+9 II+2 I, 12. 3 IV+7 II+6I, 13.1 IV+9 II+10 I, 14. 4 IV+7 II+3 I, 15. 2 IV+11 II+2 I. 16-17. Anaphase I 16:16 (equal distribution), 18-19. Anaphase I with laggards. (Quadrivalents marked by arrow heads and laggards with arrow) Bar: 10 µm.

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

Project Leader: Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding)

Associates: V. V. Singh, Principal Scientist (Genetics and Plant Breeding); Binay Kumar Singh, Scientist SS (Plant Biotechnology)

Evaluation of promising crosses for high temperature stress tolerance and productivity

A total of 36 entries including 28 F_1 crosses and 8 parents were evaluated in complete randomized block design with three replications in two rows of five metre length for their per se performance with respect to their high temperature stress tolerance at seedling stage. Two hundred counted seeds of each thirty six entries were sown in the field under heat stress (28th September) condition. The entries differed significantly for productivity and physiological parameters namely; population survival (%) at 10 DAS, population survival (%) at 25 DAS, membrane stability index (%), excised- leaf water loss (%), relative water content (%), water retention capacity of leaves (%), 1000-seed weight (g), oil content (%) and seed yield per plant (g). The population survival (%) ranged from 63.0 (NRCDR-601) to 88.0 % (BPR-549-9) and 53.0 (NRCDR-601) to 82.0 % (DRMR-HT-13-20), at 10 and 25 DAS respectively. Among the parents & crosses, PMSI was high in BPR-549-9 (36.8), DRMR-HT-13-20 (36.4), BPR-543-2 (33.3) and DRMR-HT-13-13 (31.9) under heat stress condition while it was low in NRCDR-601(8.7) and DRMR-HT-13-15 (18.5). Thermo-tolerant crosses have less percent excised leaf water loss compared to thermo-susceptible crosses. Cross DRMR-HT-13-22 (23.1), DRMR-HT-13-13 (23.8), parent BPR-549-9 (24.2) and BPR-543-2 (24.5) recorded minimum percent excised-leaf water loss, while, cross DRMR-HT-13-9 (43.3) and DRMR-HT-13-15 (43.2) recorded maximum percent excised leaf water loss.

The high PRWC was observed in the parent BPR-549-9 (90.0), cross DRMR-HT-13-2 (89.3), DRMR-HT-13-6 (88.9), DRMR-HT-13-26 (88.5) and DRMR-HT-13-13 (86.6) under heat stress condition to while, it was low in cross DRMR-HT-13-15 (61.8), JN-032 (62.7) and DRMR-HT-13-24 (64.2). Among the crosses percent water retention capacity of leaves was high in BPR-549-9 (43.4), DRMR-HT-13-7 (43.1), BPR-543-2 (42.7) and DRMR-HT-13-26 (42.6) under heat stress environmental condition. Whereas, cross DRMR-HT-13-8 (23.2) and DRMR-HT-13-24 (24.8) recorded minimum percent water retention capacity of leaves. Cross DRMR-HT-13-10 (7.1 g), DRMR-HT-13-26 (7.0 g), Urvashi (6.7 g), DRMR-HT-13-24 (6.4 g) and DRMR-HT-13-25 (6.2 g) attained maximum 1000-seed weight whereas NRCDR-601 (3.7 g), DRMR-HT-13-8 (4.7 g) and DRMR-HT-13-15 (4.8 g) recorded the minimum 1000-seed weight. Similarly, among the parents and crosses oil content was high in NRCDR-601 (43.3%), DRMR-HT-13-8 (43.1%), DRMR-HT-13-2 (42.8%), DRMR-HT-13-23 (42.7%) and DRMR-HT-13-7 (42.6%) under heat stress condition, while, it was low in DRMR-HT-13-10 (40.2%) and DRMR-HT-13-28 (40.1%) under heat stress condition. Significant reduction occurred in seed yield per plant under heat stress condition. Among parents and crosses DRMR-HT-13-28 (36.5 g), DRMR-HT-13-7 (34.2 g), DRMR-HT-13-12 (34.2 g) and DRMR-HT-13-14 (33.5 g) recorded maximum seed yield per plant under heat stress condition whereas DRMR-HT-13-4 (17.5 g) and DRMR-HT-13-23 (18.7 g) recorded the minimum seed yield per plant under heat stress condition. Siliqua moisture weight loss per hour is an important parameter to screen the thermo-tolerant genotypes. Cross DRMR-HT-13-8 alongwith DRMR-HT-13-13 and DRMR-HT-13-20 recorded min siliqua moisture weight loss during 1st to 8th hours whereas, NRCHB 101, NRCDR 601 and DRMR-HT-13-26 recorded max siliqua moisture weight loss during 1st to 8th hours.

Genetic Variability Created through hybridization for heat stress tolerance

The analysis of variance for all the traits showed highly significant difference among the

genotypes indicating sufficient amount of variability in the material. Genetic parameters were studied to examine genetic worth of seed yield and heat stress traits, based on genetic variability estimates *viz.*, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as percentage of mean. Higher estimates of phenotypic coefficient of variation than genotypic coefficient of variation for all the traits reflected influence of environmental factor on these traits with variable influence. The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were high for membrane stability index (%), seed yield per plant, water retention capacity of leaves (%) and relative water content (%). The genotypic coefficient of variation was high for membrane stability index, seed yield per plant and water retention capacity of leaves, which provide good opportunity for selection for desirable levels of these heat stress traits. High heritability estimates (broad sense) were observed for membrane stability index (96.7%) and relative water content (95.2%) 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 (77.3%), seed yield per plant (26.4 %), 1000 seed- weight (23.4 %) while, the other characters showed moderate to low genetic advance. The heritability (broad sense) of membrane stability index (77.3 %) with maximum genetic advance (37.5%) was observed which might be due to heritability with additive gene impact therefore selection may be effective.

Evaluation of genotypes under heat stress situation

Two hundred counted seeds of each fifty four genotypes including two checks were sown in the field under heat stress (28th September) situation during rabi 2013-14 in complete randomized block design with three replications in two rows of five metre length for high temperature stress tolerance evaluation. The genotypes differed significantly for growth and physiological parameters namely; population survival (%) at 10 and 25 DAS, membrane stability index (%), excised- leaf water loss (%), relative water content (%), water retention capacity of leaves (%), 1000-seed weight (g), oil content (%) and seed yield per plant (g).

Genotype BPR 325-4 (91.2 %), DRMR 1350 (90.5%), BPR 549-2 (90.5%) and Rohini (90.3%) attained maximum percent population survival at 10 DAS whereas genotype NRCHB 101 recorded the minimum percent population survival. Population survival (%) at 25 DAS ranged from 12.2 % (RH 30) to 89.3 % (BPR 349-4). Genotype BPR 349-4 (89.3 %), Rohini (88.6%), DRMR 1350 (88.6%) and BPR 325-4 (86.91 %) recorded maximum percent population survival at 25 DAS. Among the genotypes, PMSI was high in BPR-541-4 (47.9), DFS-45 (46.1), GM-2 (43.8) and Kanti (43.5) under heat stress condition, while, it was low in NRCDR-601(4.8) and Pusa Agrani (5.1). Excised-leaf water loss (%) ranged from 10.5 (DRMR-1826) to 30.5 (NRCDR-02). Genotype DRMR-1826 (10.5), RGN-12 (13.2), DRMR-729 (13.3) and DRMR-1351 (13.9) appeared to be heat tolerant for percent excised-leaf water loss. While, NRCDR-02 (30.5 %) and BPR-541-4 (27.2 %) appeared to be heat sensitive for PELWL. The higher PRWC was observed in the genotype BPR-540-6 (76.7 %), DRMR-1780 (76.3 %) and DRMR-675 (75.8%) under heat stress condition compared to genotypes JN032 (13.3%) and BPR-659-49 (30.9 %). Among the genotypes, percent water retention capacity of leaves was recorded high in JR-042 (62.4%), BPR-349-4 (61.0 %), DRMR-729 (58.6%) and DRMR-1826 (55.1%) under heat stress environmental condition. Whereas, genotypes NPJ-113 (29.1%) and BPR-541-2 (29.2%) recorded minimum percent water retention capacity of leaves. The 1000-seed weight (g)

ranged from 3.2 g (Pusa Jaikisan) to 7.1 g (GM-2). Among the genotypes oil content was high in JN-032 (43.3%), NRCHB-101 (42.9%) and DRMR-1350 (42.9%) under heat stress condition, while, it was low in Pusa Tarak (40.5 %), BPR-541-4 (40.1%). Significant reduction occurred in seed yield per plant under heat stress condition. Among genotypes DRMR-537-40 (25.0 g), BPR-549-9 (23.6 g), DRMR-729 (24.5 g) and Narendra Rai (21.1 g) recorded maximum seed yield per plant, whereas, genotypes DRMR-1321 (9.6 g) recorded the minimum seed yield per plant. Meanwhile, genotype NPJ-93, NPJ-113, RGN-13, RGN-12, Urvashi, BPR-541-2, JR-042, JN-032, JN-031, GM-2, RB-50, BPR-659-49, Kanti, GM-3, Narendra Rai, BPR-549-2, BPR-541-4, DRMR-541-44, BPR-325-4, DRMR-1826 and DRMR-675 recorded high seed yield per plant compared to check varieties BPR-543-2 and RH-30 under heat stress condition.

Generation of F_1 crosses

Twenty eight crosses were made utilizing heat stress tolerant lines of *Brassica juncea* to combine heat tolerance trait in high yield genetic background.

Maintenance of double low ('00') quality lines

Eleven low erucic acid and low glucosinolate content advanced breeding lines of Indian mustard were grown and maintained through selfing.

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

Project Leader: H. S. Meena, Scientist SS (Genetics and Plant Breeding)

Associate: Arun Kumar, Senior Scientist (Genetics and Plant Breeding)

Cytological studies of colchicine treated inter-specific F_1 hybrids

During rabi 2013-14 fifty two inter-specific crosses (*B. rapa* x *B. nigra*) were planted in pots for chromosome doubling of F_1 plants. All F_1 plants at two leaf stage were treated with 0.2% colchicine for 3 hours / day for successive 3 days by cotton swab method. Flower buds from colchicine treated F_1 plants were fixed for cytological studies. Cytological studies from fixed floral buds was carried out with the help of high resolution bright field microscope for confirmation of chromosome doubling in inter-specific F_1 hybrids and identification of true synthetic plants. The results on chromosomal distribution at various stages of meiosis revealed that chromosome doubling might have taken place in some plants of inter-specific crosses *eg.*, Jhumka x BN-2, Ragini x BN-2, Pusa Kalyani x SKJ-2, NDYS-2 x SKJ-2. Chromosomal distributions at various stages of meiosis in some representative cells of cross Pusa Kalyani x *B. nigra* are illustrated in Fig. 2.3. Seeds from 109 fertile individual plants were harvested separately for growing Syn_1 or S_1 generation during next season and selection of true *B. juncea* type plants.

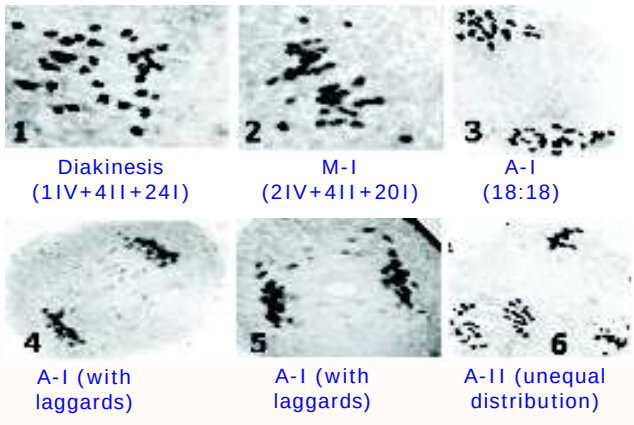


Figure 2.3. Chromosomal distribution at different stages of meiosis in colchicine treated inter-specific F_1 hybrid (Pusa Kalyani x *B.nigra*)

Effect of colchicine on survival and morphological traits of F_1 plants

The effect of colchicine on plant growth of various plant parts was observed at various stages. The major observations were the initial death of the plants due to death of cotyledonary leaves, stunted growth of surviving plants, initiation of branches from base of plant (where cotton swab was kept), increase in size of cotyledonary leaves & later the most of plant

parts, deformation of plants, brittleness of leaves, increase in size of floral parts, poor root growth & weak root system, delay in flowering & maturity, poor seed setting & high sterility. Morphological differences were observed for different traits in surviving plants. Initial germination of cross seeds, seedling mortality after colchicine treatment and sterility in F_1 plants of inter-specific crosses were recorded. The results revealed that there was 92.4% average germination of cross seeds, seedling mortality due to colchicine treatment was nearly 34.4 % and 67.5% plants could not produce seeds either due to sterility or due to deformation of various plant parts. There has been an increase in the size of floral parts of colchicine treated healthy surviving plants. The average length and width of petal in parental genotypes were 0.84 cm & 0.48 cm, respectively, while, these were 1.17 cm and 0.85 cm, respectively in colchicine treated F_1 plants of inter-specific crosses.

Raising S_1 generation

Seeds from colchicine treated 109 fertile individual F_1 plants of 35 inter-specific crosses were collected during 2013-14. Single plant progenies from these seeds were planted as S_1 generation during 2014-15 in pots. Synthetic *B. juncea* type plants were selected from S_1 progenies and bud samples were fixed for cytological studies.

Raising F_1 generation of inter-specific crosses

Eight inter-specific crosses between amphidiploids (*B. napus* x *B. carinata*) and nine between diploids (*B. rapa* x *B. nigra*) were planted in pots. F_1 plants from *B. rapa* x *B. nigra* were treated with colchicine for chromosome doubling and the floral buds were fixed for cytological studies and seeds from fertile plants were harvested separately.

Raising F_1 generation of *B. juncea* crosses

Nineteen F_1 crosses of *B. juncea* generated for various traits like high yield & oil content, yellow seed colour, white rust resistance, early maturity & dwarfness were planted during 2014-15 and data were recorded on various traits.

Generation of F_{1c}rosses of *B. juncea*

77 crosses including back crosses (14), three way crosses (12), double crosses (12), TTC (27) and fresh F_1 crosses (12) were generated.

Selection from segregating generations

230 single plants were selected from 3 F_2 populations, 110 single plants were selected from 43 F_3 progenies of 4 crosses and 107 single plants were selected from 23 F_4 progenies of a single cross during 2014-15.

Estimates of better parent heterosis

Line x Tester (9 × 4) analysis was carried out to estimate better parent heterosis for isolation of superior cross combinations of Indian mustard using thirty six F_1 crosses and thirteen parental genotypes. Thirteen crosses exhibited highly significant positive better parent heterosis for seed yield of which five crosses viz., DRMR 2486 × Ashirwad, DRMR 2243 × NRCHB 101, DRMR 2269 × NRCHB 101, DRMR 2341 NRCDR 2, and DRMR 2613 × NRCDR 2 possessed high heterosis (>25%) over better parent. These cross combinations will be advanced and utilized for development of high yielding genotypes.

2.2 Designer Brassica for oil quality

DRMR B 7 : Proteomic Studies in Oilseed Brassica

Project Leader: Ibandalin Mawlong, Scientist (Biochemistry)

Associates: M.S. Sujith Kumar, Scientist (Biochemistry), B.K. Kandpal, Principal Scientist (Agronomy), Arun Kumar, Senior Scientist, (Genetics & Plant Breeding)

Plant seeds stores triacylglycerol (TAG) as food reserves for the germination and post germinative growth of seedlings. The TAG are present in small discrete organelles called the oilbodies. The oilbodies have a spherical shape and possess a matrix of TAG surrounded with small amount of phospholipid and proteins. Many studies have shown to have an interplay of

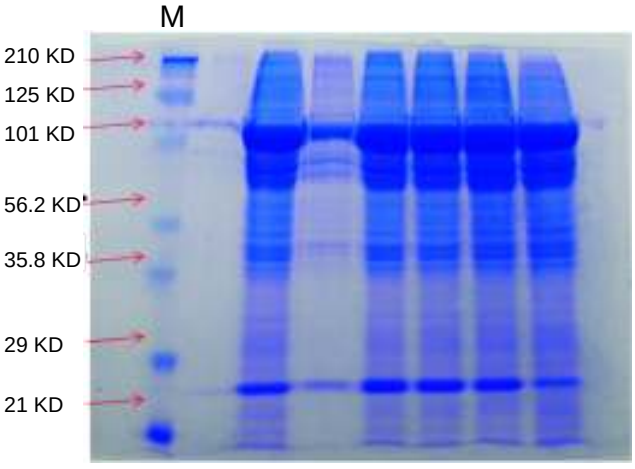


Figure 2.4 Profile of total protein isolated from *B. juncea*. M (protein marker)

protein and oil. The objective of this study is to find the correlation between the oil yield and different storage and structural proteins in different genotypes of Brassica grown under different levels of nitrogen fertilizer. A preliminary study shows that there is considerable variation in oil content measured by FT-NIR with respect to the fertilizer regime, however some shows inverse relationship. Total protein profiling by SDS-PAGE is undergoing to understand more closely the effect of nitrogen on oil yield.

DRMR B 8 : Screening of Oilseed Brassica Germplasm for Value Addition

Project Leader: M.S. Sujith Kumar, Scientist (Biochemistry)

Associates: Ibandalin Mawlong, Scientist (Biochemistry), K.H. Singh, Principal Scientist (Genetics & Plant Breeding), J. Nanjundan, Scientist, (Genetics & Plant Breeding), B. K. Singh, Scientist SS (Plant Biotechnology).

The main objective of this project is to identify genotypes rich in phytosterols and low in fibre content. Standardization of methods to estimate phytosterols and different types of fibers is undergoing. In order to shortlist genotypes for analysis based on their quality, the biochemical analysis of different genotypes was done using FT-NIR and Gas Chromatography:

Table 2.1 Number of samples analysed and range for different biochemical parameters in rapeseed mustard.

S. No.	Parameters	No. of Samples analyzed	Range
1	Total Phenol	102	1.6-2.4 µg/g
2	Erucic Acid (FT-NIR)	215	18.4-44.3%
3	Crude Fiber	102	8.4-11.7 µg/g
4	Glucosinolates	219	41.2-130.7 µmol/g
5	Oleic Acid	144	0.5-67.0 %
6	Linoleic Acid	144	10.6-50.2 %
7	Linolenic Acid	144	6.4-38.5 %
8	Erucic Acid (GC)	144	0.4-51.3 %

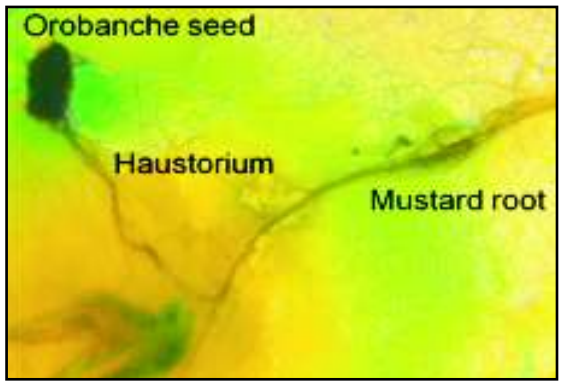
Stimulation of Orobanche Seed Germination by Mustard Root Exudates

The main objective of this study carried out at NRCPB New Delhi as part three months attachment training was to know whether the stimulation of Orobanche seed germination by mustard root exudates was genotype-dependent or not. A method reported earlier was standardized for germination of *Orobanche cernua* seeds with slight modification. Root exudates from 5 different contrasting genotypes of mustard; Durgamani (orobanche tolerant), RB 50 (Drought tolerant), RH 781 (multiple stress resistant), RH 0406 (high yielding variety) and NRCDR 2 (high yielding variety) were used to stimulate the germination of preconditioned *Orobanche cernua* seeds in vitro.

Sterilized Orobanche seeds were sown on moist Whatman filter paper in petri dish and kept in dark for 15 days for preconditioning. Root exudates were collected from 15 days old mustard seedlings by keeping the roots immersed in distilled water for 2 days. The root exudates (0.6 ml) were transferred to each petri dish containing preconditioned orobanche seeds and incubated in dark condition. The germination percentage was determined after 21 days. Mustard seeds were grown in ½ MS media for 15 days. Preconditioned seeds of orobanche were placed near the mustard root zone. The development of infection was observed under phase contrast microscope periodically.

The germination percentages recorded by orobanche seeds stimulated by different mustard varieties were 0 % (RH 781), 2 % (Durgamani), 5

Orobanche seeds placed in root zone of mustard grown on ½ MS media



Microscopic view of Mustard Orobanche interaction

Fig. 2.5. Establishment of Orobanche seeds

% (RB 50), 6 % (NRCDR 2) and 8 % (RH 0406). The formation of haustorium and its association with mustard roots was visible only in the case of NRCDR 2 (Fig. 2.5). The variability in germination percentage of orobanche seeds stimulated by root exudates from different genotypes could be due to the difference in composition of strigolactones in the root exudates which needs to be validated by detection techniques such as LC-MS.

2.3 Breeding for yield and quality enhancement in rapeseed-mustard

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

Project Leader: K.H. Singh, Principal Scientist (Genetics & Plant Breeding)

Associates : J. Nanjundan, Scientist, SS (Genetics & Plant Breeding), Ajay Kumar Thakur, Scientist, SS (Plant Biotechnology), Kapila Shekhawat, Scientist, SS (Agronomy), P.K. Rai, Principal Scientist (Plant Pathology), H.S. Meena, Scientist SS (Genetics & Plant Breeding)

Induction/promotion of promising entry / hybrid into AICRP–RM Trials

DRMRIJ 13-38 got promoted for advance testing under AVT1 late sown, rainfed conditions of zone V. Two hybrids entries DRMRHJ 2501 and DRMRHJ 4101 were inducted to initial hybrid trial (IHT) for evaluation during 2014-15. Three inbred/pureline entries namely, DRMRIJ 14-01 [MJA 27 x MJR 9 x IJ 31], DRMRIJ 14-02 (YM 8 x EC 399307) and DRMRIJ 14-03 (YM 8 x EC 399307) were inducted to initial varietal trials for timely sown, rainfed and late sown conditions, respectively. Twenty entries including DRMR MJA 35 of *B. juncea* were inducted for screening in uniform/national disease nursery trial. DRMR MJA 35 was reported resistant against white rust on the basis of testing in UDN of AICRP-RM during 2013-14.

Evaluation of hybrids/inbred lines during 2013-14

Data recorded on 26 entries including six experimental hybrids and 20 inbreds evaluated, in three different experiments during 2013-14 were analyzed. None of the hybrid could surpass the best check DMH1. In Station trial 2, 12 entries including 3 checks were evaluated of which IJ 31 produced highest yield. In station trial 3, 13 promising selections were evaluated with 2 checks of which entry 13-3-7 was the highest yielding (2034 kg/ha) followed by check variety IJ 31 (1970 kg/ha). In addition 108 F_{1s} with 2 checks NRCHB 506 and DMH 1 and 170 inbreds with 3 checks; RGN 73, IJ 31 and Kranti were evaluated in augmented block design, keeping single row plot of 3 m length. Among the F_{1s}, out of 108 crosses, four crosses; EC 597326 x RB 50, EC 597326 x EC 597313, EC 597337 x EC 597313, JN 018 x EC 597313, JN 028 x EC 597341 and MJA9 x MJR 13 outyielded the best check DMH 1(316 g/plot) by a margin of 27, 17,11,9,26 and 8 percent,

respectively. Among the inbreds five lines; DRMRIJ 13-6, 13-47, 13-76, 13-126, 13-139 and 13-140 excelled the best check RGN 73 (seed yield 320 g/plot) by a margin of 25, 41, 15, 11, 9 and 22 percent, respectively. Only two germplasm lines IC 399678 (338 g/plot) and EC 597326 (301 g/plot) produced more seed yield than the best check DRMRIJ 31(268 g/plot).

Genetic enhancement of *Brassica carinata*

Twenty genotypes including 14 selections of karan rai and six of Indian mustard were evaluated for seed yield and yield related traits. Out of 20, 16 genotypes have been derived from interspecific cross of Pusa Swarnim x NRCHB 101 and remaining four have been the outcome of population improvement. *Brassica carinata* genotypes had siliquae bearing upto shoot tip. Similarly, four genotypes of *Brassica juncea* developed from intespecific hybridization also had siliquae bearing upto shoot tip. On the basis of seed yield MCR 1-14, MCR 1-20, MCB 1-2-5, MCB 1-2-7 and MCB 1-1 were found promising. Significant improvement was recorded for maturity duration, plant height, seed weight and oil content over check variety, Pusa Swarnim.

Evaluation of hybrids/inbred lines during 2014-15

Five experimental hybrids and thirty two inbreds / promising selections including 14 of *Brassica carinata* and 18 of *B. juncea* were tested in four experiments. In addition 102 F_{1s}, 274 inbreds, 144 progeny rows and 50 germplasm lines were evaluated in augmented design.

Segregating generations 2014-15

F_2, F_3 and F_4 generations of following 17, 7 and 01 crosses, respectively were grown for selection of individual plants on the basis of specific trait.

F_2: GSC 5 x GSL 2, GSC 5 x IJ 31, GSC 6 x Pusa Swarnim, GSL 2 x IJ 31, IJ 31 x LET 36, Pusa Swarnim x IJ 31, EC 597326/RB 50, EC 597326/EC 597313, EC 597337/EC 597313, JN 018/MJR9 JN 028 x EC597341, MJA 9 x MJR13, OJA1 x OJR4, JN 018 x EC597313, MJA 27 x MCR1-10, EC 597342 x EC597313, EC 597340 x EC552577;

F_3 : EC 552577 x EC 597313, EC597311 x IJ 12-98, EC 597320 x EC 597313, IJ 31/Kranti, EC 552577 x EC 597309, MCB 1-2-3 carinata, MCR1-1 juncea

F_4 : (MJA 27 X MJR 9) X 39-3-2-2

Interspecific crosses: Following four interspecific crosses were attempted:

(GSC6 x Pusa Swarnim) x (IJ31 x LET36); (GSC5XIJ31) x (IJ31/LET36); (GSC 5 x IJ31); (GSC5XIJ31) x (MCB1-2-3-3)

Hybridization: 43 crosses in *Brassica juncea* including 20 test crosses, and 60 crosses of *Brassica carinata* were attempted during 2014-15

Conversion of A, and R lines: backcrosses were attempted to advance the generation under conversion programme of A and R lines

Breeder Seed Production: 0.21, 0.90, 1.30, 1.30, 0.025 and 0.25 q breeder seed of MJA 5 (parental line of hybrid NRCHB 506), NRCHB 101, NRCDR 02, Giriraj, DRMR 601 and NRCYS 05-2, respectively, was produced during 2013-14.

DRMR CI 06: Management of rapeseed - mustard genetic resources

Project Leader: J Nanjundan, Scientist, Sr. Scale (Genetics & Plant Breeding)

Associate: K.H.Singh, Pr. Scientist (Genetics & Plant Breeding)

Development of a core set and trait specific reference sets in Indian mustard

A core set of Indian mustard with 146 accessions (~8 %) was developed based on advance M-strategy using a modified heuristic algorithm employing the Power Core software, out of a base collection of 1627 Indian mustard accessions, which were evaluated for 16 agro-morphological traits, during the cropping season of 2009-13. Further, trait specific sets (with 135 accessions) were also developed for component traits *viz.*, early flowering (~35 days), plant

height (~ 150 cm), main shoot length (>80 cm), No. of siliquae on main shoot (>50), siliqua length (>5 cm), seeds/ siliqua (>17), 1000- seed weight (>7 g), oil content (> 42%) and harvest index (>25%). The proportion of different types of accessions in base collection, core collection and in trait specific reference sets is given in Table 2.2.

Table 2.2. Number of Indian mustard accessions in Base collection, Core Collection and Trait specific reference collection

Type of germplasm	Accessions evaluated	Core collection	Trait specific sets
Exotic collections	199	22	8
Indigenous (NATP) Collections	609	65	59
Advance breeding Lines	555	36	36
others	251	21	32
Registered line	13	2	0
	1627	**146**	**135**

Characterization of NGB, NBPGR accessions

With an objective to develop core set and trait specific reference sets out of all Indian mustard germplasm accessions available at the National Gene Bank (NGB), NBPGR (under the Consortia Research Project on Agro-biodiversity), a set of 600 accessions (481 Indian mustard, 59 toria + 16 brown sarson + 04 yellow sarson) were received from NBPGR and characterized at DRMR for 16 agro-morphological traits, during the cropping season of 2013-14. The data of 481 Indian mustard accessions were analyzed and the mean, range and CV (%) for different agro-morphological traits is presented Table 2.3. On the basis of evaluation, a total of 116 trait specific Indian mustard accessions were selected for different component traits.

Maintenance & Multiplication of accessions received from Rothamsted, U.K

A set of 1552 Indian mustard accessions (received from Rothamsted, UK) were grown for their maintenance by adopting proper pollination control measures of which 1074 accessions were established and their multiplied seeds were submitted to the NGB, NBPGR for long term conservation.

Screening of Indian mustard accessions against white rust

A subset of 471 exotic accessions (sourced from Rothamsted, UK) were grown at IARI, RS, Wellington, Tamilnadu and scored for white rust incidence (Fig 2.6). Ten accessions; EC 765323, EC 765326, EC 765330, EC 765345, EC 765383, EC 765449, EC 765451, EC 765673, EC 765944 and EC 766007 were identified as resistant based on Percent Disease Index (PDI) values. These accessions are subjected to further detailed evaluation and use.

Table 2.3. Mean, range and CV (%) for various agro-morphological characters in 481 Indian mustard accessions received from NGB, NBPGR.

Traits	Mean	Range	CV (%)	Mean of checks				
				Pusa mustard 25	Maya	RGN 73	Kranti	Pusa Bold
Days to initial flowering	56	45-106	14.4	44.4	49.9	52.6	51.3	51.9
Days to 50% flowering	69	54-127	13.5	54.3	62.3	64.8	63.7	64.3
Days to maturity	142	132-172	3.0	136.1	138.6	139.1	139.9	140.3
Plant height (cm)	187.5	128.0-253.0	11.1	171.6	188.7	213.7	172.1	191.1
Fruiting zone length (cm)	68.6	34.0-108.0	13.9	82.2	63.1	78.9	60.1	68.4
Primary branches/plant	6.2	3.4-12.0	20.9	5.7	6.9	7.1	6.3	6.1
Secondary branches/plant	9.7	2.8-23.5	33.9	9.2	9.5	15.1	9.3	6.6
Main shoot length (cm)	63.1	20.0-102.0	14.3	73.7	67.7	70.9	66.1	65.1
Siliquae on main shoot	45.8	24.2-74.8	15.2	44.8	41.7	47.1	38.1	42.9
Siliquae density	0.72	0.47-0.95	14.1	0.6	0.6	0.7	0.6	0.7
Siliqua length (cm)	3.8	1.6-5.2	13.8	3.9	4.6	3.6	3.9	4.6
Siliqua beak length(cm)	0.64	0.29-0.87	18.7	0.8	0.8	0.8	0.8	0.8
Seeds per siliqua	13.3	8.0-21.5	12.6	15.5	14.1	14.6	14.9	14.1
1000 seed wt (g)	3.5	1.1-7.2	31.8	4.5	4.6	4.3	4.5	5.6
Seed yield/plant(g)	9.9	0.4-20.5	41.6	13.3	12.7	13.5	12.1	11.5
Harvest index (%)	18.8	1.1-29.8	30.1	24.8	23.1	21.4	22.4	20.0
Oil content (%)	40.5	37.6-42.7	2.1	40.5	40.3	40.5	40.9	41.1

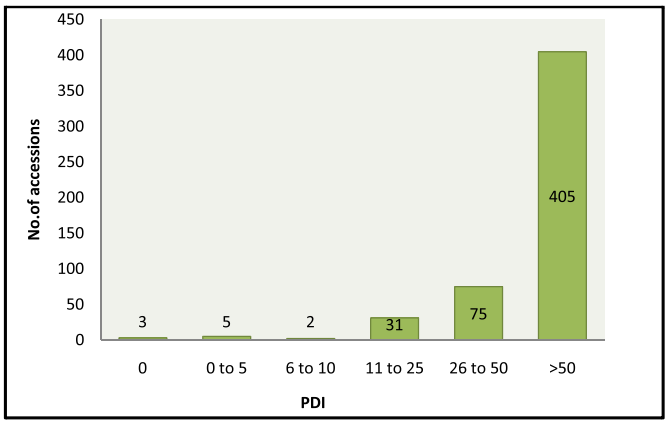


Fig. 2.6 Screening for white rust resistance at Wellington (*Kharif*, 2014)

Characterization of leafy accessions (*Brassica juncea* ssp. *rugosa*) collected from Arunachal Pradesh

With an objective to identify some potential leafy accessions for their use as vegetable/fodder purpose, a set of 86 leafy accessions **(***Brassica juncea* ssp. *rugosa* accessions collected from Arunachal Pradesh) were characterized using physiological parameters. Based on leaf growth parameters, five promising accessions were identified (Table 2.4).

Distribution of germplasm

A total of 53 accessions were distributed to various research organizations/students for their use in research work/varietal development.

Deposition of germplasm to NBPGR

A total of 1074 exotic accessions (received from Rothamsted, UK) were multiplied and submitted to NBPGR for long term conservation at the National Gene Bank (NGB).

2.4 Biotechnological interventions to improve rapeseed-mustard productivity

DRMR BT 1: *In vitro* plant regeneration and genetic transformation of *Brassica juncea* L. Czern. & Coss. with an antifungal defensin gene.

Project Leader: A.K. Thakur, Scientist, Senior Scale (Plant Biotechnology)

Associate: P.D. Meena, Senior Scientist (Plant Pathology)

Sub-Project 1a: *In vitro* plant regeneration and genetic transformation of *Brassica juncea* L. Czern. & Coss. with an antifungal defensin gene

Eight independent putative transgenic events of *B. juncea* var. NRCDR-2 were developed with *TvD1* gene via *Agrobacterium tumefaciens*-mediated gene transfer technique. Molecular characterization of the putative transgenic plants of *B. juncea* var. NRCDR-2 was carried out by PCR using *TvD1* gene specific primers and three events were confirmed PCR positive for *TvD1* gene integration. These events were multiplied and maintained under *in vitro* conditions. The well elongated shoots were transferred to rooting media (MS basal medium containing 0.3 mg/l IAA) and complete plantlets were obtained. Hardening of the putative transgenic plantlets had been carried out under culture room conditions. A 70% survival rate could be obtained during hardening.

Sub-Project 1b: Introgression of Alternaria blight tolerance from wild crucifers into Indian

Table 2.4. Promising leafy accessions identified for vegetable/fodder purpose

Collector No.	IC No.	LER (cm^2/plant/day)	LGR (cm^2/cm^2/day)	AGR (g/day/plant)	RGR (g/g/day)	NAR (mg/cm^2/day)	LAR (cm^2/g)
RAN-01	IC 597866	157.7	0.12	0.55	0.10	0.41	241.8
RAN-05	IC 597870	160.6	0.09	0.54	0.08	0.31	252.1
RAN-73	IC 597938	129.4	0.08	0.71	0.11	0.44	240.0
RAN-69	IC 597934	69.5	0.08	0.44	0.10	0.48	206.3
RAN-16	IC 597881	404.5	0.10	0.77	0.09	0.19	449.8
	Avg. (60 acc.)	119.5	0.060	0.488	0.067	0.257	278.7

mustard through embryo rescue approach.

200 crosses, each of *B. juncea* varieties Giriraj & RH 749 x *Sinapis alba* were attempted. 5-10 days old ovaries were cultured on MS medium supplemented with 2.5 mg/l BAP & 500 mg/l casein hydrolysate and the developing embryos were rescued on culture medium after 30-45 days. Shoot regeneration could take place within 10-12 days after culturing and these shoots are being multiplied and maintained on MS medium containing 2.5 mg/l BAP.

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

Project Leader : B. K. Singh, Scientist, SS (Plant Biotechnology)

Back cross populations derived from popular varieties Pusa Bold, Laxmi, Bio-902, Varuna, Maya, Vasundhara, Rohini and NRCDR-02 with white rust resistant genotypes JMY-11 and Heera were advanced to BC_3F_2 and some of the plants were selected for desirable agro-morphological traits. Selected plants were screened for their heterozygous nature with the help of intron polymorphic markers, At5g41560 and At2g36360, closely linked to white rust resistance loci AcB1-A4.1 and AcB1-A5.1. In addition to these, BC_1 plants derived from the crosses between highly resistant east European germplasm Donskaja-IV and Indian mustard varieties Pusa Bold, Laxmi, Bio-902, Varuna, Maya, Vasundhara, Rohini and NRCDR-02 were also advanced to BC_2.

Development of genic-SSR markers in Indian mustard

47,962,057 high quality expressed sequence reads were generated using Illumina MiSeq paired-end sequencing technology. These reads were assembled into 45,280 unigene contigs from which a total of 4,108 perfect SSR loci of $\geq$ 10 bp were identified. Trinucleotide was the most common repeat unit with a frequency of 59.9% followed by di- (38.7%), tetra - (0.71%), hexa - (0.49%) and pentanucleotide repeats (0.24%). PCR primers were designed from the unique sequences flanking 2,863 SSR loci out of which 460 were selected for primer synthesis. A total of 339 genic SSR loci amplified successfully of which 134 (39.5%) exhibited polymorphism among six *B. juncea* genotypes with polymorphism information content (PIC) values ranging from 0.18 to 0.81. Twenty-five polymorphic SSR markers were used for analysis of genetic variability and phylogenic relationships in a set of 25 genotypes representing cultivars/registered genotypes/exotic collections of *B. juncea*, and related cultivated and wild species. The number of alleles at these loci ranged from 2 to 5 and the PIC values ranged from 0.22 to 0.66. The dendrogram constructed using UPGMA algorithm and Nei and Li similarity coefficients clearly distinguished the studied genotypes/taxa in definitive groups corresponding well with their published pedigree and recognized taxonomy. The large number of genic-SSR markers developed in this study will be valuable for diversity analysis and genetic mapping in *B. juncea* and related species (Fig. 2.7, 2.8)

Fig 2.7. PCR amplification of genic-SSR marker using genomic DNA extracted from *Brassica juncea* cv CS-52. Agarose gel showing PCR amplification of genic-SSR markers: 1 BjSSR-207, 2 BjSSR-220, 3 BjSSR-228, 4 BjSSR-258, 5 BjSSR-259, 6 BjSSR-261, 7 BjSSR-264, 8 BjSSR-277, 9 BjSSR-278, 10 BjSSR-280, 11 BjSSR-310, 12 BjSSR-312, 13 BjSSR-313, 14 BjSSR-347, 15 BJSSR-348, 16 BjSSR-358, 17 BjSSR-361, 18 BjSSR-362, 19 BjSSR-373, 20 BjSSR-376, 21 BjSSR-392, 22 BjSSR-393, 23 BjSSR-411, 24 BjSSR-418. M-100 bp DNA ladder

Fig. 2.8. Allelic variation for genic-SSR marker BjSSR-876 among *Brassica juncea* and related cultivated and wild species. Agarose gel showing allelic variation among 27 genotypes with genic-SSR marker BjSSR-876: 1 Rohini, 2 RH-819, 3 NPJ-112, 4 RGN-48, 5 Navagold, 6 DRMRIJ-31, 7 Bio-YSR, 8 PHR-2, 9 Donskaja-IV, 10 Loiret, 11 PT-30, 12 NRCYS-05-2, 13 KOS-1, 14 Surya, 15 GSC-6, 16 Kiran, 17 *Brassica fruticulosa*, 18 *B. spinescens*, 19 *B. tournefortii*, 20 *Diplotaxis assurgens*, 21 *D. muralis*, 22 *D. tenuisiliqua*, 23 *D. siettiana*, 24 *D. Gomez-campoi*, 25 *Lipidium sativum* 26 *Capsella bursa pastoris*, 27 *Camelina sativa*. M-50 bp DNA ladder

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

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

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

Project Leader: O. P. Premi, Principal Scientist (Agronomy)

Associate: B. K. Kandpal, Principal Scientist (Agronomy)

The long term replicated experiment 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 was started in 2004-05. In general SGM significantly increased mustard seed yield by 32.6% over control. MSI + SGM further augmented the seed yield by 9.4% over SGM alone and by 45.0% over control (Table 2.5). And application of balance fertilizer (F_8) increased the seed yield at least by 11.8% over suboptimal doses F_1, F_2 and F_3. Seed yield of Indian mustard at all fertilizer levels (F_1 to F_8) were found statistically at par after nine years of fallow-mustard system. Probably some other factor or nutrient has become limiting. While growing of SGM significantly enhance the nutrient uptake capacity thereby increasing the seed yield at F_8 by >11.4% over F_1, F_3 and F_5. Adoption of MSI + SGM system further augmented the seed yield at F_8 at least by 9.2% over suboptimal doses (F_1 to F_5) indicating better nutrient recycling and availability for sustainable higher yields. The main effect of SOC management strategies over the period is presented in Fig 2.9.

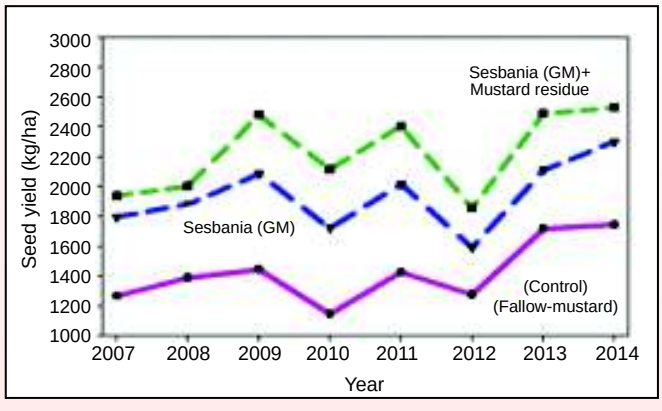


Fig. 2.9. Temporal effect of various mustard production systems

Table 2.5. 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	1651	1707	1735	1735	1762	1763	1790	1817	**1745**
Sesbania (GM)	2117	2350	2144	2394	2200	2422	2428	2450	**2313**
Mustard straw @ 2.5 t/ha + *Sesbania* (GM)	2158	2192	2508	2397	2635	2714	2758	2877	**2530**
Mean	**1975**	**2083**	**2129**	**2175**	**2199**	**2299**	**2325**	**2381**	-
CD (P=0.05)	CS : 290, Fertility level: 210								

*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, SGM significantly improved the SOC, soil organic microbial biomass, infiltration rate, available NPK status, but decreased bulk density over CP. MSGM further augmented the soil health attributes. The increase in fertilizer levels from $N_{40}P_{8.7}K_0$ to $N_{80}P_{17.4}K_{33.3}$ also improved the soil attributes gradually. This gradual improvement in soil health was clearly visible in yield attributes and seed yield from 4th year of experimentation. Overall, mustard seed yield was increased by 40.6% due to SGM and by 61.1% due to MSGM over CP in 9 years. Increase in fertilizer levels from N_{40} to N_{80} and $P_{8.7}$ to $P_{17.4}$ also improved the seed yield significantly while results of K application were inconsistent. The combined application of $N_{80}P_{17.4}K_{33.3}$ synergistically increased the seed yield by 53.6% over $N_{40}P_{8.7}K_0$. The growth in relative yield of mustard over years followed logarithmic function and predicted the achievement of plateau yield in 11 years under MSGM and 18 years under SGM in comparison to 33 years under CP.

Evaluation of nutrient management strategies for sustainable mustard production

Oilseed Brassica (OSB) is a high nutrient demanding crop but mostly cultivated by small and marginal farmers in nutrient deficient soil of semi-arid region and continuous cultivation of OSB in the region has resulted in stagnation of yield, increased cost of production and decline in factor productivity. This trend could be reverted to dynamic mustard production system of higher resilience to biotic stress and changing climate through adoption of soil site specific fertilizer and organic input management strategies. With this hypothesis a 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

Table 2.6. Effect of fertilizer management strategy and organic sources on mustard productivity (kg/ha)

Fertilizer management strategy (FMS)	Organic Sources (OS)						Mean
	SGM	MSI	MSI + SGM	MS mulch	FYM	VC	
CFM: Conventional (100% RDF)	2468	2213	2822	2169	2259	2370	**2383**
MFM: Moderate (50% RDF)	1959	1820	2241	1751	1774	2168	**1952**
SFM: Subsistence (no fertilizer)	1406	1267	1691	1174	1429	1313	**1380**
Mean	**1944**	**1767**	**2251**	**1698**	**1821**	**1950**	-
AC: Absolute control- 961							
CC: Conventional control (100%RDF)- 1405							
	CD 5%: FMS=37, OS= 60, FMS x OS= 103						

2011-12, keeping three fertilizer management levels (CFM: conventional-100% RDF, MFM: moderate – 50% RDF and SFM: subsistence- no fertilizer) in main plot and six organic sources (SGM: Sesbania green manuring, MSI: 2.5t/ha mustard straw incorporation, MSI+SGM, MSM: 2.5t/ha mustard straw mulch, FYM: 2.5t/ha farm yard manure and VC: 2.5t/ha 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.

In general, addition of organic source increased the seed yield by 43.6% over absolute control (no fertilizer) and remained at par with conventional control (100% RDF). Supplementing organic source with fertilizers further augmented the seed yield of OSB by 41.4% due to MFM and 72.7% due to CFM strategies (Table 2.6).

Among the organic sources, MSI + SGM produced significantly higher seed yield than rest of the organic sources. It was followed by VC and GM. The interaction between FYM and OS was found significant. At SFM strategy, MSI and MSM significantly reduced the seed yield atleast by 9.8% from CC (100% RDF). SGM, FYM and VC remain at par with CC while MSI = SGM produced 20.4% higher seed yield than CC. At MFM level, MSI + SGM and VC produced significantly higher seed yield than rest organic sources. The increase in seed yield due to MSI + SGM or VC at MFM level was more than 54.3% over CC. At CFM level, MSI = SGM increased the seed yield significantly over other organic sources and by 100.9% over CC (100% RDF).

DRMR CP 11: Standardization and evaluation of resource conservation technologies for mustard based cropping systems in semi-arid conditions of Rajasthan

Project Leader: Kapila Shekhawat, Scientist, SS (Agronomy)

Associate: S.S. Rathore, Senior Scientist (Agronomy)

To evaluate the effect of different crop establishment methods on crop productivity, soil properties and economics of mustard under various cropping systems, a field experiment has been initiated with five mustard-based cropping systems, *viz.*, fallow-mustard, green manure-mustard, brown manure-mustard, cluster bean-mustard, and pearl millet-mustard, grown under conventional tillage (CT), reduced tillage (RT), zero tillage (ZT) and permanent furrow irrigated raised beds (FIRB) in a split-plot design replicated thrice. The variable tillage practices significantly affected the seed, stover, biological yields, production efficiency, and economics of mustard along with the bulk density and soil organic carbon dynamics of soil.

After five years of the experimentation, during 2013-14, the highest mustard seed yield was obtained under FIRB (2,456 kg/ha, 14.3% higher over CT), followed by ZT (2,362 kg/ha, 9.9% higher over CT) because of more dry matter accumulation, higher translocation efficiency, and greater sink/source potential at the seed filling stage (Table 2.7). The seed yield obtained under RT was found at par with CT. A higher number of primary and secondary branches were also recorded under ZT and a linear relationship of branches with seed yield was recorded (Fig. 2.10. Among the cropping systems, the highest yield was obtained under the green manure-mustard cropping system (2,420kg/ha) followed by the brown manure-mustard system. However, the seed yield under brown manure-mustard system was recorded similar to cluster bean-mustard system. The highest assimilate supply (0.33g/siliqua) was recorded under ZT. The higher assimilate supply in ZT and FIRB is thus closely associated with HI and 1000 seed weight. Sustainability parameters, including harvest index (0.29), sustainability yield index (0.85), and production efficiency (16.1 kg/ha/day) were also found highest under ZT after 4 years of experimentation. Soil organic carbon increased to 0.39% and 0.36% in ZT and FIRB, respectively, from 0.26% in CT (Table 2.8). A higher mass of soil organic carbon and carbon sequestration potential rate was recorded under ZT. The bulk density, however, decreased in ZT

and FIRB compared with CT. The soil organic carbon, mass of soil organic carbon, and carbon sequestration potential rate were highest in the green manure-mustard system. These parameters were similar between the pearl millet-mustard system and fallow-mustard system, indicating that an additional pearl millet crop can be successfully grown without exhausting the soil organic carbon levels.

Table 2.7. Seed, stover and biological yields of mustard as influenced by various tillage methods and cropping systems.

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index	Assimilate supply (g/siliqua)	Sustainability yield index	Production efficiency (kg/ha/day)
Tillage operation						
CT	2149^{a}	8084^{c}	0.21^{a}	0.26^{a}	0.59^{a}	13.48^{a}
RT	2191^{a}	7768^{b}	0.22^{a}	0.31^{b}	0.75^{b}	14.21^{a}
ZT	2362^{b}	7086^{a}	0.25^{c}	0.33^{c}	0.71^{b}	13.49^{a}
FIRB	2456^{c}	8222^{c}	0.23^{b}	0.29^{b}	0.85^{c}	16.06^{b}
Cropping systems						
Fallow-M	2271^{a}	8849^{d}	0.20^{a}	0.26^{a}	0.73^{a}	13.84^{a}
GM-M	2420^{d}	7740^{c}	0.24^{c}	0.32^{b}	0.81^{b}	15.17^{c}
BM-M	2301^{bc}	8058^{c}	0.22^{b}	0.31^{b}	0.73^{a}	14.22^{b}
CB-M	2287^{b}	7248^{b}	0.24^{c}	0.31^{b}	0.79^{b}	14.75^{b}
PM-M	2167^{a}	7054^{a}	0.23^{b}	0.27^{a}	0.72^{a}	13.56^{a}

Table 2.8. Bulk density, soil organic carbon, mass organic carbon and carbon sequestration potential of soil as influenced by various tillage methods and mustard based cropping systems.

Treatment	SOC (%)	Bulk density (g/m^3)			MSOC (Mg/ha)			CSPR		
		0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Tillage operation										
CT	0.26^{a}	1.54^{c}	1.58^{c}	1.61^{c}	6.20^{a}	6.16^{a}	6.28^{a}	0.09^{a}	0.08^{a}	0.11^{a}
RT	0.34^{b}	1.56^{b}	1.55^{c}	1.54^{b}	7.85^{b}	7.91^{b}	7.85^{b}	0.50^{b}	0.51^{b}	0.50^{b}
ZT	0.39^{c}	1.55^{a}	1.50^{a}	1.49^{a}	8.89^{c}	8.78^{d}	8.72^{c}	0.76^{c}	0.73^{c}	0.72^{c}
FIRB	0.36^{b}	1.55^{a}	1.52^{b}	1.53^{b}	8.21^{b}	8.21^{c}	8.26^{c}	0.59^{b}	0.59^{b}	0.60^{b}
Cropping system										
Fallow-M	0.26^{a}	1.58^{b}	1.59^{b}	1.59^{c}	6.16^{a}	6.20^{a}	6.20^{a}	0.08^{a}	0.09^{a}	0.09^{a}
GM-M	0.39^{b}	1.51^{a}	1.52^{a}	1.50^{a}	9.29^{c}	9.35^{c}	9.23^{c}	0.86^{d}	0.87^{d}	0.84^{d}
BM-M	0.37^{b}	1.52^{a}	1.52^{a}	1.52^{a}	8.44^{b}	8.44^{b}	8.44^{b}	0.65^{b}	0.65^{b}	0.65^{b}
CB-M	0.38^{b}	1.53^{a}	1.53^{a}	1.54^{b}	8.72^{b}	8.72^{b}	8.78^{b}	0.72^{bc}	0.72^{bc}	0.73^{bc}
PM-M	0.26^{a}	1.56^{b}	1.56^{b}	1.57^{c}	6.08^{a}	6.08^{a}	6.12^{a}	0.06^{a}	0.06^{a}	0.07^{a}

Note: Initial soil organic carbon: 2.6g/kg and initial bulk density: 1.50 g/m^3.

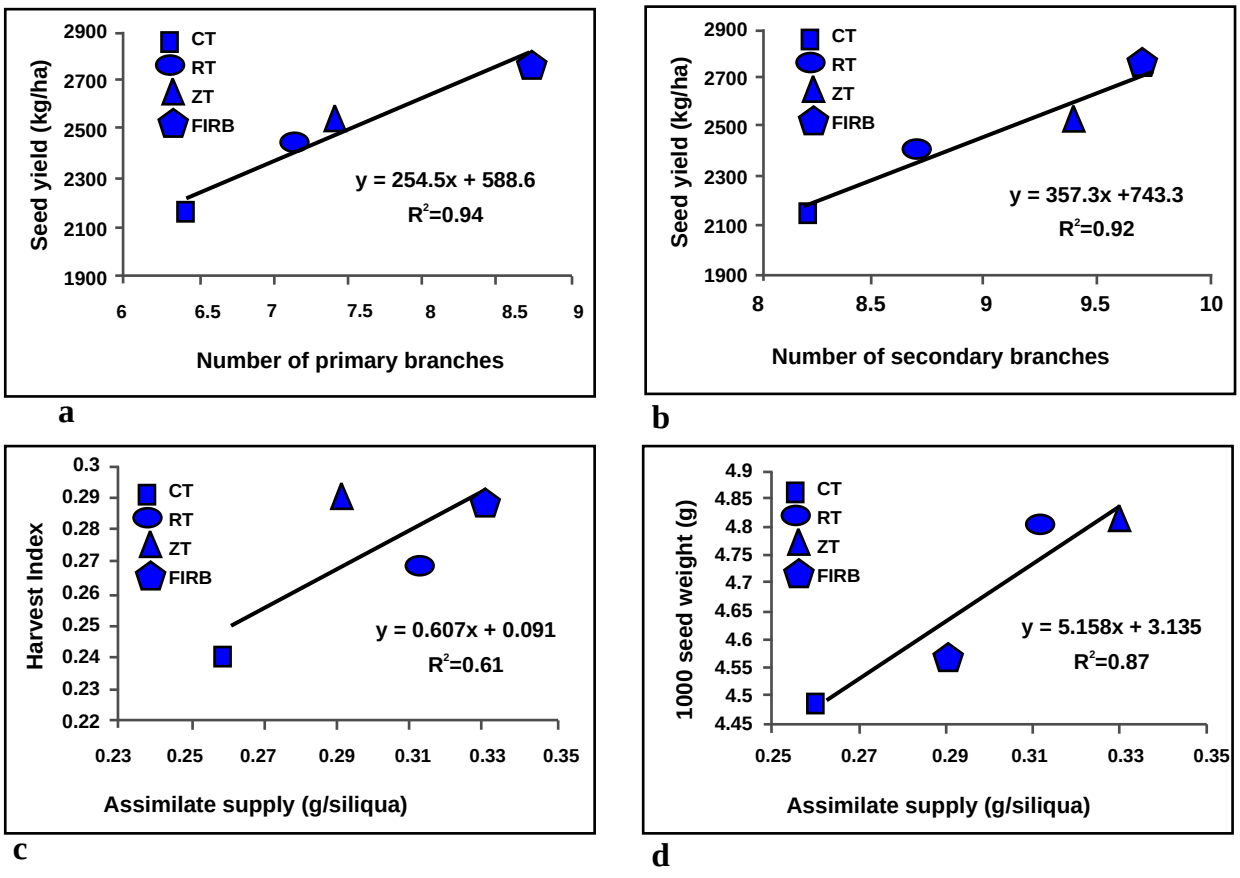


Fig. 2.10. Relationship between a. seed yield and primary branches, b. seed yield and number of secondary branches, c. assimilate supply and harvest index and d. assimilate supply and 1000-seed weight

DRMR CP 13: Characterization and classification of soil-site conditions to delineate rapeseed-mustard production zones

Project Leader : B. K. Kandpal

Associates: O. P. Premi Principal Scientist (Agronomy), S. S. Rathore Senior Scientist (Agronomy)

Road map to enhance oilseed brassica production in the country

OSB is a cash crop of 242 districts in 18 states. The districts were grouped into 5 land utilization types (LUT) on the basis of weather-normal, land use capabilities, socio-economic conditions, technology available, institutional support and present seed yield levels to develop general strategies to increase the production in the country (Fig. 2.11). The 5 LUTs on OSB are (1) Subsistence producers, (2) Transitional producer, (3) Subsistence commercial producer (4) Subsidiary commercial producer, and (5) Commercial producer.

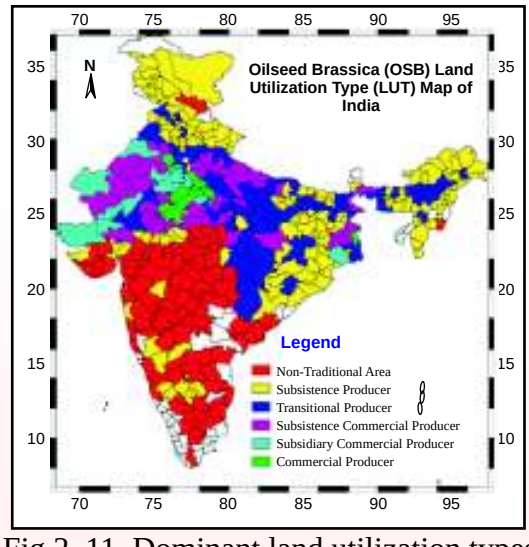


Fig 2. 11. Dominant land utilization types (LUT) of oilseed Brassica in India

Subsistence producers: Seventy eight districts in 11 states traditionally cultivate OSB as a minor catch crop of marginal lands with marginal management. The acreage and yield levels are low. The technology adoption rates are low. Still seeds of very old varieties are used. On an average the crop is being cultivated in 3579 ha

area (which is more than 8% of average GCA in the districts) having average yield below 749 kg/ha. Districts have great potential to enhance OSB production through adoption of strategies *viz.* (i) Effective replacement of old varieties with latest varieties suitable for the LUT, (ii) Adoption of low cost production and protection technologies (*viz.* line sowing, plant population, timely sowing etc.), (iii) Ensure use of balance NPK fertilizers, (iv) Effective weed control measures, (v) Adoption of soil-water conservation technologies, (vi) Adoption of suitable intercropping sequence, and (vii) Extensive FLDs on single component technologies especially varieties, NPK fertilizers, plant population and sowing time.

Transitional producer: The OSB production in 38.4% districts over 14 states is under transition from subsistence to commercial farming with low acreage but moderate OSB yields. Average acreage under OSB in the districts is 10437 ha area with mean seed yield of 908 kg ha^{-1}. The crop is grown by small and marginal farmers with residual resources. Sometimes it is taken up as catch crop between main *kharif* and *rabi* crops. Almost half area under OSB is irrigated indicating increasing importance of the crop in the districts. Appropriate market intervention and excess to input resources could boost OSB production in these districts. Important strategies to improve seed yield in these districts include (i) Adoption of latest high yielding varieties, (ii) Seed treatment with biofertilizers and other agrochemicals, (iii) Ensure use of NPKS fertilizers, (iv) Irrigation scheduling, (v) Effective plant protection measures, (vi) Ensure support from market, (vii) Promotion of OSB based small scale industries, and (viii) Extensive FLDs and OFTs on Component technologies.

Subsistence commercial producer: OSB is one of the important commercial crops in 17.8% districts across 7 states. The crop occupy moderately high acreage of 29412 ha per district with average yield of 1018 kg ha^{-1}. The crop is primarily grown with protective irrigation. This zone has very high potential for area expansion and productivity improvement through appropriate market intervention. Major strategies to increase production in this LUT include (i) Assured supply of quality seed at affordable price, (ii) Seed treatment with biofertilizers and agrochemicals, (iii) Soil-test based application of K, S, Zn and B, (iv) Support for adoption of pressurised irrigation technology, (v) Effective management of biotic stress of weeds, pest and diseases, (vi) Effective market support, and (vii) FLDs and OFTs on whole package of practices.

Subsidiary commercial producer: The OSB is produced as high acreage high yielding cash crop in 5% districts of three states. In these districts, it is being cultivated as second important commercial crop with assured irrigation. The crop occupy almost 12% GCA in the districts with 95377 ha average acreage and 1319 kg ha^{-1} yield. Adoption of new technological advances in irrigation and fertilizer management could further strength the position of OSB in these districts.

Commercial producer: OSB is cultivated as most dominant *rabi* crop in 6.6% districts across 5 states. The crop covers more than 26% of the GCA in the districts and utilizes average 35% of existing irrigation potential of the districts. The crop occupies high acreage (average 94895 ha) and high productivity (1416 kg ha^{-1}) under protective irrigation. The dominance of OSB in these districts could further strengthen through addressing various soil health issues and adoption of soil-site based production technologies.

Sustenance of productivity in subsidiary commercial producer and commercial producer districts is major concern. Major strategies for the LUTs include (i) Assured supply of quality seed, (ii) Balance application of micronutrients Zn, B, Cu and Fe besides NPKS, (iii) Promotion of pressurised fertigation, (iv) Effective management of crop residues and soil health resilience, (v) Effective management of abiotic stresses, (vi) Application of biofertilizers, (vii) FLDs and OFTs on whole package of practices

The technologies for different LUTs are already available, but needs appropriate refinement for

easy adoption at different land use conditions. A strong support from extension agencies, policy planner and other stake holders is also required to achieve the targets.

Studies on sustainable oilseed brassica production intensification for small farms

Project Leader : B. K. Kandpal Principal Scientist (Agronomy)

Associates: K. H Singh, Principal Scientist (Genetics & Plant Breeding), O. P. Premi, Principal Scientist (Agronomy), S. S. Rathore, Senior Scientist (Agronomy), Kapila Shekhawat, Scientist SS (Agronomy)

Performance of Indian mustard under different dates of transplanting : A field experiment was conducted to assess the performance of transplanted Indian mustard crop under different environment conditions. Seedlings of two Indian mustard varieties- NPJ 112 (short duration) and NRCHB 101 (medium duration) were raised in root-trainers and 10-14 days old seedlings were transplanted at 60 cm x 60 cm spacing in field on 7 dates at about 15 days interval form Sept 13 to Dec 13. Var. NRCHB 101 produced significantly higher biomass (10.8t/ha) and seed yield (3.3t/ha) at Sept 13 transplanting (Table 2.9). A decreasing trend in biomass production was observed with delayed transplanting. The reduction was gradual up to Oct 31 transplanting and thereafter the reduction was geometric. However, the geometric decline in seed yield began form Oct 31 transplanting itself. Probably, the plant could not avail the benefits of larger biological frame due to comparatively shorter reproductive period. However, the crop growth of short duration var. NPJ 112 gradually increased with advancement of transplanting time up to Oct 31 and thereafter gradually declined beyond this dates. Plateau seed yield of 2.07 t/ha was recorded at Oct 17 transplanting. In general significant variation in yield attributes was observed between the two varieties (Fig 2.12).

Table 2.9. Biological and seed yield (kg/ha) of Indian mustard varieties under different dates of transplanting.

Date of transplanting	NRCHB 101		NPJ 112	
	Biol. Yield (kg/ha)	Seed Yield (kg/ha)	Biol. Yield (kg/ha)	Seed Yield (kg/ha)
Sept 13	10790	3286	5785	1941
Oct 1	8913	2784	5639	1887
Oct 17	8728	2635	6729	2072
Oct 31	8157	1652	6874	1582
Nov 13	5894	1181	4671	1005
Nov 29	2390	300	2569	293

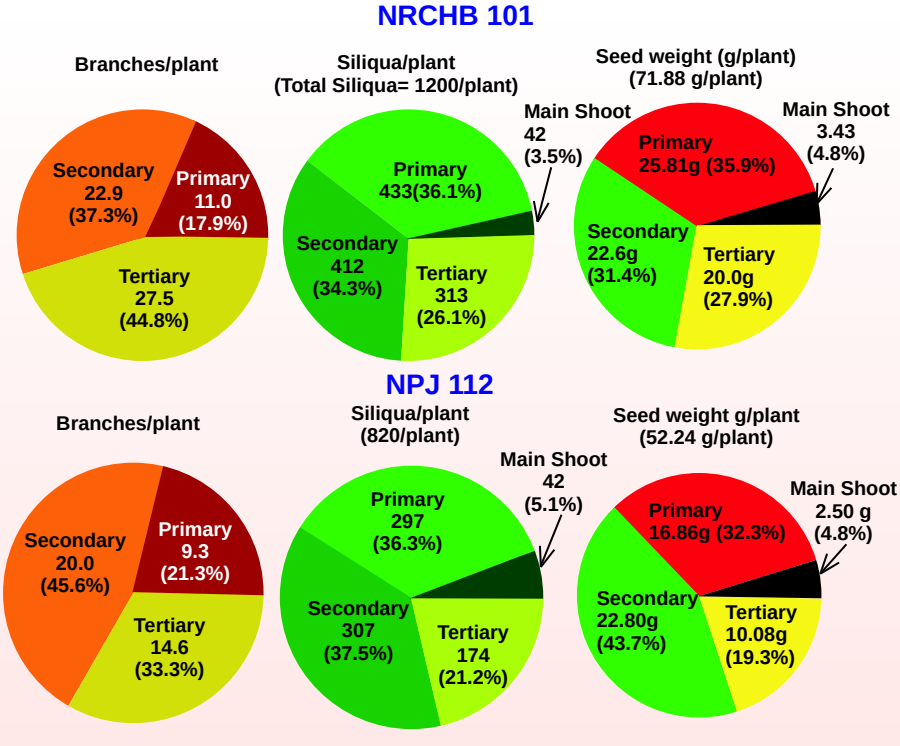


Fig. 2. 12. Partitioning of yield attributes of Indian mustard varieties under transplanting.

In general, var. NRCHB 101 recorded 18.3% more primary, 14.5% more secondary and 88.4$ tertiary branches than var. NPJ 112. Larger biological frame of NRCHB 101 produced more siliqua in primary branches by 45.8%, secondary branches by 34.2% and tertiary branches by 79.9% over NPJ 112. Overall, NRCHB 101 produced 46.3% more siliqua than NPJ 112 (820 siliqua/plant). And more site of primodia in NRCHB 101 finally resulted in 37.6% higher seed weight (71.8 g/plant) than NPJ 112 (52.24 g/plant). The seed weight per plant was partitioned as 32.3-35.9% to primary branches, 31.4-43.2% to secondary branches and 19.3-27.9% to tertiary branches. The contribution of main shoot was almost 4.7% only in both varieties.

Critical studies on harvest index (HI) confirm the superiority of NRCHB 101 over NPJ 112 as better sink translocator (Fig 2.13). The HI in NPJ

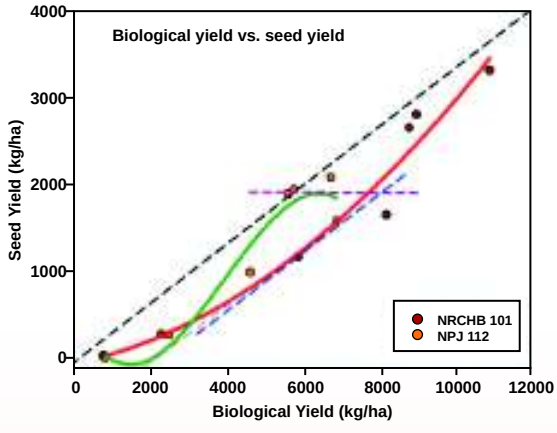


Fig. 2.13. Effect on harvest index as a function of biological yield of Indian mustard varieties

112 gradually increased with increase in biomass produced and attained highest value (HI) at total biomass of 6.4 t/ha. Beyond this the HI declined. Contrary to this, HI in NRCHB 101 exponentially increase even beyond total biomass production of 11.0 t/ha, indicating better adoption capacity and elasticity of the variety to divers climatic conditions.

Screening of oilseed brassica germplasms for low nitrogen requirement: OSB is traditionally cultivated in semi-arid regions usually deficient in N-the most critical nutrient for crop growth and yield. High yielding OSB genotypes with low N requirement will be important for sustainable cultivation of crop. Therefore 125 OSB germplasm/breeding lines/varieties were evaluated for their uptake efficiency under N deficient environment during 2012-13. Initially 24 lines showed significantly superior performance. These 24 liens were sown in replicated trials under N deficient (0 kg N/ha) and N sufficient (80 kg N/ha) environments. Among the genotypes evaluated, 6 lines- EC 399307, DRMRIJ 31, HB 9902, IC 212031, HB 9912 and QM 16 showed narrow ratio (<1.00) between biological yield at N80 and N0. While the ratio of seed yield at N80 and N0 was narrow for DRMRIJ 31, EC 399307, DHR 991 and HB 9902. And combining the two findings, three lines- DRMRIJ 31, EC 399307 and HB 9902 could be considered N efficient lines with higher harvest index. However, the finding needs further confirmation from laboratory data.

DRMR CP 15: Efficient water management in *Brassica juncea*

Project Leader : S. S Rathore Senior Scientist (Agronomy)

Associates: O. P. Premi Principal Scientist (Agronomy) and Kapila Shekhawat, Scientist SS (Agronomy)

Increasing WUE through use of hydrogel under adequate and deficit irrigation scheduling

Four experiments were conducted for increasing water use efficiency (WUE) of Indian mustard through use of superabsorbent polymer (SAP), hydrogel under adequate and deficit irrigation scheduling with 8 treatment combinations (no irrigation, 0.4, 0.6 and 0.8 IW/CPE with and without hydrogel) in completely randomized block design replicated thrice. The rain fall received during crop season was more than average which nullified the effect of hydrogel and irrigation treatments.

Land configuration under surface drip irrigation to enhance water use efficiency

Drip irrigation was evaluated for different row spacing under flat and raised bed conditions of Indian mustard. The surface drip irrigation under land configuration flat sowing in 60/30 and 30/60 flat resulted in maximum seed, oil productivity, biological yield, and production

efficiency and significant effect was also observed on harvest index. This higher mustard productivity under 60/30 and 30/60 was possible because of better growth of yield attributes (biomass/plant, main shoot length, primary branches, number of siliquae on primary and secondary branches as well as total number of siliquae per plant, seeds per siliqua and 1000 seed weight). Maximum B:C ratio was obtained from flat 60/30 sowing but was at par with 30/60 flat sowing. With regards to production efficiency and profitable efficiency 60/30 and 30/60 was found to be the best (Table 2.10).

Enhancing resource use efficiency of *Brassica juncea* through nano-particles

Chitosan Nano Particles and Titanium Oxide Nano powder were used as seed treatment and foliar spray to enhance resource use efficiency of *Brassica juncea*. Among all the treatment combination, the seed treatment with Titanium oxide @1000 ppm resulted in maximum increase in seed yield higher harvest index, oil productivity, profitable efficiency and economics (Table 2.11). The unique physico-chemical, optical and biological properties of Titanium oxide resulted in better growth and seed productivity. Most of these effects of are related to the appearance of quantum effects as the size decreases, and are the origin of phenomena such as Plasmon resonance etc. Nanoparticles may help to improve nutrient use efficiency because of their small size, more surface area and their slow rate of release, which facilitate to the plants to take up most of the nutrients without any waste.

Table 2.10. Seed & oil yield, harvest index, production efficiency and economics of Indian mustard under micro sprinkler

	Treatments	Seed yield (kg/ha)	Oil yield (kg/ha)	Harvest index	1000-seed wt (g)	Net returns (Rs/ha)	B:C Ratio	Production efficiency (Kg/ha/day)	Profitable efficiency (Rs/ha/day)
1	Flat (30CM)	2781^{d}	562^{a}	32.7^{b}	5.3^{cde}	75455^{d}	3.6^{cd}	18.9^{d}	513^{d}
2	30/60 ridge	2178^{c}	1273^{d}	33.1^{b}	5.2^{bcd}	78457de	3.4^{c}	14.8^{c}	534de
3	60/30 furrow	1808^{b}	1176^{d}	31.8^{b}	4.9^{ab}	57923^{c}	2.5^{b}	12.3^{b}	394^{c}
4	90/60 furrow	1111^{a}	469^{a}	17.8^{a}	4.7^{a}	29254^{a}	1.3^{a}	7.6^{a}	199^{a}
5	Flat60/30	3035^{d}	767^{b}	34.9^{b}	5.5^{de}	88815^{e}	4.3^{e}	20.7^{d}	604^{e}
6	30/60 flat	2803^{d}	921^{c}	23.8^{a}	5.5^{e}	84429de	4.1^{de}	19.1^{d}	574d^{e}
7	90/60 flat	1326^{a}	1176^{d}	34.8^{b}	5.0^{abc}	45150^{b}	2.2^{b}	9.0^{a}	307^{b}

Table 2.11. Effect of nano particles on seed &oil yield, production efficiency and economics of Indian mustard

Treatments	Seed yield (kg/ha)	Oil yield (kg/ha)	Net returns (Rs/ha)	B:C Ratio	Production efficiency (kg/ha/day)	Profitable efficiency (Rs/ha/day)
ST Titanium oxide @500 ppm	1672^{a}	706^{a}	48682^{c}	2.32^{e}	11.61^{a}	338^{c}
ST Titanium oxide @1000 ppm	2011^{b}	852^{b}	62226^{d}	2.95^{f}	13.96^{b}	432^{d}
ST Chitosan @500 ppm	1524^{a}	645^{a}	46742^{bc}	2.23^{e}	10.57^{a}	325^{bc}
ST Chitosan@1000 ppm	1630^{a}	690^{a}	47191^{bc}	2.23^{e}	11.30^{a}	328^{bc}
Foliar spary of titanium oxide @500 ppm	1545^{a}	652^{a}	39086^{ab}	1.46^{c}	10.71^{a}	271^{ab}
Foliar spary of titanium oxide @1000 ppm	1587^{a}	672^{a}	34377^{a}	1.05^{ab}	11.04^{a}	239^{a}
Foliar spary of chitosan @500 ppm	1524^{a}	642^{a}	37124^{a}	1.33^{bc}	10.57^{a}	258^{a}
Foliar spary of chitosan @1000 ppm	1566^{a}	665^{a}	31097^{a}	0.89^{a}	10.87^{a}	216^{a}
Thiourea @0.1 %	1460^{a}	610^{a}	39424^{abc}	1.86^{d}	10.13^{a}	274^{abc}

Enhancing WUE of Indian mustard under deficit and adequate irrigation scheduling with hydrogel under surface irrigation

Experiment on "enhancing WUE of Indian mustard under deficit and adequate irrigation scheduling with hydrogel" had resulted with similar fate except in 0.6 IW/CPE Irrigation scheduling recorded better yield performance. It was due to fact that water requirement was adequately met at early stage by irrigation scheduling, when there was no rain fall. However at deficit irrigation effect of higher dose of super absorbent polymers was better on seed yield and at 0.6 IW/CPE ratio the lower dose (2.5 kg/ha) was better in enhancing the seed yield of Indian mustard. At early and pod development stages the relative water content was higher under hydrogel.

2.6 Management of biotic stresses in Indian mustard

DRMR ENT 2: Biological control of major pests of *Brassica* with special reference to mustard aphid

Project Leader : Dr. Y.P. Singh Principal Scientist (Agril. Entomology)

Evaluation of bio-agents against mustard aphid under net cover in pots

B. juncea cv. NRCDR-2 was sown in field under late condition to evaluate the field efficacy of three bio-agents *i.e. Coccinella septempunctata* (Both adult and grub), Chrysoperla carnea (Larva) and syrphid fly (Maggot) against the mustard aphid. 50 number of mustard aphid per plant were released on the selected plants. The aphids settled on the twig of plants in field in 1-3 days after release. The bio-agents were released after settlement of aphids and the observations were recommended on 3, 7 and 10th day after release. The results are presented in the following Table 2.12.

BR = No. of aphids Before Release; DAR = Days After Release

The feeding potential of bioagents in the field condition was found very effective except *Chrysoperla carnea* and syrphid fly. More than 90% reduction of aphids was recorded in *Coccinella septempunctata* when released 2 and more individuals (Adult or grub) per plant depicting their high voracious rate of consumption.

DRMR ENT - 3 : Plant-pest interaction of major pests of *Brassicas*

Project Leader : Dr. Y. P. Singh, Principal Scientist (Agril. Entomology)

Screening of germplasm against mustard aphid:

Two hundred forty three accessions were screened for resistance/tolerance against mustard aphid. Each accession was sown in 3 m long paired row in three replications. Seventeen entries *i.e.* DRMRHJ 4109, RSPN 29 (*B. juncea*), NUDB 26-11 (*B. napus*), DLSC 1 (*B. carinata*), RTM 1351, RTM 1359, RTM 314, RTM 1415, RTM 1375, RTM 1355, RTM 2002, RTM 1212, TMB 2030, TMB 29, TMB 2031, TMB 2032 and T 27 (*E. sativa*) were found highly resistant having the AAII less than 1.

Population dynamics of insect pests in rapeseed-mustard

Four species of rapeseed-mustard *i.e.* (Indian mustard PCR 7), (gobhi sarson GSC-6), (brown sarson BSH 1) and (yellow sarson YST-1) in three replications were sown under two conditions *i.e.* timely sown and late sown. The population of insect pests was observed on weekly basis. The highest mustard aphid population in timely sown was observed in 9th std. week in PCR 7, 10th std. Week in GSC 6 and YST 151 and in 8th std. week in BSH-1. Under late sown condition all the species had the peak aphid population in 10th Std. week except BSH 1 (in 8th week) and DLSC 2 (in 11th std. Week) (Fig. 2.14).

The population of painted bug appeared during the 44th std. week in all entries and remained active up to 50th std. week with a peak in 48th std. week under timely sown condition. The pest population again appeared in the 6th std. week and

Table 2.12. Evaluation of bio-agents against mustard aphid on single plant under field net cover

Bio-agent/Treatments	BR	Reduction in mustard aphid population					
		3 DAR		7 DAR		10 DAR	
		Aphid	Red. %	Aphid	Red. %	Aphid	Red. %
(A) *Coccinella septempunctata*							
(i) 1 grub/plant	50	41.4	17.3	23.8	52.5	14.1	71.8
(ii) 2 grub/plant	50	31.5	37.1	13.5	73.1	2.1	95.9
(iii) 3 grub/plant	50	21.7	56.7	6.1	87.8	0.0	100.0
(iv) 4 grub/plant	50	11.8	76.5	1.2	97.6	0.0	100.0
(v) Control	50	121.8	-	219.4	-	337.1	-
(B) *Coccinella septempunctata*							
(i) 1 adult/plant	50	39.0	22.0	19.7	60.7	11.4	77.3
(ii) 2 adult/plant	50	27.3	45.5	7.0	86.1	1.3	97.5
(iii) 3 adult/plant	50	18.4	63.3	4.8	90.4	0.0	100.0
(iv) 4 adult/plant	50	6.3	87.5	0.0	100.0	0.0	100.0
(v) Control	50	127.5	-	250.7	-	315.2	-
(C) *Chrysoperla carnea*							
(i) 1 larva/plant	50	40.6	18.9	21.1	57.8	27.4	45.2
(ii) 2 larva/plant	50	36.3	27.5	16.5	67.1	24.1	51.9
(iii) 3 larva/plant	50	30.5	39.1	10.3	79.5	17.8	64.5
(iv) 4 larva/plant	50	21.3	57.4	6.3	87.5	12.5	75.1
(v) Control	50	119.7	-	217.5	-	320.1	-
(D) Syrphid fly							
(i) 1 maggot/plant	50	41.1	17.8	26.1	47.8	22.4	55.2
(ii) 2 maggot/plant	50	33.3	33.4	16.0	68.1	10.1	79.9
(iii) 3 maggot/plant	50	22.7	54.7	11.3	77.5	5.3	89.5
(iv) 4 maggot/plant	50	18.5	63.1	8.4	83.2	3.5	93.1
(v) Control	50	118.9	-	223.1	-	347.4	-

remained active till harvest in 14th std. week with peak, except in BSH 1 and YST 151 which were harvested in 12th std. week. The same pattern was observed under late sown condition with peak was observed in the 14th std. week.

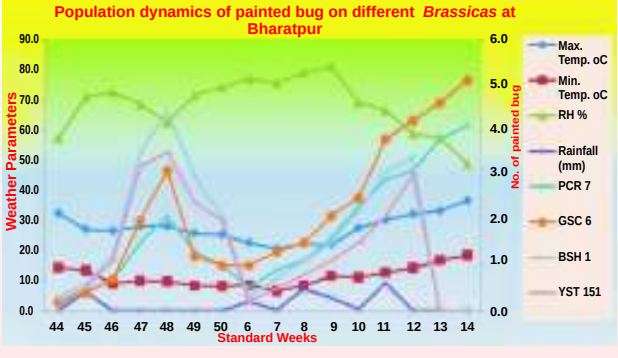


Fig. 2.14 : Population dynamics of painted bug on different Brassicas

The population of leaf miner was first observed during 51st std. week in BSH-1 and YST 151 and during 52nd std. week in PCR 7 and GSC 6. The leaf miner attained the peak during 8th std. week in BSH-1 and YST 151 and in 9th std. week in GSC 6 and in 10th std. week in PCR 7. In late sown crop the peak was observed in 9th std. week PCR-7, BSH-1 and YST 151 while, in 14th Std Week in GSC 6.

Honeybee population appeared in different species of Brassica in 50th std week under timely sown condition and attained peak during 6th std week in PCR 7 and BSH 1, while, peak was observed late under sown late conditions. Honeybee pups appeared in 52nd std week in GSC 6 and YST 151. In late sown condition, appeared

in 52nd std. week and attained peak in 8th, 9th and 10th std. weeks respectively in PCR 7, BSH 1 and YST 1519th std. week in, and in GSC 6

Leaf webber was also observed damaging the timely sown crop specially PCR 7 and GSC 6.

Assessment of yield losses due to insect pests in Brassica crops

Two rows of *B. juncea* cv NRCDR2 and Rohini and one of *B. rapa* cv BSH 1 were sown under protected and unprotected conditions. Each variety was grown in plots of 4.2 X3 m. size and replicated eight tines. In the protected plots weekly spray of recommended insecticide was provided to control the insect pests. The highest yield loss of 34.7% was recorded in BSH 1 followed by Rohini (22.3%) and NRCDR 2 (17.4%).

Bio-efficacy of newer insecticides against mustard aphid

The crop was sown in plot size of 4.2 x 3 m in three replications having cv. NRCHB 101. Eight treatments *i.e.* fipronil 5SC @ 50g *a.i.* per ha, thiam ethoxam 25WG @ 25 g *a.i.* per ha, imidacloprid 17.8 SL @ 20 g *a.i.* per ha, acetamiprid 20 SP @ 10 g *a.i.* per ha, acephate 75 SP @ 350g *a.i.* per ha, dimethoate 30 EC@ 300 g *a.i.* per ha, oxy-demeton methyl 25 EC@ 250g *a.i.* per ha and control were taken for the evaluation against the mustard aphid. The maximum reduction in aphid population was recorded in dimethoate 30 EC@ 300 g *a.i.* (98.3%) with highest yield followed by imidacloprid 17.8 SL @ 20 g *a.i.* per ha (96.8%). Incremental cost benefit ratio (42.5) was, however, higher in imidacloprid 17.8 SL @ 20 g *a.i.* than dimethoate 30 EC@ 300 g *a.i.* (31.3).

Efficacy of chemical insecticides and Botanicals against painted bug in Indian mustard

The crop was sown in plot size of 4.2 x 3 m in three replications having cv. NRCDR 2. Ten treatments *i.e.* thiamethoxam 25WG @ 25 g *a.i.* per ha, imidacloprid 17.8 SL @ 20g *a.i.* per ha, dimethoate 30 EC@ 300g *a.i.* per ha, Malathion 50 EC @ 500 g *a.i.* per ha, Fenvalerate 20 EC @ 200 g *a.i.* per ha, NSKE @ 5%, Neem Oil @ 2 %, Chlorpyriphos 20 EC @ 200g *a.i.* per ha, Quinalphos 25 EC @ 250g *a.i.* per ha and control were taken for the evaluation against the painted bug. The maximum reduction in painted bug was recorded in imidacloprid 17.8 SL @ 20 g *a.i.* per ha (100.0%) followed by Malathion 50 EC @ 500 g *a.i.* per ha (96.2%) and thiamethoxam 25WG @ 25 g *a.i.* per ha (94.9%). Incremental cost benefit ratio was also highest in Imidacloprid 17.8 SL @ 20 g *a.i.* per ha (61.2) followed by Thiamethoxam 25 WG @ 25 g *a.i.* per ha (44.9) and Malathion 50 EC @ 500 g *a.i.* per ha (43.8).

Monitoring of mustard aphid on yellow sticky traps

The population of alate mustard aphid (*Lipaphis erysimi* Kalt.) was monitored with the help of yellow sticky traps in the field. The mean population of alate aphid of five traps was found very low this year. The highest number of alate mustard aphid (96.3 alate/trap) was recorded during 9th std. week.

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

Project Leader: Pankaj Sharma, Senior Scientist (Plant Pathology)

Associate: P.D. Meena, Senior Scientist (Plant Pathology)

Epidemiology

Epidemiological studies of Sclerotinia rot was done using three dates of sowing starting on Oct 8, 2014 at three-week intervals with four replications in plot size of 4.8 x 5 m using cultivar Rohini of Indian mustard. Data for disease incidence was recorded apart from petal infection, weather data and soil moisture to identify the suitable conditions for disease development. Soil moisture was also recorded since 2008-09 to 2012-13 (5 years) and models were developed (Table 2.13), which indicated soil moisture as an important variable in SR infestation. Per cent petal infection (PPI)

Table 2.13. Models developed using data from 2008-09 to 2012-13 (Tmax Tmin RHmor, RHeve, BSSH and soil moisture).

Date of owing	Models	R^2	% Disease forecast 2013-14	
			observed	forecast
8 October	Y= 4.550 + 0.017 * Z_{161}	0.81	17.2	17.1
29 October	Y= 21.585 + 0.023 * Z_{161}	0.77	27.8	27.7
19 November	Y = 4.270 + 0.014 * Z_{161}	0.66	13.9	13.8

Z_{161} is weighted interaction of maximum temperature and soil moisture

Table 2.14. Per cent petal infection (PPP) observed during 2008-09 to 2012-13.

Standard week	Sowing Date		
	8 Oct	29 Oct	19 Nov
1	9.4	11.0	2.0
2	19.9	21.9	3.8
3	16.1	18.4	2.0

*Mean of 5 years (2008-09 to 2012-13)

resulted, initiation of SR incidence in first standard week in all dates of seeding which was maximum in 29th Oct sown crop (Table 2.14). PPI increased in 2 and 3 standard week in 8 and 29 Oct sown crop. In this study, relative humidity, BSSH and temperature were the variables most closely associated with disease development when petal infestation was high. During the petal infestation, soil moisture was also recorded maximum.

During 2014-15 maximum incidence of Sclerotinia rot was observed in 29 Oct (39.4%) followed by 8 Oct (32.2%) sowing. During month of January rainfall play an important role in increasing carpogenic infection of S. sclerotiorum when crop was in full bloom stage. Maximum petal infection as well as apothecia were observed during 1-3 standard week.

Germplasm Screening for Sclerotinia rot

One hundred fifty one (42 SBG, 9 NDN, 100 core collection) germplasm lines of *Brassica juncea, B. carinata and B. napus were screened* under sick plot at DRMR during 2014-15 season, sown on 28 Oct 2014 in single row of 3 m length with 30 cm x 10 cm spacing maintaining two test rows per plot along with border rows of cv. NRCYS 5-2 (susceptible check) in randomized block design with two replications. Pathogen inoculum was mass multiplied on autoclaved sorghum grain and mixed with soil prior to sowing to create epiphytotic field conditions. Further, the plants were inoculated with the mycelial bit of pathogen tied to stem with parafilm. All the test lines were found susceptible. SR 14-68 (*B. juncea*) showed tolerant reaction (lesion size <3.0 cm and disease incidence <10%).

850 germplasm lines received from National Gene Bank and 95 breeding lines were evaluated for white rust and Alternaria blight. 36 lines from National gene bank and RH 2014, RH 345, WR 14-03 to 14-09, WR 14-13, WR 14-16 and WR 14-17 breeding lines were found highly tolerant to white rust.

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. The crop was sown on 28th Oct 2014 with seed treatment of *Trichoderma* (8 g/kg) and carbendazim (2g/kg), combinations of seed treatment (ST) and foliar spray (FS) (0.2%) of carbendazim, ST+FS *Trichoderma* and FS *Pseudomonas fluorescens* (10^8 cfu/ml) at flowering stage. Among different treatments, carbendazim ST+ FS provided highest yield

(2588 Kg/ha) and minimum per cent disease incidence (8.9%) followed by ST *Trichoderma* + FS carbendazim (2310 Kg/ha, 20.7%) as compared to control (1266 Kg/ha and 53.2%).

Mycelial growth of *S. sclerotiorum* on PDA supplemented with leaf and petal

Potato Dextrose Agar (PDA) was supplemented with six different concentrations (0.1,0.5,1,2,5 and10%) of petal extract and seven (0.1,0.5,1,2,5,10 and 20%) leaf extract concentrations to observe the mycelial growth and sclerotia formation of *S.sclerotiorum* at 48,72 and 96 hours. All concentrations of petal and leaf extract increased the mycelial growth of *Sclerotinia* as compared to control. Petal extract with 1.0% concentration produced maximum mycelial growth of Sclerotinia at 48, 72 and 96 hours (49 mm, 83 mm, 90 mm). However, the number and weight of sclerotia formed was maximum in 5.0% extract. In leaf extract maximum growth, number and weight of sclerotia were observed at 5, 10 and 20% concentration, respectively (Fig. 2.15).

Isolation of phylloplane microflora

The phylloplane, the surface of plant leaves is a complex terrestrial habitat that is characterized by a variety of microorganisms including bacteria, filamentous fungi and yeast. Phylloplane fungi are the mycota growing or the surface of leaves. The fresh leaves of *B. juncea* and *B. rapa var yellow sarson* at 30 and 60 DAS were collected and placed in sterile plastic bags, and immediately brought to the laboratory. Leaves were shaken in flasks filled with 200 ml of distilled water. From the suspension of microorganisms prepared in this way 0.2 ml was transferred into Petri plates containing potato dextrose agar medium with streptomycin and nutrient agar. The inoculum was spreaded uniformly and kept in BOD for 3-5 days. The fungal and bacterial colonies were observed and pure cultures were maintained. As the plating method yield phylloplane fungi and bacteria were identified referring the standard manuals. A total number of 19 fungal and 3 bacterial species were isolated.

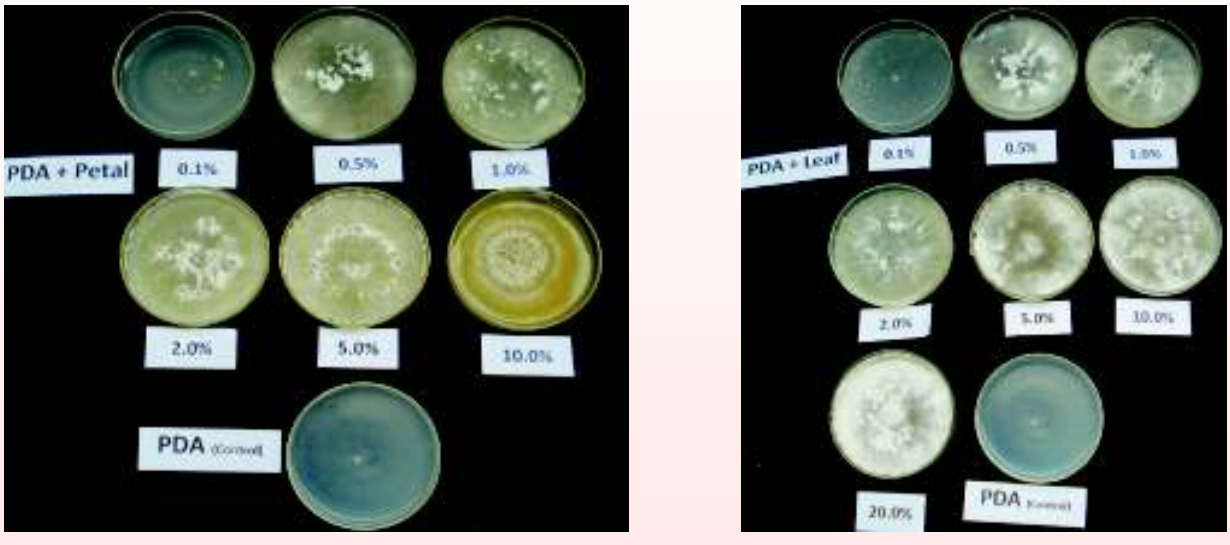
DRMR PP 3: Management of alternaria blight in rapeseed-mustard

Project Leader : P.D. Meena, Sr. Scientist (Plant Pathology)

Associate : Pankaj Sharma, Sr. Scientist (Plant Pathology)

Screening for tolerance against alternaria blight

Total 25 advanced breeding lines were characterized against Alternaria blight (*Alternaria brassicae*) under artificially created conditions. Promising tolerance was found in



a. **b.**

Fig. 2.15. a. Mycelial growth on PDA + petal extract, b. Mycelial growth on PDA+ leaf extract

breeding lines including DRMR-14-2800 (8.3%), DRMR-14-2805 (8.7%), DRMR-14-2806 (9.0%) and DRMR-14-2807 (10.0%) which were at par with EC-399299 (9.7%), but superior than tolerant source PHR-2 (11%), and PAB-9511 (14.3%) and susceptible check cultivar Varuna (25.0%).

Characterization of white rust resistance in Indian mustard

One hundred twenty breeding lines of Indian mustard (*Brassica juncea*) were screened against white rust (*Albugo candida*) disease under epiphytotic field conditions by spraying the inoculum. The progenies including DRMR-2010-2035 (PHR 1/BEC 107), DRMR-2010-2019 (EC-399288 x BEC-107), DRMR-2010-2036 (NBPGR-272 x RK-9903), DRMR-2010-2014 (GSL-1 x Bio-902), DRMR-2010-2178 [(RH-819 x BPKR-13) x (RH-819 x MDOC-3)] and DRMR-2010-2457 [(PYSR-2 x PBR-181) x (GSL-1 x Bio-902)] were found resistant to white rust.

Maintenance of *Alternaria brassicae* repository

Total 30 *Alternaria brassicae* isolates were maintained at DRMR, Bharatpur using Brassica broth and tomato broth.

Effect of nitrogen sources on growth of *Alternaria brassicae* isolates in Elliot's medium

Various nitrogen sources including potassium nitrate, sodium nitrate, peptone, yeast extract and asparagines which are incorporated in Elliot's medium were evaluated for growth response of different geographical *Alternaria brassicae* isolates. The Elliot's medium was used which preferentially encouraged the growth of the pathogen *Alternaria brassicae* infecting cruciferous plants. Different nitrogen sources showed variation in results. Highest mycelia radial growth of *A. brassicae* isolates was recorded in yeast extract, formed by potassium nitrate and peptone, while minimum growth was observed in aspargine and sodium nitrate sources of nitrogen. It appeared that nitrogen sources are

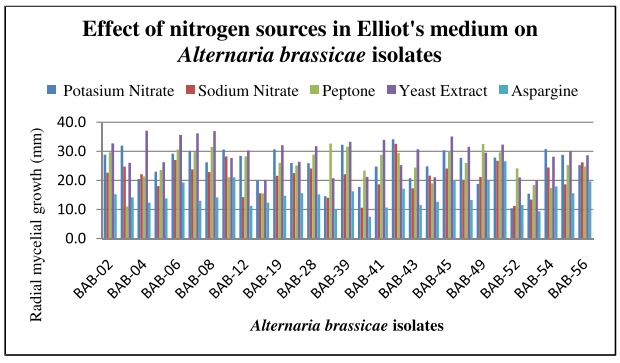


Fig. 2.16. Effect of nitrogen sources in Elliot,s medium on *Alternaria brassicae* isolates

essential for growth of isolates of *Alternaria brassicae*. The present study was an attempt to explore the requirement of the nitrogen as nutrient source (*in vitro*) for development of growth of pathogen so that to overcome disease development in the host. The study could enable to know the possible sources of development of pathogen so those can be avoided during cultural practices.

DRMR PP 5: Epidemiology and management of white rust

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

Associates : Pankaj Sharma, Senior Scientist (Plant Pathology), V.V. Singh, Principal Scientist (Genetics & Plant Breeding)

Under epidemiological trial, the experiment was laid out under RBD in plot size 5x5m, spacing 30 x 10 cm on three dates of sowing *i.e.* Oct 25, Nov 09 and Nov 24, 2013 with four replications using cv. Rohini. Data on disease incidence was taken twice and correlated with prevailing weather conditions, especially rainfall and relative humidity. Data on soil moisture was also recorded. The maximum disease index (72.2%) was observed on late sown (09th and 24th November, 2013) crop whereas, the minimum disease index (29.9%) was observed on timely sown (25st October, 2013) crop. High incidence of staghead (55.6%) was recorded in 24th November sown crop. High relative humidity during the growing season, due to frequent rain, favoured the high incidence and rapid spread of the disease. No significant correlation was

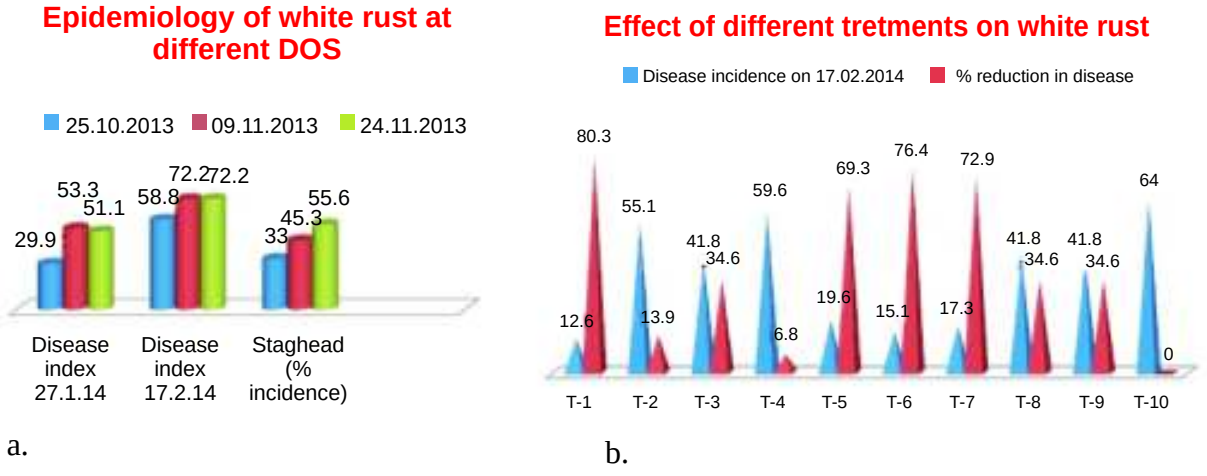


Fig.2.17.a. Effect of dates of sowing on white rust disease index, b. Percent reduction in white rust disease index with different treatments.

observed between the soil moisture and disease index (Fig. 2.17a). For effective management of white rust with minimum use of chemical fungicides, ten treatments involving PGPR, new generation fungicides and neem based product alone and in different combinations were tested. The maximum (80.3%) reduction in disease index was observed within T1 (seed treatment with metalaxyl 35 @ 6g/kg seed + foliar spray of metalaxyl 8% + mancozeb 64% @ 0.2% followed by T6 (seed treatment with metalaxyl 35 @ 6g/kg seed + foliar spray of tebuconazole @ 0.1% and T7 (seed treatment with metalaxyl 35 @ 6g/kg seed + foliar spray of carbendazim @ 0.1%. Foliar spray of carbendazim was found least effective in controlling the disease followed by quintal (iprodione+carbendazim) @ 0.2%. *Pseudomonas fluorescence* and *Bacillus subtillis* were at par in controlling the disease (41.8% disease reduction) (Fig.2.17b).

A total 21 entries of rapeseed-mustard under advance varietal trial were sown in augmented design for screening against white rust in paired row of 3 m length with 30 cm x 10 cm spacing using 6 resistant and susceptible checks (Rohini, DLSC-1, EC-399299, EC-339000, EC-399301 and PHR-2). White rust inoculation was done twice 45 and 60 DAS to create disease pressure. Periodical observations on disease incidence were recorded after 90 and 105 days of sowing. None of *B. juncea* entry was found resistant to white rust**.** However, RTM-1355, TMB-29 and RTM-1351 of *Eruca sativa* and PT-2006-4 and RAUDT-10-33 of *B. rapa* var *toria* showd resistant reaction to white rust.

In order to standardize differential hosts for identification of A. candida races, 11 genotypes of rapeseed-mustard (EC-399301, Rohini, Basanti, PBR-97, EC-399299, DMH-1 Aravali, and RH-30 of *B. juncea;* PBC-9221 of *B. carinata;* GSL-1 of *B. napus* and EC-414293 of *B. rapa*) were sown in two sets of single row of 3 m length on 23rd October, 2013. Inoculation of two isolates of *Albugo candida* (BPR and HSR isolate) was done separately by spaying the zoospore suspension twice at 45 and 60 DAS. Reaction of genotypes to both the isolates was recorded twice at 90 and 105 DAS and disease index was calculated. Based on reaction of 11 rapeseed-mustard genotypes to HSR and BPR isolates of A. candida, Rohini, Basanti and RH-30 were categorized as primary differential. PBC-9221 (*B. carinata*) and GSL-1 (*B. napus*) showed resistant reaction to both the isolates.

2.7 Technology Assessment and Dissemination

DRMR TAD 2 : Participatory extension for dissemination of rapeseed-mustard technology

Project Leader : Ashok Kumar Sharma, Senior Scientist (Agril. Extension)

Associate : Vinod Kumar, Senior Scientist (Computer Application)

Cost of cultivation of mustard and returns thereof, level of adoption and constraints in adoption of recommended technologies

A survey was carried out to study the cost of cultivation of mustard and returns thereof, level of adoption and constraints in adoption of recommended technologies. For the purpose of the study, data were collected from 240 mustard growing farmers who participated in 5 days training programmes organized by DRMR during 2013-14 and sponsored by concerned ATMA/ Department of Agriculture. Respondents represented different villages of 4 districts of MP (Morena, Gwalior, Shivpuri and Bhind) and 4 districts of Rajasthan (Bharatpur, Karoli, SwaiMadhopur and Tonk).

The study was based on the primary as well as secondary data. The field data on input and output along with other required information were collected through pre-structured schedules and questionnaires by personal interview method, focussed group discussion, etc. Findings are based on the verbal expression and responses of the respondents. The secondary data on prices, wages, land use, etc. were collected from records and reports of different departments and Krishi Mandies.

Cost of cultivation of mustard

The study was undertaken to work out the cost of cultivation of mustard and returns from the resulted production of these crops. The study included only variable cost which incurred by the farmers in cultivation of the crop. The study reported that the overall average cost per hectare in mustard ranged from Rs. 23750 to 32500 where one irrigation was applied and from Rs. 27250 to 38500 where two irrigations were applied. Since majority of respondents were applying one irrigation in mustard, therefore, percent share of costs of different components were calculated accordingly. The study revealed that farmers applying one irrigation incurred maximum per cent of cost *i.e.* 21.5- 25.4 on ploughings which was Rs 6000-7000 per ha. It was observed that majority of respondents were practicing fallow mustard cropping system in the study area and to conserve the soil moisture and proper land preparation for sowing, they were doing about 6-10 ploughing and 3-5 planking that cost Rs 6300-7500/ha (about 23.1-26.5 per cent of the total cost).

The study reported that threshing was the second most important component which cost Rs 4000-5000/ha that shares about 15.4 to 16.9 per cent of the total cost of mustard cultivation followed by harvesting which cost Rs. 3500-4000 per hectare and shared 12.3 to 14.8 per cent of total cost of cultivation. The total cost shared by harvesting and threshing was 27.7 to 31.7 %. The high cost of threshing and harvesting was due to increased wages of labourers.

Applying irrigation for getting higher yield of mustard is an important technology intervention. There is recommendation of applying one or two irrigation depending of soil condition, water quality, temperature, *etc*. Applying one irrigation was costing Rs. 3500-6000 depending on availability of water in the area, which shared 14.8 to 18.5 per cent of the total cost. The study reported that cost of purchase of seed of mustard shared only 1.5-4.6 per cent of total cost. It was also reported that the farmers of the study area also incurred 9.8 to 12.7 per cent of the total cost on purchase of fertilizers. Respondents incurred Rs. 1800-3000 per hectare in miscellaneous items/labour for different operations like fertilizer applications/pesticides/packing/ transportations/carrying, *etc*.

Returns and income against the cost incurred in the production of mustard.

The study also showed the gross income, total

cost of cultivation, average yield, net income and input-output ratio per hectare of mustard crop. It was recorded that overall average yield of mustard per hectare in the study area was 1500-2000 kg/ha. The overall gross income (average value of production) came to Rs. 45000-60000 per hectare from mustard, while the overall average net income from mustard came to Rs. 20560-25310 per hectare. The study shows that the Benefit: Cost ratio of mustard was 1.8-1.9. When we calculate monthly income keeping in view of about 5 month crop of mustard, then it was only Rs. 4250-5500.

Study the adoption level of different recommended mustard technologies

An adoption scale was also used to collect the data from selected respondents (240) for 12 major cultivation practices *viz*. variety, field preparation, soil treatment, seed treatment, sowing time, seed rate & spacing, fertilizer management, irrigation management, weed management, pest management, disease management and harvesting & threshing. Score was assigned to each practice according to its importance. After assigning the scores to different adopted practices by the farmers, Adoption index were computed for selected 12 practices as mean per cent scores (MPS).

The study reported that adoption of time of sowing recommendation was maximum with 77.8 followed by irrigation practices (76.1 MPS). The adoption of improved varieties of mustard was also high (75.0 MPS). The level of adoption of fertilizer management (54.0 MPS), harvesting & threshing (52.3 MPS), seed rate & spacing (46.5 MPS) and seed treatment was medium. There was very low adoption in case of Weed management, soil treatment, field preparation, pest and disease management with 39.4, 17.5, 16.7, 15.5 and 12.6 to MPS, respectively.

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

The study (Table 2.15) also identified and prioritized the major constraints in mustard production with the farmers' participation, in order to provide farmers' feedback to the research and extension systems for taking corrective measures and enhance the mustard productivity. Respondents identified ten major constraints related to mustard production system and as per the intensity, the identified constraints were ranked.

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

From the present study, the ten major constraints were identified which are responsible for low productivity of mustard in the area. It has been observed that lack of knowledge about improved mustard production technology and ability to identify insect-pest and diseases and their management are the constraints which can be overcome by effective extension system which are to be easily accessible by the farmers. The extension system should communicate and transfer the technology effectively to the farmers through various extension educational techniques/ programmes, so that farmers keep themselves apprised about the improved mustard production technology.

Further, effective measures are needed by the Govt. and concerned agencies/ departments to make the required quality inputs available to the farmers in time at locally. Regarding the problem of non-availability of farm machinery and farm labourers, farmers are required to work on cooperative basis.

The research system should also come out with the effective technology suitable in rainfed condition, low water requirement, problematic saline and alkaline soil and water. Under this condition, the farmers of the area have limited option for the change in the cropping pattern replacing mustard, as the crop has low water requirement and can also tolerate the salinity and alkalinity of soil and water better than the other crops. In such a situation, it is imperative for the research system to speed up its programme for

Table 2.15. Prioritization of major Constraints perceived by respondents in production of mustard crop

Constraints	Rank
Lack of Knowledge about improved technology (New variety/balance fertilizers/ micronutrients/weed management, etc. & resources to access the required knowledge.	I
Non availability and inferior quality of required inputs in time (seeds, fertilizers, pesticides, insecticides, etc.)	II
Lack of soil moisture/irrigation facility/rainfall	III
Problems of insect-pest and diseases (Painted bug, Aphid, Sclerotinia, White rust, Termite,)	IV
Problems of weeds especially orobanchae	V
Problematic soil and water	VI
Lack of ability to identify attack/incidence of insect-pest and diseases imely, lack of knowledge of their management and unavailability of plant protection chemical sprayer in the local area	VII
Non-availability of farm machinery on hire and skilled farm labour in time	VIII
Problems of frost, fog, untimely rain, etc	IX
High cost (inputs, Labourers, etc.)	X

technology generation for this important problem of the mustard production system.

Participatory Varietal Selection and Evaluation (PVSE)

A number of improved mustard varieties have been developed by research stations for different agro climatic conditions and there is a need to communicate the production potential and performance of the developed and released varieties to the end users *i.e.* farmers. However, a survey conducted by ICAR-DRMR during 2013-14 showed that only 30 per cent farmers were using varieties of public sectors. Majority of farmers reported that they didn't have access to or information about the new varieties released by the public sectors. Many farmers were using other varieties of low yields or they use the same varieties for many years because of a lack of awareness and confidence in recently released improved varieties. The extension workers of State Department of Agriculture have the prime responsibility of educating and motivating the farmers about adoption of improved and latest released varieties. Therefore, it is essential that extension workers have the complete knowledge and confidence in varieties developed by research stations.

Keeping in view of this, an on-station Participatory Varietal Selection and Evaluation (PVSE) programmes were conducted at ICAR-DRMR during Jan.-Feb. 2015 with 120 extension workers of Rajasthan and Uttar Pradesh who participated in the training programmes organized by ICAR-DRMR.

Extension workers evaluated 10 Indian mustard varieties for grain yield and other agronomic characteristics in researcher-managed demonstration/trials at ICAR-DRMR during 2014-15 to identify best performing high-yielding varieties for dissemination to farmers. Extension workers were asked to rate the varieties on 0 to 10 scale for minimum to maximum on characteristics like number of branches/plant, number of pod/branch, number of seed/pod, oppressed siliquae, bold seeded, tolerance to frost, dwarfness of plant, tolerance to disease and pests, *etc*. On the basis of evaluation and scoring, RH- 749 (78 MPS) DRMRIJ-31 (76 MPS), NRCDR-02 (74), NRCHB-101 (73 MPS), RH-406 (71 MPS) were most preferred by the participating extension workers.

DRMR CA-1: Development of Application Software for Rapeseed-Mustard Information Management

Project Leader : Vinod Kumar, Senior Scientist (Computer Application)

Associate : Ashok Kumar Sharma, Senior Scientist (Agril. Extension)

Designed and developed web-based bibliography information system (RMBiblio), offer researchers easy and fast access of most comprehensive resource for research articles in rapeseed-mustard disease research. System supports a wide range of publication types, and has features like advanced search option, extraction of publications statistics based on a variety of visual form based queries, *etc*. Metadata formats suitable for describing scientific publications have been used in creating

the database. Sophisticated and versatile searching facility has been implemented using MySql full text search options, the rows returned are automatically sorted with the highest relevance first. HTML, CSS, was used for development of user interface; PHP is the middleware and MySql for the backend.

Externally Funded Projects

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

Under this project the major activities carried out were testing a 20 rapeseed-mustard varieties including 5 new, 2 VCK, and 13 Farmers Varieties. In addition, 115 rapeseed mustard varieties were maintained through appropriate mating system.

ICAR seed project on Seed Production in Agricultural Crops

Project Leader : V.V. Singh, Principal Scientist (Plant Breeding)

Associates : Ashok Kumar Sharma, Sr. Scientist (Ag. Extn.) and Bhagirath Ram (In charge Farm).

Seed Production : 90 q foundation seed of wheat and 290 q certified & 36.9 q TL seed of mustard varieties was produced. It also includes 136.3 q certified seed of mustard varieties NRCDR 02 & NRCHB 101 which was produced at farmer's field under participatory mode.

Farmers training programme : A two days farmers training programme on Seed Production techniques during 23-24 Jan, 2015 was organised under ICAR seed project. Progressive farmers Alwar district participated in the training programme. The farmer's trainees were given theoretical as well as practical training on various aspects of seed production by experts in the field. Farmers also visited seed production fields of DRMR. Total 34 farmers participated in the programme. Besides, a two days tribal farmers training programme on Seed Production technology during 4-5 Feb, 2015 was organised under TSP component of ICAR seed project. Tribal farmers from Pratapgarh district of southern Rajasthan participated in the training programme.

BRL II trials of transgenic mustard hybrid DMH 11

In this activity BRL II trials of transgenic mustard hybrid DMH 11 at Ludhiana, Bathinda and New Delhi were coordinated and monitored.

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

Project Leader: Dr. Ashok Kumar Sharma, Sr. Scientist, (Ag. Extension)

During 2014-15, Five hundred FLDs on rapeseed-mustard and 20 trainings of extension workers/input dealers were approved by Department of Cooperation, Ministry of

Agriculture, Govt. of India for ICAR-DRMR. The 500 FLDs were conducted through different AICRPRM centers across the country. The 18 training programme of extension workers on "Scientific production technology of rapeseed-mustard" were organized by ICAR-DRMR wherein 353 extension workers of State Department of Agriculture representing five districts of Rajasthan, one Madhya Pradesh and 4 districts of Uttar Pradesh participated. Two training programmes were conducted for 30 input dealers of Bharatpur district of Rajasthan.

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

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

Associates : B.K. Singh, Scientist (Biotechnology), V.V. Singh, Principal Scientist (Genetics & Plant Breeding)

Phenotyping of advance recombinant inbred lines (RILs)

Phenotyping of F_6 population of RILs (Rohini × PHR-2) for Alternaria blight tolerance was done during 2013-2014 at ICAR-DRMR, Bharatpur and RAU, Pusa, Dholi in augmented design with 44 entries per block. At Bharatpur, the Alternaria blight disease pressure was low to moderate. At RAU, Pusa, Dholi, the Alternaria blight disease incidence in infector row (YS-66-197-3) was 60 and 65% on leaves and pods, respectively. Based on modified 0–9 scale (Conn *et al.*, 1990), 22 recombinant inbred lines numbering 17, 18, 20, 22, 35, 41, 53, 55, 60, 71, 73, 77, 82, 89, 92, 116, 131, 146, 158, 233, 239 and 268 showed resistant reaction to Alternaria blight.

Performance of 8 promising inbred lines of crosses Rohini × RH-819 and Rohini × PBR-97, selected on the basis of drought related traits in F_5 generation, were evaluated for yield performance in F_6 generation under un-irrigated condition in augmented design at ICAR-DRMR, Bharatpur.

Table 2. 16. Alternaria blight reaction during 2013-14 at Dholi (RAU, Pusa)

Resistant inbred lines	PDI on leaves	PDI on pods	Resistant inbred lines	PDI on leaves	PDI on pods
17	10	4	77	10	4
18	5	0	82	10	5
20	10	0	89	10	5
22	10	4	92	10	5
35	10	4	116	10	5
41	10	5	131	10	4
53	10	4	146	10	5
55	10	4	158	10	5
60	10	4	233	10	5
71	10	5	239	10	5
73	10	4	268	10	5

3 Transfer of Technology

17th Beej Pakhwada organized

The 17th Beej Pakhwada (Seed fortnight) was organized during Sept. 20 – Oct 5, 2014 at DRMR. The seed of 8 improved varieties (RH-749, NRCDR-02, NRCHB-101, RH-406, RH-0119, Bio-902, Rohini, Uravashi) and one hybrid (NRCHB-506) was sold to the farmers on first-

come-first-serve basis. About 418 quintal seeds of 8 improved varieties of Indian mustard amounting Rs. 26.37 lakh was sold to nearly 6000 farmers of Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Jharkhand, *etc*.

Front line demonstrations (FLDs) on mustard conducted.

Ninety five frontline demonstrations (FLDs) on three components *viz*; varietal (55), thio urea (10), sulphur through SSP (30) were laid out in

different villages of Bharatpur district of Rajasthan during the crop season 2013-14 to show the impact and production potential of these technological components on farmers' field and for effective transfer of mustard production technologies. Improved varieties NRCDR-02 and NRCHB-101 had yield advantage of 9.6 and 8.9 per cent, respectively over other varieties. The average yield of both improved varieties was 1882 kg/ha against the other varieties (1721 kg/ha) with additional net monetary return (ANMR) of Rs 5975 /ha.The highest average yield increase *i.e*. 13.2 % was recorded from use of thio urea component demonstrations. The average yield of improved plot was 1938 kg/ha against 1712 kg/ha of farmers' plot. The additional net monetary return was Rs 6884/ ha in response to additional cost of Rs. 800/ha for the demonstrations. The average yield of improved plot with sulphur application through SSP was 1915 kg/ha against average yield of 1730 kg/ha recorded from farmers plot with yield advantage of 10.7 percent. The component gave Rs 6290/ ha additional net monetary return in response to no additional cost involved in replacement of fertilizer combinations. During 2014-15, 100 FLDs on varietal and sulphur components in Indian mustard were conducted in different villages of Bharatpur district of Rajasthan with newly released varieties viz., RH 749, DRMRIJ 31 and NRCDR 02. These FLDs were conducted and organized by Dr. Ashok Kumar Sharma Sr. Scietist and I/c, TAD, unit. Regular monitoring visit and scientists-farmers meetings were organized for motivating the farmers.

DRMR- All India Radio Linkage Programme

Keeping in view of increasing popularity and feedback from farming community about DRMR's popular transfer of technology programme through All India Radio under the name of Sarson School on AIR (Radio Krishi Shiksha Programme), DRMR extended the coverage of this programme by signing MoUs with 10 different All India Radio stations for broadcasting this programme through AIR stations of Jaipur, Alwar, Kota, Sawai Madhopur,

Suratgarh & Jhalawar of Rajasthan; Gwalior of Madhya Pradesh; Agra, Mathura, and Rampur of Uttar Pradesh during Sept., 2014 to Feb., 2015 for popularization and dissemination of rapeseed-mustard production technology among the farmers in a timely manner. The 24 instructional modules of different aspects of mustard production were developed which were broadcasted coinciding with the different stages of crop growth of mustard at weekly intervals from September 2014 to February 2015 through 10 All India Radio (Akashvani) stations, that benefitted to thousands of farmers of Rajasthan and parts of Uttar Pradesh and Madhya Pradesh. The programme provided timely advice about various advanced production practices that created confidence for adoption of improved technology among the farmers. The programme was designed, organized and coordinated by Dr. Ashok Kumar Sharma, Sr. Scientist as Nodal Officer. Dr. Dhiraj Singh, Director, ICAR-DRMR urged the farmers to regularly listen the programme for upgrading their knowledge and provide the feed back to the Directorate for making more effective and farmer friendly.

Exhibitions organized

DRMR organized 5 exhibitions displaying scientific technologies of rapeseed- mustard, research and development activities of DRMR. More than 3000 farmers, farm women, extension personnel and students were educated through

these exhibitions organized at Dr. KN Modi University, Niwai (Tonk) during May 1-3, 2014; Deen Dayal Dham Mela, Mathura (UP) during Sept 20-22, 2014; CAZARI, Jodhpur on Sept. 24, 2014; CSWRI, Avikanagar on Nov. 12, 2014 and DOR, Hyderabad during Jan. 18-19, 2015. Visitors were also provided literatures on scientific cultivation of rapeseed-mustard.

Visitor Advisory Service

Under Visitor Advisory Service, successfully organized/ coordinated 40 interaction meetings and counselling sessions on rapeseed-mustard cultivation for visiting groups from Rajasthan, Uttar Pradesh, Madhya Pradesh and Gujarat consisting of 1442 stakeholders including 1201 farmers, 139 farm women, 72 students and 30 extension personnel/teachers. The visiting groups were educated/trained through lectures, visits to technology park, experimental fields, museum and also provided literatures. Besides, other visiting farmers were also provided timely technical advice to their problems in mustard cultivation.

e-publication for promoting scientific cultivation of mustard.

Keeping in view the several advantages of e-Publication, ICAR-DRMR designed and developed 6 "e-Bulletins for e-Learning Extension Module for mustard cultivation" on different aspects of scientific cultivation of mustard for rapid and wide spread of the technology through the use of ICT. These e-publications were prepared, designed and developed on "Agronomic management practices in rapeseed-mustard crop", "Improved varieties of rapeseed-mustard", Weed management in rapeseed-mustard ", Nutrient management in rapeseed-mustard crop", Insect management in rapeseed-mustard" and " Disease management in rapeseed-mustard ".

Sarson Field Schools organized

ICAR-DRMR organized successfully 5 Sarson Farm schools in five adopted villages namely, Dhor, Sinpini, Neotha, Gudawali and Seorawali of Bharatpur districts of Rajasthan for effective transfer of mustard production technology to the

targeted farmers during Oct. 2014-March 2015. These schools were organized for empowering farmers with knowledge and skills about use of scientific production technology of rapeseed-mustard, making farmers experts in their own fields, sharpening the farmers' ability to make critical and informed decisions and helping farmers learn how to organize themselves and their communities through demonstrations of improved components of mustard and regular visits/ interaction meetings with farmers during different crop stages in the selected villages. Dr. Ashok Kumar Sharma, Sr. Scientist organized and coordinated these 5 farm schools as Nodal Officer. Farm schools provided opportunities for learning by doing. The scientists, as a technically competent persons led group members through the hands-on exercises. The farmers learnt optimally from field observation and experimentation. In regular sessions, from sowing till harvest, groups of farmers observed and discussed the growth of crop, integrated nutrient management, integrated insect-pest and disease management practices, weed management, abiotic stress management, *etc*.

Impact of farm School : The farm schools are playing important role in enhancing the knowledge of the farmers and motivating them to adopt the improved technology. Since the Directorate has been organizing the farm schools in different villages for last 3 years, therefore. The impact of Sarson Farm School was also studied through pre and post knowledge and adoption test based on 120 respondents (15 respondents from each of the Farm Schools) participated in 8 farm schools organized in different districts of Bharatpur during 2012-2013 which shows that there was knowledge improvement from 30 to 75 per cent for different aspects, while improvement in adoption level of recommended technologies was 20 to 60 per cent.

Farmers Interest Groups (FIGs) organized

Farmers' organizations of all types have an important role in agriculture development. Keeping in view, ICAR-DRMR has been continuously working for formation of crop based Farmers Interest Groups (FIGs) and 4 FIGs comprising more than 25 farmers each in 4 selected villages namely Dhor, Sinpini, Gudawali and Seorawali-Saharai. Farmers were made aware about importance of scientific cultivation in mustard production through lectures, discussion and consultations by the scientists during crop season and motivated them for adoption of scientific recommendation of mustard cultivation. The technology introduced to the farmers through the training and lectures were also demonstrated to them in their own village through technology demonstration plot.

21st Sarson Vigyan Mela organized

ICAR-DRMR in collaboration with Department of Agriculture, Govt. of Rajasthan organized 21st Sarson Vigyan Mela sponsored under NMOOP for three days during Feb. 24-26, 2015 at ICAR-DRMR. Inaugurating the mela, Sh. Shiv Singh Bhont, Mayor of Bharatpur emphasized to adopt mixed farming for increasing income and

reducing the risk. Dr. Dhiraj Singh, Director, DRMR, while addressing the farmers, farmwomen, extension personnel participating in mela, stressed for the need of better linkages among all institutions/agencies working for agriculture development and technology dissemination for effective and rapid transfer of technology. He also reminded about wide yield gap of rapeseed-mustard in different states and urged farmers to come forward for adoption of scientific technology enhancing oilseed production for making the country self-sufficient in the edible oilseeds. About 25 exhibitions stalls were put by different departments/ research institutes, input dealers, *etc*. for educating the visiting farmers about their technology, products, *etc*.

The winners of crop competition, kisan Prashnotharies, progressive farmers were also felicitated in mela. More than 3500 farmers, farm women, extension workers, *etc*. from Rajasthan, Uttar Pradesh, Haryana and Madhya Pradesh participated in the mela. Dr. Amar Singh, In Charge, KVK, Kumher, Sh. R.B. Srivastav, Joint Director, Agriculture, Bharatpur division; Sh. Yogesh Sharma, Deputy Divisional Director (NHM); Sh. Deshraj Singh, DD, Agriculture (Bharatpur) also addressed the participants of mela. The mustard crop competition, kisan gosthies, visit of experimental field, exhibitions, *etc*. were also organized on all the three days. The valedictory function was graced by Sh. Shital Sharma, additional Director (NMOOP), Department of Agriculture, Govt. of Rajasthan as chief guest. He appreciated the efforts of ICAR-DRMR for technology dissemination by organizing number of effective extension programmes to reach out to large number of the farming community.

4 Training and Capacity Building

Education and Training

Trainings imparted

Name of the Student	Name of the Guide	Topic
Ms Richa Singh	Dr Dhiraj Singh, Director, DRMR	Validation and molecular marker At 5g 211560 of white rust resistance *loci* in Indian mustard
Ms Beena Verma	Dr Dhiraj Singh, Director, DRMR	Molecular characterization of double low quality lines of *Brassica juncea* using STMS markers
Mr Ram Lakhan	Dr Bhagirath Ram, Senior Scientist, Plant Breeding	Genetic variability and DNA isolation protocol in Indian mustard genotypes
Tanwar Singh	Dr B K Singh, Scientist, Biotechnology	Validation of molecular markers for resistance to white rust in Indian mustard
Ankur Saraswat	Dr Ajay Thakur, Scientist, Biotechnology	Molecular characterization and genetic diversity evaluation in Indian mustard varieties using SSR markers
Dolly Sharma	Dr B K Singh, Scientist, Biotechnology	Comparative physiological and molecular analysis of salinity tolerance in Indian Mustard

Trainings attended

Participants	Training Programme	Duration	Institute
Dr. Ibandalin Mawlong	Professional Attachment Training	August 27-November 27, 2014	NRCPB, New Delhi
Mr. M.S. Sujith Kumar	Professional Attachment Training	August 27-November 27, 2014	NRCPB, New Delhi
Dr Y P Singh	International Training on Pest Risk Analysis	September 1-September 5, 2014	National Institute of Plant Health Management, Hyderabad
Dr Era Vaidya	Winter School on "Strategies to enhance oilseed brassica production under climate and resource constraints scenario"	Nov 11-Dec 1, 2014	DRMR, Bharatpur
Mr. Prashant Yadav	Winter School on "Strategies to enhance oilseed brassica production under climate and resource constraints scenario"	Nov 11-Dec 1, 2014	DRMR, Bharatpur
Ms. Reema Rani	Winter School on "Strategies to enhance oilseed brassica production under climate and resource constraints scenario"	Nov 11-Dec 1, 2014	DRMR, Bharatpur

Participation in Conferences, Meetings, Seminars, Symposia and Workshops

Event	Venue	Period	Participant
Annual group meeting of National Seed Project (NSP)	SKUAT, Srinagar	April 25-26, 2014	K.H. Singh
3rd Mini workshop of TSP	ICAR-DRMR, Bharatpur	May 23-24, May 2014	A.K. Sharma
Annual Zonal workshop of KVK Zone VI	SDAU, SK Nagar, Gujarat	May 24-26, 2014	Pankaj Sharma
Review meeting of DRMR-NGOs Linkage Programme	ICAR-DRMR, Bharatpur	June 4, 2014	A.K. Sharma
Interface meeting of operationalization of distict contigent plan	Pant Krishi Bhawan, Jaipur	June 13, 2014	Pankaj Sharma
Orientation workshop on National Mission on Oilseed and Oil Palm (NMOOP)	SIAM, Durgapura Jaipur	June 20-21, 2014	Pankaj Sharma
21st Annual Group Meeting of AICRP-RM	BCKV, Kalyani, West Bengal	Aug 20-22, 2014	Y.P. Singh, V.V. Singh, K.H. Singh, B.K. Kandpal, P.K. Rai, O.P. Premi, Ashok Sharma, P.D. Meena, Vinod Kumar, Pankaj Sharma, S.S. Rathore, Arun Kumar, B.K. Singh, J. Nanjundan, Ibandalin Mawlong, M.S. Sujith kumar
District level Farmers-Scientist Interaction	ICAR-DRMR, Bharatpur	June 24-25, 2014	A.K. Sharma
EFC meeting of ICAR consortia platform on hybrid and molecular breeding	Krishi Bhawan, New Delhi	July 9, 2014	Dhiraj Singh, V V Singh, K H Singh, A K Thakur
Scientist-Farmers meet	Sikrori and Bartai village, Bharatpur	July 9, 2014	A.K. Sharma
Commission for Agriculture Cost and Prices	ICAR-DRMR, Bharatpur	July 18, 2014	A.K. Sharma

Meeting on transgenic mustard hybrid DMH 11 and collaborative research in biotic and abiotic stress management of rapeseed mustard through transgenic	Krishi Bhawan, New Delhi	July 24, 2014	V V Singh
Summer school on Exploitation of Heterosis in crops	GBPUAT, Pantnagar	Sept 18, 2014	K.H. Singh
Workshop on IARI-SAU/ICAR institutes collaborative National Extension Programme (NEP)	IARI, New Delhi	Oct 16, 2014	Pankaj Sharma
National symposium on Crop Improvement for Inclusive Sustainable Development	PAU, Ludhiana	Nov. 7-9, 2014	V V Singh
7th National Extension Education Congress-2014 on Translational Research-Extension for Sustainable Small Farm Development	Umiam, Meghalaya	Nov 8-9, 2014	A.K. Sharma, Vinod Kumar
Meeting on VISION 2014 and institute project	Krishi Bhawan, New Delhi	Nov 10, 2014	V V Singh
Workshop-cum-Review Meeting of NMOOP and NFSM for NE-states	Guwahati	Nov 10-11, 2014	A.K. Sharma, Vinod Kumar
National symposium on Plant health for sustainability in the field and horticultural crops at Citrus Research Station	Dr YSR Horticultural University, Tirupati	Nov 18-20, 2014	Pankaj Sharma
8th Review Meeting of ICAR-Network Project on Transgenics in Crops	NRCPB, New Delhi	Dec 2-3, 2014	Ajay Kumar

National conference on Environment: Ancient and Modern perspective	M.S.J. Govt. College, Bharatpur	Dec 4-6, 2014	Y.P. Singh
Talk on Genetic Improvement in Rapeseed-Mustard to Agricultural department employees of Madhya Pradesh	KVK, Morena	Dec 23, 2014	K.H. Singh
Review meeting of BRL-II trial	DUSC, New Delhi	Dec 23, 2014	V V Singh
Review workshop and Action Plan of KVKs Zone VI	MPUAT, Udaipur	Dec 24-25, 2014	Pankaj Sharma
National Workshop on Mustard	SIAM, Durgapura, Jaipur	Jan 5-6, 2015	S.S. Rathore
Meeting of state level standing committee of NMOOP	Pant Krishi Bhawan, Jaipur	Jan 7, 2015	V V Singh
Annual breeder seed review	Umiam, Meghalaya	Jan 7-8, 2015	K.H. Singh
National Seminar on Technologies for Enhancing Oilseeds Production through NMOOP	ICAR-DOR, Hyderabad	Jan 18-19, 2015	Arun Kumar, H.S. Meena, Ajay Kumar
International Conference on emerging trends in biotechnology and science with special reference to climate change	KVK Banasthali Vidyapeeth	Feb 18-20, 2015	Pankaj Sharma
National Seminar on Strategic interventions to enhance oilseeds production in India	ICAR-DRMR, Bharatpur	Feb 19-21, 2015	Y.P. Singh, V V Singh, K.H. Singh, O.P. Premi, P.D. Meena, Pankaj Sharma, Vinod Kumar, S.S. Rathore, H.S. Meena, Ajay Kumar, Ibandalin Mawlong, M.S. Sujith Kumar, Reema Rani

Workshop on Training needs assessment for HRD nodal officers of ICAR	ICAR-NAARM, Hyderabad	Feb 26, 2015	Ajay Kumar
3rd Rajasthan Science Congress	Manipal University, Jaipur	Feb 28-Mar 2, 2015	Pankaj Sharma
National Seminar on New frontiers in organic farming for sustainable development of Indian agriculture	RBS College, Agra	March 14, 2015	S.S. Rathore, Kapila Shekhawat
36th All India Rabi Seminar on oilseeds, oil trade and industry	Birla Auditorium, Jaipur	March 15, 2015	Pankaj Sharma

Workshop, Meetings, Seminars, Short Courses and Trainings Organized

Winter School

Winter school was organized on "Strategies to enhance oilseed Brassica production under

climate and resource constraint scenario", at DRMR, Bharatpur from November 11 to 1st December 2014. The winter school was designed to enhance knowledge base of participants in Oilseed Brassica production technologies, develop strategies to optimise genetic, physical and input resources for horizontal and vertical expansion in the country. The participants included scientists from ICAR, SAUs and KVKs involved in research, development and extension activities in oilseed crops.

Review Meeting on Innovation Action Plan (IAP)

The review meeting on Innovation Action Plan (IAP) was on 3rd December, 2014 under the Chairmanship of Director, ICAR-DRMR, Dr Dhiraj Singh. The chief guest of the meeting was Dr Sain Dass, Ex-Project Director, Directorate of Maize Research, New Delhi. Dr J.P. Singh, Professor and Ex- Head, Department of Soil Science, CCS HAU, Hisar was the expert member of the meeting. The meeting was attended by the entire DRMR staff, including the scientific, technical and supporting staff. This meeting was organized to get the feedback from the experts on the new concepts, innovations and ideas of the DRMR staff. Dr. Dhiraj Singh, Director, DRMR called up on the entire DRMR staff to gear up the performance with better speed and with greater transparency. He assured the house to provide the best facilities and environment to develop a sustainable work culture of innovation.

Scientist- Farmers Interaction meeting organized

DRMR organized 2 day district level Scientist-Farmers interaction meeting during 24-25 June 2014 sponsored by P.D., ATMA, Bharatpur. Inaugurating the programme, Director, DRMR, Dr. Dhiraj Singh said that farmers getting low farm income due to small land holdings, decreasing resources and low adoption of scientific agriculture technology. For livelihood security, the adoption of integrated farming model is the need of the hour. He urged the farmers to take horticulture, vegetable cultivation, animal husbandry along with conventional crops to increase farm income. Farmers should adopt the scientific technology to increase the crop productivity. He advised the farmers to use mustard straw in the field that will convert in organic manure and increase soil fertility. He urged the farmers to cooperate each others in farming activities in their village.

Sh. Yogesh Sharma, P.D., ATMA, Bharatpur said that participants of this interaction meeting should adopt the learned technology on their field first then motivate others to adopt the same. He also apprised about different programmers carried out by the ATMA for farmers. Sh. Deshraj Singh, Deputy Director, Agriculture, Bharatpur provided the knowledge of different schemes and activities of department of agriculture for the benefit of the farmers. He advised the participants to adopt organic farming and reduce the use of insecticides and chemicals in farming.

In interaction meeting, Dr. Amar Singh, In-charge, KVK, Kumher, Dr. Udaibhan Singh, In-charge, ARSS, Kumher, Dr. Mahesh Prajapati, veterinary doctor and scientists of DRMR delivered lectures on different aspects and participated in the meeting. A total of 34 progressive farmers of Bharatpur district participated in this 2 days interaction programme.

Organizing Model Training Course (MTC).

ICAR-DRMR successfully organized 2 Model Training Courses (MTC) during 2014-15 sponsored by Directorate of Extension, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi.

A MTC was organized on “Advances in Eco-friendly Management Practices for Sustainable Rabi Oilseed Production” during December 03-10, 2014" to refresh and upgrade the knowledge and skill of participants in advances in eco-friendly management practices for sustainable rabi oilseeds (rapeseed-mustard, safflower and linseed) production. A total of 20 officers of State Department of Agriculture from Chhattisgarh (1), Himachal Pradesh (2), Madhya Pradesh (1), Maharashtra (2), Odisha (3), Punjab (2), Rajasthan (6), Uttar Pradesh (2) participated in this MTC. The study of impact of MTC showed that there was 69.15% average improvement in knowledge of participants after the training. There were 90% trainees whose expectations from the course were fulfilled to a great extent as they found the course useful with respect to their role and responsibilities. The 80% participants rated the course as excellent, 20% as very good.

Another MTC was organized on “Modern perspectives of conservation agriculture for sustainable crop production” during January 28-Feb 04, 2015 to augment the participants' knowledge and skill on technical, organizational, institutional and economic aspects of conservation agriculture for sustainable crop production.

A total of 20 officers of State Department of Agriculture from Assam (4), Chhattisgarh (2), Himachal Pradesh (4), Madhya Pradesh (1), Odisha (2), Rajasthan (5), Uttar Pradesh (2) participated in this MTC. The study of impact of MTC showed that there was 91% average improvement in knowledge of participants after the training. There were 85% trainees whose expectations from the course were fulfilled to a great extent as they found the course useful with respect to their role and responsibilities. The

90% participants rated the course as excellent, 10% as very good.

Training programmes organized

Training programmes for extension personnel/officers

ICAR-DRMR took new initiative to organize 22 training programmes of 2 to 5 days duration on "Scientific production technology of rapeseed-mustard" for field level extension functionaries of States Department of Agriculture. A total of 460 extension personnel of Rajasthan, Madhya Pradesh and Uttar Pradesh were provided training for refreshing and upgrading the knowledge and skills about scientific technology of rapeseed-mustard.

Two days training programmes sponsored by DAC, New Delhi

ICAR-DRMR organized 18 two days training programmes on "Scientific production technology of rapeseed-mustard" for field level extension functionaries of State Department of Agriculture from 5 districts of Rajasthan, one district of Madhya Pradesh and 4 districts of Uttar Pradesh during 2014-15. These 18 training programmes were organized in 9 batches (2 training programmes simultaneously) during 2013-14. These training programmers were sponsored by DAC, MoA, Govt. of India under Annual Action Plan for Implementation of Frontline Demonstrations (FLDs) and other related activities on oilseeds during 2014-15.

Five days training programmes sponsored by State Institute of Agriculture Management (SIAM)

Keeping in view of importance of rapeseed-mustard crop for Uttar Pradesh, State Institute of Agriculture Management, Lucknow also realized the need of extensive training of extension personnel of Uttar Pradesh in scientific technology of rapeseed-mustard. Therefore, ICAR-DRMR also organized 4 training programmes of five days duration each for extension personnel from different districts of Uttar Pradesh sponsored by SIAM, Lucknow.

Dr. Ashok Kumar Sharma, Course Director, said that in 2 days training programmes, a total of 353 extension personnel including Agriculture Supervisor/Technical Assistant/Assistant Agriculture Officers/ATM/BTM from the selected districts namely Karoli (5-6 Sept.14 for 36 personnel), Bharatpur (10-11 Sept. 14 for 39 personnel), Dholpur (15-16 Sept.14 for 41 personnel), Alwar (22-23 Sept.14 for 38 personnel) and Sawai Madhopur (29-30 Sept.14 for 38 personnel) districts of Rajasthan; Morena (23-24 Dec.14 for 40 personnel) district of Madhya Pradesh; Aligarh & Mathura (16-17 Jan.15 for 40 personnel) and Agra & Firozabad (27-28 Jan.15 for 40 personnel) districts of Uttar Pradesh and Bharatpur (18-19 Feb. 15 for 41 personnel) were trained.

In five days training programmes, a total of 107 extension personnel from selected districts namely Firozabad, Mathura, Agra & Etah (9-13 Feb. 2015 for 31 personnel); Kasganj, Aligarh, Mainpuri & Etah (9-13 March 2015 for 28 personnel); Rampur, Muradabad, Sambhal, Amroha, Bijnor & Bulandshahar (16-20 March 2015 for 26 personnel) and Kanpur Nagar, Kanpur Dehat, Kannoj & Farukhabad (23-27 March 2015 for 22 personnel) districts of Uttar Pradesh participated.

The participants were trained on recent advances in rapeseed-mustard technology, scientific agronomic practices, fertilizer management, varietal selection, insect-disease management, adoption process and extension approaches, *etc* through lectures-cum-discussion and practical-

cum-field visit sessions. Participants appreciated the efforts of ICAR-DRMR for upgrading the knowledge and skills about recent research developments in the field of rapeseed-mustard.

Training programme for Input dealers

Many extension studies reported that input dealers (seeds, pesticides, fertilizers, machinery etc) are also important source of information to the farmers. It is felt that input dealers need to be trained and made aware of the new technologies and developments in rapeseed-mustard cultivation so that they communicate the same to the farmers to come in their contacts. Therefore, ICAR-DRMR organized 2 training programmes on "Scientific cultivation of rapeseed-mustard" during 2-3 March 2015 sponsored by DAC, New Delhi, wherein 30 input dealers of Bharatpur district of Rajasthan participated.

Training programmes for Field Coordinators and SMSs of NGOs.

ICAR-DRMR organized two training programmes of 2 days on "Mustard production techniques and agriculture management". Training was organized during September 25-26, 2014 at ICAR-DRMR for field coordinators/ SMS/staff of different NGOs working in different districts of Rajasthan for transfer of agriculture technology among the farming community. The programme was sponsored by Centre for Micro-finance, Jaipur under Mahila Kisan Sashktikaran Pariyojna (MKSP). A total of 30 participants from 6 NGOs namely PRADAN, Dholpur; SRIJAN, Bundi; IBTADA, Alwar; G.D.S., Ajmer; Saheli Samiti, Dausa; and CmF participated in the programme. Another training programme was organized during Oct. 9-10, 2014 for Krishi Sakhi of SRIJAN (an NGO) Sponsored by SRIJAN, Dooni, Tonk (Raj). A total of 32 participants attended the programme (28 Krishi Sakhi and 4 staff of NGO). Training programmes covered basic agriculture, improved agronomic practices of mustard cultivation, integrated nutrient, irrigation, pest and disease management, organic method of pest control, extension approaches, etc.

Training programmes for farmers

ICAR-DRMR organized 3 capacity building programmes of 4 days duration each during 2014-15 wherein 60 farmers from different districts namely Gwalior (9-12 Dec. 2014 for 15 farmers), Datia (9-12 Dec. 2014 for 13 farmers) and Morena (13-16 March 2015 for 32 Farmers) Madhya Pradesh. Besides, a 2 days farmers' training programme was also organized under ICAR seed project during Jan 23-24, 2015, wherein 35 farmers from Alwar district of Rajasthan participated. These farmers were provided extensive training about scientific production technology of mustard and agriculture management through these programmes. These training programmes enhanced the knowledge level of farmers about scientific agronomic practices, integrated nutrient, disease-pest, weed management, improved varieties, seed production techniques in mustard, etc and motivated them to adopt the scientific recommendations. Participants were also given the opportunity to interact with other progressive farmers, visit of field and research experimental plot.

Farmers Training Programme on Seed Production Techniques

A two days farmers training programme on Seed Production techniques during 23-24 Jan, 2015 was organized under ICAR seed project. Progressive farmers from Alwar district participated in the training programme. The trainee farmers were given theoretical as well as practical training on various aspects of seed production by experts in the field. Farmers also visited seed production fields of DRMR. Total 34 farmers participated in the programme.

Tribal Farmers Training Programme on Seed Production Technology

A two day tribal farmers' training programme on Seed Production technology was conducted during 4-5 Feb, 2015 under TSP component of ICAR seed project. Tribal farmers from Pratapgarh district of southern Rajasthan participated in the training programme.

5 Awards and Recognitions

Mahindra India Agri Award

ICAR-Directoarte of Rapeseed-Mustard Research was conferred with first prize of

Mahindra Samriddhi Krishi Sansthan Samman 2015 in recognition of its contributions towards the betterment of rapeseed-mustard cultivation in India. Dr. Dhiraj Singh, Director, Directoarte of Rapeseed-Mustard Research received the award on behalf of the directorate from honourable minister of agriculture in a function hosted by Mahindra India in New Delhi on 25th February 2015.

Dr. Dhiraj Singh, Director ICAR-DRMR was honoured with **Lifetime Achievement award**

by the Indian Society of Genetics, Biotechnology Research and Development (ISGBRD), Banasthali for his contribution to rapeseed-mustard improvement in the country.

Dr. Ashok Kumar Sharma, Senior Scientist (Agricultural Extension) was conferred with **Best Scientist Award** of ICAR-DRMR, Bharatpur on the occasion of 21st Foundation Day of the directorate on 20th October, 2014 for his significant contributions in research, extension and overall growth of the ICAR-DRMR during the year 2013-14. He also received **Best Extension Professional Award** by Society of Extension Education, Agra for significant contribution in transfer of agriculture technology on the occasion of 7th National Extension Education Congress held at ICAR Research Complex, Umiam, Meghalaya during November 8-10, 2014.

Dr. Binay Kumar Singh, Scientist (Biotechnology) received **Young Scientist Award-2014** and **Best Oral Presentation** at National Conference on Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management (ECOBASM-2014) organized at Directorate of Rice Research, Hyderabad by Society for Scientific Development in Agriculture & Technology, Meerut (UP).

Dr. Pankaj Sharma won **Young Scientist Award** in the International Conference **at Banasthali Vidyapeeth during Feb 18-20, 2015.**

Dr. Vinod Kumar, Senior Scientist (Computer Applications) was awarded **Rajbhasha Utkrasth Seva Purskar** by the Town Official

Language Implementation Committee (TOLIC). The award was presented by Sh. R. K. Saluja, Chairman, TOLIC and Circle Head, Circle Office, Punjab National Bank (PNB) in the half

yearly meeting of committee held on June 11, 2014 at PNB, Bharatpur. Dr. Vinod also won **Third position in Extempore Speech** Competition organized by Town Official Language Implementation Committee (TOLIC), Bharatpur.

Following five scientists were conferred Fellow award by different societies:

Dr. Y.P. Singh, Principal Scientist (Entomology) **- Fellow Society for Biocontrol Advancement (FSBA), Bengaluru**

Dr. P.K. Rai, Principal Scientist (Plant Pathology) - Fellow Indian Society of Mycology and Plant pathology, Udaipur

Dr. V.V. Singh, Principal Scientist (Genetics and Plant Breeding) - Fellow Indian Society of Genetics and Plant Breeding, New Delhi.

Dr. Pankaj Sharma, Senior Scientist (Plant Pathology) - Fellow Indian Society of Plant Pathologists, PAU, Ludhiana

Dr. Binay Kumar Singh, Scientist (Biotechnology) - Fellow Society for Applied Biotechnology (FSAB)-2014 Krishnagiri, TN

Dr. Pankaj Sharma, Senior Scientist (Plant Pathology), Dr. Vinod Kumar, Senior Scientist (Computer Applications) and Mr. M.S. Sujith Kumar, Scientist (Biochemistry) received Best Poster awards in National Seminar on Strategic interventions to enhance oilseed production in India, organised by ICAR-Indian Institute of Oilseeds Research, Hyderabad at ICAR-DRMR, Bharatpur during February 19-21, 2015.

Dr. Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding) - Fellow Indian Society of

Genetics, Biotechnology Research and Development (ISGBRD), Banasthali

Promotion/Transfer of Staff

Name	New Position	From
Selection		
Dr. (Ms) Era Vaidya	Scientist (Biotechnology)	13-10-2014
Ms. Reema Rani	Scientist (Biotechnology)	13-10-2014
Mr. Prashant Yadav	Scientist (Biotechnology)	13-10-2014
Transfer		
Mr. Ajay kumar Tandon	Junior Account officer, ICAR-DRMR	12-11-2014
Mr. P.K. Tiwari	Finance and Account officer, ICAR-DRMR	10-12-2014
Mr. K.S. Tanwar	Finance and Accounts Officer, ICAR-CAZRI	20-10-2014
Promotion		
Dr. K.N. Meena	Senior Technical Officer	02-12-2014

6 Linkages and Collaborations

DRMR-NGOs Linkage program

ICAR-DRMR successfully implemented DRMR-NGOs Linkage program for rapeseed-mustard technology dissemination with 10 NGOs of Bharatpur district to reach large number of rapeseed-mustard farmers of the

district working with NGOs. A multi-pronged strategy involving frontline demonstrations, trainings, farmer-scientist interactions, farm schools, *kisan goshtis etc* was adopted in collaboration with NGOs to spread the awareness about improved technology of mustard and to ensure its adoption for achieving higher productivity during the period. A meeting to review the DRMR-NGOs Linkage Program for dissemination of scientific technology of rapeseed-mustard cultivation in Bharatpur was organized on June 4, 2014. Dr. Dhiraj Singh, Director, DRMR urged for better linkages and coordination among different departments/ agencies/NGOs working for the benefit of farmers through dissemination of improved agriculture technology. About 50 farmers and 10 NGOs representatives participated in the review meeting.

ICAR-DRMR-KVK Extension Program

Directorate successfully coordinated and implemented ICAR-DRMR-KVKs Extension Programme for transfer of technology and popularization of newly released varieties of Indian mustard during 2014-15. Under the programme, 10 KVKs at Bharatpur, Dholpur, Karoli, Navgaon (Alwar) and Dausa in Rajasthan; Mathura, Avagarh, Bichpuri in Uttar Pradesh and Morena and Shivpuri in MP conducted frontline demonstrations at the farmers' field.

ICAR-DRMR-IARI National Extension Programme

Demonstrations of Improved Varieties

Under the project, successfully conducted demonstrations on pearl millet and sorghum in *Kharif* 2014 and wheat, carrot, spanich, pea in *rabi* 2014-15 in different villages of Bharatpur and Dausa district of Rajasthan and Firozabad district of Uttar Pradesh. Under the project

farmers were also made aware about the importance of biogas unit for sustainable agriculture production. Participated in one day workshop of IARI National Extension Programme on Oct. 16, 2014. Progress report of ICAR-DRMR-IARI collaborative Program was presented. The work done by ICAR-DRMR was highly appreciated by all concerned. Besides, 3 demonstrations on improved varieties of carrot (Pusa Rudhira), spinach (Pusa Bharti) and pea (Pusa Pragati) were conducted at ICAR-DRMR farm during 2014-15 to show the production potential of these improved varieties to the visiting farmers, & extension personnel, participants of training programmes at DRMR. About 3000 farmers and farm women visited these demonstration.

Mustard Seed Production Mela organized

ICAR-DRMR, Bharatpur organized a Kisan Mela with a focus on seed production of mustard in collaboration with Pt. Deen Dayal Upadhyaya Pashu-Chikitsa Vigyan Vishwavidyalaya evam Gau Anusandhan Sansthan (DUVASU) at its Madhuri-Kund farm, Mathura on 3rd March 2015

sponsored by DAC under NMOOP with a financial assistance of Rs. 4.00 lakh. The production technologies of mustard, other Rabi crops and animal health improvement were exhibited by DRMR, DUVASU and KVK, Mathura. The mela was inaugurated by Dr. J. S. Sandhu, Deputy Director General (CS), ICAR. Dr. Sandhu said that it is imperative to attract youth towards agriculture with enhanced use of IT for faster and precise dissemination of technologies. Dignitaries at this occasion, asked farmers to adopt organic farming including conservation agriculture (zero tillage) with recycling of bio-resources including weeds, good quality manure with use of gobar gas/ bio-gas plants and solar pumps.

More than 1500 farmers including about 100 women from 4 major mustard growing states namely Haryana, MP, Rajasthan and UP participated in the mela along with scientists from DRMR, faculty of DUVASU, officials of UP State and officials from DAC, personnels from seed industry participated in the Mela. A publication entitled "Improved Agronomic Practices for Cultivation of Rapeseed–Mustard in India" brought out by DRMR, Bharatpur was released during the mela.

7 All India Coordinated Research Project on Rapeseed-Mustard

ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur successfully organized 21st Annual Group Meeting of AICRP on Rapeseed-Mustard during August 20-22, 2014 at Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. Prof. C. Kole, Vice-chancellor, BCKVV, Nadia, presided over the inaugural session. Dr. S.K.Datta, DDG (Crop Science) and Dr. B B. Singh, ADG (OP). New-Delhi graced the occasion as Chief guest and Guest of honour, respectively. Dr. Biswapati Mandal, Director of Research and Pro Vice-chancellor BCKV, Kalyani extended heartiest welcome to all the dignitaries, distinguished delegates, faculty members of BCKV, Kalyani, participants and media personnel.

Director, ICAR-DRMR, Dr. Dhiraj Singh presented the research highlights and the total scenario of rapeseed-mustard in different states of country. He informed that the overall weather situation was good for rapeseed-mustard cultivation in the country during 2013-14. The major highlights of the programme included promotion of 31(17.6 %) strains to advance stage of testing, production of 213.3 q breeder seed of 76 rapeseed-mustard varieties. Foliar spray of agro-chemicals (Urea 1%, KNO3 1%, Thio-urea 0.05%) increased the mustard productivity up to 40% over control. Many donor sources *viz*., DRMRMJA 35, PRE 2011-15, DRMR-100, RH-1230, RH 1239, BCS and NPC-18 for different abiotic/biotic stresses were identified. He also mentioned that foliar spray of 0.2% Mancozeb followed by 0.05% Hexaconazole 25EC was found most effective to control the Alternaria blight. A total of 493 FLD's on rapeseed (86) and mustard (407) were conducted in 67 districts across 15 states of the country. He informed that in general, all the action taken points made in previous annual group meeting were implemented.

Dr. B. B. Singh, ADG (OP), ICAR, New Delhi suggested to breed varieties of high harvest index for a breakthrough in rapeseed-mustard productivity. He also emphasized the need for re-structuring of plant ideotype and good agronomic management practices.

Dr. C. Kole, Chairman of the function in his inaugural address explained the contribution of Brassica research to basic sciences. He emphasized need for path breaking research to make country self sufficient in edible oil under changing climate scenario. He further emphasized inclusion of heat tolerance in breeding objectives, use of wild gene pool for resistance against biotic stress and genotyping and phenotyping of Brassica genes.

Dr. S. K. Datta, DDG (CS), ICAR, New Delhi thanked Dr. C. Kole, Vice- Chancellor, BCKV, Nadia for extending full support in holding 21st annual group meeting of AICRP-RM workers and welcomed more than 170 rapeseed - mustard researchers who have come from across the country. He mentioned that the productivity of West Bengal is low due to short winter, the short duration materials developed at different centres could be utilized for the purpose. He also complemented the SK Nagar Scientists for achieving the highest mustard productivity through GDM 4. He suggested biotechnological intervention, effective management of *Orobanche* and exploitation of Barnase barstar system in mustard hybrid development programme. He emphasized strong need for multi-disciplinary approach in research and extension activities to improve productivity of rapeseed-mustard crop in the country.

The eleven sessions including presentation of reports wherein all PIs presented the progress report of 2013-14 of their respective disciplines, technical programme formulation, technology dissemination and impact analyses, presentations in key areas and plenary were held during the meeting. Technical programmes for the year 2014-15 were also formulated for various disciplines.

In session on presentation in key areas, Dr. Premjit Singh, Director of Extension, CAU, Imphal, Dr. P R Verma, Ex. Professor, Plant Pathology, Saskatoon and Dr. Harvir Singh,

former Head and Professor, Plant Protection, DOR, Hyderabad presented at length deliberations on "scope and strategies to enhance rapeseed- mustard production in NEH region", "Advances in *Brassica* pathology research and plant protection", respectively.

Varietal Identification Committee under the Chairmanship of Dr B. B. Singh, Assistant Director General (Oilseed & Pulses), ICAR, considered proposals Indian mustard and of taramira and identified 3 varieties: Albeli, RGN 298 and RGN 303 of Indian mustard and RTM 1355 of taramira for release. 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. Harvir Singh, Ex. Head, Plant Protection, DOR, the meeting was successfully concluded on 22nd August, 2014.

The following actions were suggested for implementation:

1. All advanced varietal trials in which number of locations remained less than three due to rejection of data, shall be repeated during 2014-15
2. Looking the limited area under gobhi sarson and taramira, intial varietal trial in these crops should be formulated after every three years/ whenever promising material is developed.
3. A meeting of all stakeholders for formulation of guidelines to conduct the yield evaluation trials of salinity/alkalinity should be conducted.
4. Looking the possibilities of expansion of area under NEH region it was decided to formulate a separate zone as NEH region including Asom, Tripura, Manipur, Nagaland, Arunachal Pradesh and Meghalaya. Bihar, Orissa, West Bengal, Chhattisgarh, Jharkhand shall remain in zone V.
5. The conduct of hybrid evaluation trials at additional locations in zone II and III may be allowed to those private seed companies which are contributing hybrid entries in this trial.
6. All centres should make efforts for better coordination and linkages with State Departments of Agriculture for involving them in conducting FLDs for further dissemination of the improved technology to relatively large population of farmers.
7. Concerted efforts should be made to replace the older varieties of rapeseed- mustard with the recently released ones.
8. Technology used in FLDs should be clear and thoroughly described along with complete package and situations in the report for their further effective dissemination.

The following recommendations were made on the basis of multilocation experimentation at various AICRP-RM centres:

1. Foliar spray of agro-chemicals at 50% flowering+ 50%pod filling stage effectively mitigates the terminal drought stress and significantly increase the seed yield over control. The average increase in seed yield was 16.7% due to foliar spray of 1% urea, 21% due to 0.05% thiourea and 24.8% due to 1% KNO_3 at Zone II; 26.5% due to 1% urea, 33.10% due to 0.05% thiourea and 37.6% due to 1% KNO_3 at Zone III and 41.4% due to 1% urea, 52.0% due to 0.05% thiourea and 45.7% due to 1% KNO_3 at Zone V. The mean maximum ICBR (8.64) was recorded with foliar spray of KNO_3 followed by 0.05% thiourea (7.59) and 1% urea (6.28).

2. Dimethoate 30 EC@ 300g *a.i.*/ha or Imidacloprid 17.8 SL @ 20 g *a.i.*/ha was found effective against mustard aphid and recommended for its management.

3. Foliar spray of 0.2% Mancozeb at 45 DAS followed by 8% Metalaxyl + 0.2% Mancozeb at 60 DAS was found effective in controlling white rust.

8 Publications

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9 Research Programmes and Projects

Name of the Programme	Project Code	Leader/PI
Programme 1 : Genetic enhancement for stress tolerance in Indian mustard		**Dr. V V Singh**
Population improvement for high productivity and oil content in Indian mustard under normal and moisture stressed conditions	DRMR CI 10	Dr. V V Singh
Widening of gene pool in Brassicas through Interspecific and Intergeneric hybridization	DRMR CI - 12	Dr. Arun Kumar
Breeding for earliness and high temperature tolerance in Indian mustard	DRMR CI-14	Dr. Bhagirath Ram
Resynthesis of Indian mustard (Brassica juncea L. Czern. & Coss.) through Inter-specific hybridization	DRMR CI- 15	Dr. H S Meena
Programme 2 : Designer Brassica for oil quality		**Dr. V V Singh**
Breeding for quality traits in Indian mustard	DRMR CI- 13	Ms. Priyamedha
Proteomic studies in oilseed Brassica	DRMR B7	Dr. Ibandalin Mawlong
Screening of oilseed Brassica germplasm for value addition	DRMR B8	Mr. M S Sujith Kumar
Programme 3 : Breeding for yield and quality enhancement in rapeseed-mustard		**Dr. KH Singh**
Development of hybrids in Indian mustard	DRMR CI – 5:	Dr. K H Singh
Augmentation, Characterization, Evaluation, Rejuvenation and Maintenance of Rapeseed- Mustard Germplasm	DRMR CI6	Dr. J Nanjundan
Programme 4 : Biotechnological interventions to improve rapeseed-mustard productivity		**Dr. Ajay Thakur**
In vitro plant regeneration and genetic transformation of *Brassica juncea* L. Czern. & Coss. with an antifungal defensin gene	DRMR BT-1	Dr. A K Thakur
Genetic analysis of white rust resistance loci of Indian Mustard and their marker assisted introgression to some of the popular Indian cultivars	DRMR BT-3	Dr. B K Singh
Programme 5 : Enhancing resource use efficiency and abiotic stress management for resilient rapeseed-mustard production system		**Dr. B K Kandpal**
Enhancing soil resilience in Indian mustard based system through integrated crop management practices	DRMR CP-6	Dr. O P Premi
Evaluation and Standardization of RCT's for mustard based cropping systems under semi-arid conditions of Rajasthan	DRMR CP:11	Dr. Kapila Shekhawat

Characterization and classification of soil-site conditions to delineate rapeseed-mustard production zones	DRMR CP13	Dr B K Kandpal
Long-term fertility experiment to study changes in soil quality, mustard productivity and sustainability	DRMRCP-14	Dr S S Rathore
Efficient water management in *Brassica juncea*	DRMR CP15	Dr S S Rathore
Programme 6 : Management of biotic stresses in Indian mustard		**Dr. Y.P. Singh**
Biological control of major pests of *Brassicas* with special reference to mustard aphid	DRMR ENT-2	Dr Y P Singh
Pest-plant interaction of major pests of *Brassicas*	DRMR ENT-3	Dr Y P Singh
Management of *Sclerotinia* rot in Rapeseed-Mustard	DRMR PP-1	Dr Pankaj Sharma
Management of *Alternaria* Blight in Rapeseed-Mustard	DRMR-PP 3	Dr P D Meena
Epidemiology and management of white rust	DRMR PP-5	Dr P K Rai
Programme 7 : Technology assessment and dissemination		**Dr A K Sharma**
Development of application software for rapeseed-mustard information management	DRMR CA-1	Dr. Vinod Kumar
Participatory extension for dissemination of rapeseed-mustard technology	DRMR ECT – 4	Dr. AK Sharma

Externally funded projects

DRMR EA- 2	Characterization of rapeseed-mustard varieties for distinctness, uniformity and stability (DUS) testing	Dr. K.H. Singh
DRMR EA- 4	ICAR seed project on seed production in agricultural crops	Dr. V.V. Singh
DRMR EA- 7	Intellectual property management and transfer/ commercialization of agricultural technology scheme	Dr. K.H. Singh
DRMR EA -8	Gramin Krishi Mausam Sewa	Dr. B.K. Kandpal
DRMR NP- 2a	ICAR-NPTC: Development of aphid resistant transgenic Brassica	Dr. A.K. Thakur
DRMR NP- 2b	ICAR-NPTC: Brassica functional genomics for Alternaria blight and drought/ heat tolerance	Dr. P.K. Rai
DRMR NP- 5	Diagnosis and management of leaf spot diseases of field and horticultural crops	Dr. P.D. Meena
DRMR NMOOP-1	Frontline demonstrations and other related activities of Oilseeds	Dr. A.K. Sharma
Project code: SB/YS/LS-86/2014	Development of a core set of SSR markers for characterization of *Brassica juncea* varieties and germplasm.	Dr. A.K. Thakur

10 IRC and IMC Meetings

Institute Research Council meeting

ICAR-DRMR organized its 24th Institute Research Council (IRC) meeting on September 1-2, 2014, under the Chairmanship of the Director, DRMR. The scientists presented the research findings of the year 2013-14 and proposed technical program for 2014-15. The Chairman emphasized to strengthen IRC through in-house positive and constructive suggestions. The Chairman called up on all the scientists for building inter-disciplinary linkages and to make joint efforts for rapeseed-mustard research development in the country. The Chairman gave major thrust on two issues; one is to develop team work and second to accept inputs and suggestions from the fellow-colleagues. The scientists involved in the programs were asked to give their activity profile for the project. The Chairman advised to keep a uniform nomenclature for all the breeding material. The name should include the following information in the order of first DRMR name-year-specific trait-derivative. The material of population improvement for different component traits should be grown at one place for systematic study, which will be convenient for showcasing also. The Chairman suggested that all agronomists should take the seed of different varieties from the respective breeder to get precised results. All the pathologists of the Directorate were suggested to integrate along with the breeders in the programme for development of disease resistance in Indian mustard. The seed production programme should also be reflected in the IRC. A technology cafeteria should be planned where all tested technologies can be showcased. The Chairman congratulated all scientists for their good work and pointed out the pinches which need attention. The Chairman assured full support for the scientists and promised a constraint free working environment for good science and technology dissemination.

Institute Management Committee meeting

17th Institute Management Committee meeting was held on August 8, 2014 under the chairmanship of Dr. Dhiraj Singh, Director, DRMR. The committee discussed different agenda, small equipments and facilities required for the ongoing research and made suitable recommendations for approval of the council.

IMC	
Director, ICAR-DRMR, Bharatpur	Chairman
Joint Director of Agriculture, Deptt. of Agril., Govt. of Rajasthan, Bharatpur	Member
Joint Director of Agriculture (Oilseeds), Deptt. of Agril., Govt. of Madhya Pradesh, Bhopal	Member
Dr Swarup Singh, Director, Rajasthan Agriculture research Institute, Durgapura, Jaipur (Raj.)	Member
Dr A N Sharma, Principal Scientist, DSR, Indo re	Member
Dr A L Singh, Principal Scientist, DGR, Junagarh	Member
Dr Arjun Lal, Head (Germplasm Exchange), NBPGR, Pusa, New Delhi	Member
Dr B D Sharma, Principal Scientist (Soil Chemistry/ Fertility), CIAH, Bikaner	Member
Dr B B Singh, ADG (O&P), ICAR, New Delhi	Member
Sh. Mohan Singh, Finance and Accounts Officer, NRC-PB, New Delhi	Member
Sh. Harbhan Singh, Vill- Daurda, Bharatpur	Member
Sh. Ramesh Yadav, Vill - Paharsar, Bharatpur	Member
Sh. Karan Singh Tanwar	Special invitee
Sh. Shitanshu Kumar, Adminisrative Officer, DRMR, Bharatpur	Member Secretary

11

Tribal Sub-Plan

ICAR-DRMR implemented Tribal Sub-Plan during 2014-15 for augmenting rapeseed-mustard production for sustainable livelihood security of tribal farmers in collaboration with CAU, Imphal (Manipur), BAU, Kanke (Ranchi), AAU, Jorhat (Assam) and RVSKVV, Gwalior (MP). The activities like participatory varietal selection/demonstrations and capacity building of tribal farmers and farmwomen, organizing field days/*kisan diwas*, on and off-campus trainings, distribution of small farm implements, construction of water harvesting ponds, establishment of beehives, publication of extension literature, *etc* were undertaken in the jurisdiction area of respective universities for the benefit of selected tribal farmers.

Organized 3rd TSP Mini Workshop

ICAR-DRMR organized 3rd TSP Mini Workshop on "Augmenting Rapeseed-Mustard Production of Tribal Farmers for Sustainable Livelihood Security under Tribal Sub Plan" at DRMR during 23-24 May 2014. The 2 days workshop was attended by Dr. R. P. Singh, Director of Extension, BAU, Ranchi; Dr. M. Premjeet Singh, Director of Extension, CAU, Imphal; Dr. Shobna Gupta, Deputy Director, Extension, RVSKVV, Gwalior; Dr. Mrinal Saikia, Principal Scientist, Director of Research, AAU, Jorhat along with other team members working in TSP programme of respective universities, besides DRMR scientists and staff.

Dr. Dhiraj Singh, Director, DRMR, inaugurated the workshop on May 23, 2014. He emphasized on the effective planning and execution of Tribal Sub Plan for technology dissemination to the farm families of tribal community for their sustainable livelihood. He also presented "Strategies for enhancing rapeseed-mustard production and productivity in tribal areas", in which he briefed about the status of area, production and productivity of rapeseed-mustard in Jharkhand, Madhya Pradesh and North Eastern states of India dominating the tribal farmers. Dr. Ashok Kumar Sharma, Sr. Scientist & Nodal Officer, TSP gave a presentation on "Tribal Sub Plan: Role of DRMR" giving an overview about the genesis, components, basic aims and objectives of TSP. Thereafter, the progress reports of TSP made during 2013-14 were presented by Nodal Officers/ Team leaders of the respective collaborative universities. The 11 point programme of TSP was also discussed.

An interaction meeting with participants on "how to implement TSP programme effectively" was held on May 24, 2014. Thereafter, Annual Plan for TSP 2014-15 was presented by respective universities and after thorough discussion, MoUs of all 4 participating universities were finalized for implementation of TSP programme during 2014-15 with a total budget outlay of 37.39 lakh. The Workshop was concluded with the following remarks by the Director, DRMR

- The activities under the TSP are for the tribal farmers benefit; hence the focus should be to outreach the tribal areas with all good efforts.
- The burning of straws should be discouraged due to environmental issues by standardizing the practice of broad casting the mustard in standing paddy field in relay cropping mode.
- The excess use of seeds should be avoided to maintain optimum plant population.
- In Madhya Pradesh and Jharkhand, toria should be replaced by high oil containing short duration and early maturing mustard. Even yellow seeded mustard can be introduced.

Exposure trip-cum- training organized

Three exposure-cum- training to ICAR-DRMR of 3 days duration each for capacity building of the 75 tribal farmers, farm women and 4 extension staff for dissemination of scientific technology of rapeseed-mustard among them were organized at ICAR-DRMR jointly with RVSKV, Gwalior (18-20 Dec 2014 for 30 tribal farmers of Jhabua district of MP); BAU, Ranchi (20-22 Jan. 2015 for 25 tribal farmers and 5 farm women of Lohardaga, Pashim Singhbhoomi, Purvi Singhbhoomi and Ranchi districts of

Jharkhand) and AAU, Jorhat (6-8 Feb. 2015 for 15 tribal farmers of Dhemaji and Karbi Along district of Assam) under the ICAR-DRMR Tribal Sub- Plan. Besides, one exposure trip-cum-training was also organized during Feb. 4-5, 2015 at ICAR-DRMR under ICAR Seed project, wherein 25 participants from tribal area of Udaipur district participated.

TSP activities carried out during 2014-15 by CAU, Imphal (Manipur)

ICAR-DRMR, Bharatpur and Directorate of Extension Education, Central Agricultural University, Imphal Manipur implemented a Project entitled" Augmenting Rapeseed-Mustard Production of Tribal Farmers of NE States for Sustainable Livelihood Security" in rice fallow during *rabi* 2014-15. Zero tillage cultivation of rapeseed-mustard was demonstrated in 1013 ha covering 9 (nine) districts of Manipur (Imphal East, Imphal West, Thoubal, Bishnupur, Churachandpur, Ukhrul, Chandel, Tamenglong, Senapati) and 2(two) districts of Arunachal Pradesh(Papum pare, East Siang) by using 3(three) rapeseed varieties, M-27, TS-36 and TS-38 and 2(two) varieties of yellow sarson, Ragini and YSH-401 and 1(one) variety of Indian Mustard, NRCHB-101. Altogether 1125 farmers across 11 districts of North Eastern Hill Region were involved in the project for On-Farm Demonstrations and participatory varietal selection trials. Under On-farm demonstration, no tillage (zero tillage) practice, use of organic pesticides, bio-pesticide, use of 4 bee colonies per hectare during crop

bloom and spray of botanical/organic pesticides without affecting pollinators population and to harvest organic honey were the components of demonstration for improving tribal farmers growing practices of rapeseed mustard. Under participatory varietal selection trials, rapeseed variety, TS – 38 gave average yield of 6.4 q/ha with wide variation of yield from lowest 3.2 to highest 12.8 q/ha. Similarly, rapeseed variety M-27 gave average yield of 6.6 q/ha (4 to 15.36 q/ha) and TS-36 gave average yield of 7.0 q/ha (3.3 to 9.6 q/ha). Yellow sarson variety Ragini gave average yield of 6.4 q/ha (3.5 to 13.24 q/ha) The Indian mustard variety NRCHB-101 gave the highest average yield of 9.6 q/ha (4.8 to 17.6 q/ha). During the period under report one Farmers Field Day was organized and about 306 farmers including 112 farm women from the project site participated in the Field Day and farmers' scientist interaction programme. Five numbers of animal drawn zero till seed drills were distributed at project site and 10 no. of water harvesting pond having the size of 15 m x 10m x 2 m were constructed at three different villages with 10 beneficiaries.

TSP Activities carried out during 2014-15 by RVSKVV, Gwalior (Madhya Pradesh)

ICAR-Directorate of Rapeseed-mustard Research, (DRMR), Bharatpur and Directorate of Extension services, Rajmata Vijayaraje Scindia Krishi Vishwavidyalay, Gwalior at Krishi Vigyan Kendra Jhabua implemented a Project entitled" Augmenting Rapeseed-Mustard Production of Tribal Farmers of Madhya Pradesh for Sustainable Livelihood Security" during rabi 2014-15. 200 Demonstrations were conducted in 200 hactare covering six blocks of Jhabua district *viz.*,Thadala (Morjhary, Bordy, Khawasa, Gularipada, Rojia) Rama (Vill. Jhumka, Baki, Sad, Padalghati, Lakhpura and Amba), Jhabua (Bisoli, Mokampura, Melpada,) and Ranapur (Vagaibadi, & Ban, Chayan, Samalkhedi), Meghnagar (Chotaguda) Petalabad (Mohankot) under TSP mustard project. Seed (Bharat Sarso-1), Urea, NPK (19:19:19), Carbendazim, Trizophos and Imidachloprid as critical inputs were provided to the beneficiaries. Sowing of all the demonstrations were completed in between

first fortnight of November and harvesting up to 25 March 2015. Average yield in the demonstration plots was 13.37 q/ha while in farmers field average yield was 11.06 q/ha. Yield of demonstration plot was higher by 28.01 percent as compared to farmers field. Maximum yield in the demonstration plot was 14.95 q/ha. Average B: C ratio generated in FLD's was 2.16 as against 1.92 in farmers' practices. During the period under report Three Farmers Field Day were organized and about 180 farmers including 36 farm women from the project site participated in the Field Day and three farmers' scientist interaction programme. Hundred numbers of sickle and khurpi were distributed at project site and 11 no. of grain storage box were distributed at six different blocks in villages with 11 beneficiaries.

TSP activities carried out during 2014-15 by AAU, Jorhat (Assam): Directorate of Rapeseed-Mustard Research, (DRMR), Bharatpur and Assam Agricultural University, Jorhat, Assam at two Regional Agricultural Research Stations, *viz.*, North Lakhimpur and Diphu, KarbiAnglong implemented a Project entitled" Augmenting Rapeseed-Mustard Production of Tribal Farmers of Assam for Sustainable Livelihood Security" during *rabi* 2014-15. Altogether 200 numbers of demonstrations has been carried out at two tribal dominated districts of Assam (*viz.*,Dhemaji and KarbiAnglong) and the programme has been completed as per the proposed work plan. 175 numbers of demonstrations were carried out at Dhemaji and 25 demonstrationswere carried at KarbiAnglong district. Out of 200 demonstrations, 75 hectares area covering 21 villages at Silapathar and Bongalmari blocks of Dhemaji district (vill:RekhaChapori, 3 no. Deurighat , MedhiPamuwa, Kanduli Mathura, PiyangChapori, sardarChuk, Kulajan, KachariPathar, Kulamuwa, DighaliChapori, Sitalmari, Borchelek, Dipugaon, Ayengiabali, Geluwa, TanganiMazgaon, Tantari, Bhotmara, Bongalmari) and 8 villages at East KarbiAnglong and West KarbiAnglong blocks of KarbiAnglong district (vill. Joporajan, Balipathar, Diliojen, Horihojan, Deopani, DonkaRongpigaon, Vomu Atar Donka, Hanthorgaonunder TSP mustard project. Toria seed (TS-36, Ts-38 and JT-90-1)), **Recommended dose of NPK (in the form of urea, SSP and MOP @ 87, 220, 25 kg/ha), Borax, Carbendazim, and chloropyriphos** as critical inputs were provided to the beneficiaries at both the districts. Sowing of all the demonstrations were completed in between second fortnight of November and harvesting was done up to 20 February 2015. Average yield in the demonstration plots were 11.50 q/ha while in the farmers field average yield were 6.80 q/ha. Yield of demonstration plot were higher by 40.87 percent as compared to farmers field. Maximum yield in the demonstration plot was 11.50 q/ha while minimum was 8.50 q/ha. Extension bulletin on production technology of rapeseed and mustard cultivation were distributed among the participating farmers. During the period under report three field days were organized and about 190 farmers including 50 farm women from the project site participated in the Field Day and one farmer's-scientist interaction with four on-farm training programme were conducted. Fifteen farmers (Dhemaji and KarbiAnglong) visited DRMR, Bharatpur from $6^{th} - 8^{th}$ February, 2015 where scientists from the institute imparted training on recent production technology of Rape and Mustard also visited field trials at DRMR, Bharatpur and later visited KVK, Kumher, Rajasthan.

TSP activities carried out during 2014-15 by BAU, Ranchi (Jharkhand): Birsa Agricultural University, Ranchi is one of the centre in the state of Jharkhand, where the project "Augmenting Rapeseed-Mustard Production of Tribal Farmers of Jharkhand for Sustainable Livelihood Security" is under operation since 2011. The basic objective of FLDs is to demonstrate improved proven technology of recently released, high yielding, bold seeded and disease resistant varieties. During *rabi* 2014-15, a total numbers of 855 On-farm demonstration on five varieties namely, NRCDR-02 NRCHB-101 and RH 749 were demonstrated in Ranchi, Lohardaga and East Singhbhum districts but in West Singhbhum only three varieties were demonstrated.

Demonstrations were conducted in 230 hactare covering 18 blocks of **Ranchi** (Kanke, Namkum, PiskaNagri, Ratu& Tamar), **Lohardaga** (Kisko, Bhandra, Lohardaga&Kairo), **West singhbhum** (Chakadharpur, Manjhgaon, Noamundi, Hatgamhgaria&Jagarnathpur), **East Singhbhum** (Musabani, Dhalbumgarh, Jamshedpur &Ghatsila) under TSP mustard project. Improved Seeds,**Urea and SSP** as critical inputs were provided to the beneficiaries. Sowing of all the demonstrations were completed in during November and December and harvesting up to March 2015. In all four districts mustard variety NRCDR-02 gave the highest average yield than all other varieties. Highest average yield was 13.90 q/ha, 13.30q/ha, 12.35q/ha and 11.87 q/ha in Ranchi, Lohardaga, East Singhbhum and West Singhbhum respectively. In three agro-climatic region of Jharkhand the result shows that variety NRCDR-02 (12.86 q/ha) was found to be superior. Also, an 50% extra yield was found in variety NRCDR-02 against local check. It is concluded that the mustard variety **NRCDR-02 (12.86 q/ha)** found superior over other mustard varieties viz**.** RH 749 (11.80 q/ha), NRCHB-101 (11.24 q/ha), Shivani (9.92 q/ha) and Pusa Bold (9.73q/ha).

The variety NRCHB-101 (11.24 q/ha) was also resulted good but, there was only 37% enhancement in yield against local check and was at par with variety Shivani (9.92q/ha) and Pusa Bold (9.73 q/ha).Among different mustard varieties, the highest gross return was observed in NRCDR-02 in all four districts which was Rs. 43090/ha, Rs. 40565/ha, Rs. 43225/ha and Rs. 35610/ha in Ranchi, Lohardaga, West Singhbhum and East Singhbhum respectively.

For wider dissemination of mustard production technology five filed days were organized in all four project districts. A total number of 367 farmers of 6 villages, namely, Tigra, Choubey Khatanga of Ranchi district, Koyla Toli of Lohardaga, Chitpil of West Singhbhum, Jamshedpur, Gorgora of East Singhbhum participated in field days.For technological backstopping to farmers seven On-farm training on mustard production technology were organized in all four districts. A total number of 368 farmers of 11 villagers attended the training programme.

The greatest limitation of Jharkhand agriculture is that the majority of the cultivable area remains fallow after Kharif due to lack of irrigation facilities. The improved varieties of rapeseed and mustard and other components of the package of practice introduced through TSP project during Rabi season have raised the hope of farmers for increasing their income and sustaining the livelihoods. It holds promise to bring big chunk of land under rapeseed and mustard and increase cropping intensity in the state of Jharkhand.

Monitoring of TSP and NEH component project : The activities carried out by Central Agricultural University, Imphal Manipur under TSP and NEH component projects being implemented in collaboration of ICAR-DRMR were monitored by Dr. Dhiraj Singh, Director, ICAR-DRMR; Dr. Bhagirath Ram, Sr. Scientis ,

ICAR-DRMR; Dr. M. Premjeet, Director of Extension, CAU, Manipur along with other team personnel visited during Feb. 10-11, 2015 the cluster demonstrations of yellow sarson (YSH 401) and Indian mustard (NRCHB 101) conducted at Thoubal and Andro districts of Manipur. The performance of rapeseed-mustard in the demonstrations was satisfactory. A Farmer's Field Day programme was also organized at Poiroupat, Imphal. A series of lectures were organized on improved cultivation practices of rapeseed-mustard and emphasis was given to use less quantity of seed for sowing and to adopt line sowing practices in the region.

12 Krishi Vigyan Kendra, Gunta-Bansur (Alwar)

On and off-campus trainings

Eighteen on campus trainings including six sponsored from ATMA, were organised at KVK on different aspects *viz*. improved production

and protection technologies for mustard, integrated nutrient management in wheat, termite and rat control in wheat. Total 600 farmers were benefitted by these trainings.

Thirty five off campus trainings were conducted in different villages to provide knowledge on different aspects of plant protection and animal nutrition. Through these trainings 1205 farmers were benefitted.

Front Line Demonstrations

During Kharif 2014, twenty FLDs in 8.0 ha area were conducted on cluster bean var. RGC 1003.

On an average 25.2% higher seed yield was obtained over local cultivar. Farmers liked this variety for short duration (85-90 d) and good yield. A field day was also organised on cluster bean.

In Rabi 2014-15, sixty FLDs were conducted on mustrad var. NRCDR-2, RH-749 and Giriraj covering 30 ha area in villages Babariya, Basai Naruka,Burja, Rampur,Chula and Bhupseda. Ten FLDs were also conducted on Wheat var. HD-3086 on 5 ha area in Bhupseda and Ramnagar villages .

Maximum and average yield in mustard varietiy NRCDR 2 (22.6, 19.5q), RH 749 (23, 20.1q), Giriraj (22, 19.2 q) while in local (Pioneer 15q) was recorded. Percentage increase in yield over local was 27-33.5. Farmers liked all three

varieites for their high number of pods, length of pod, number of seeds/siliquae and yield. Vegetative growth was high in RH 749 .

Other Demonstrations

For livestock health improvement 100 demonstrations of mineral mixture were distributed to fifty farmers in village Ratanpura. 5 demonstrations were conducted on bio-agent (Trichoderma) in chickpea at village Neemuchana covering 2.5 ha.

On Farm Trial (OFT)

Twenty on farm testing (OFT) on IPM, IDM, weed management and INM were conducted at farmer's field during rabi 2014-15. In mustard OFTs were taken on white rust, painted bug and Orobanchae management, while in wheat effect of balance fertilization and bioregulators for enhancing productivity were evaluated.

Exposure visit of farmers

Farmers from KVK Bansur area visited DRMR, Bharatpur and Madhuri Kund, Mathura on exposure visit during 21st Sarson Vigyan Mela and Seed production mela, respectively.

Scientific Advisory Committee (SAC) meeting

Second Scientific advisory committee (SAC) meeting was organized along with KVK Kotputli on 12 March 2015. The meeting was chaired by Dr. Madhuri Joshi , Dy-Director Extension Education, SKN Agriculture University, Jobner. The other guests were Dr Ashok Sharma (Director, RARI, Durgapura, Jaipur) Dr. Sudhesh Kumar Sharma (RARI, Durgapura), Dr. R.K.Bansal (Zonal Director Research, ARS, Navgaon).

Foundation day

4th Foundation day of KVK Bansur was organised on 28.3.2015. The Chief guest Dr. Dhiraj Singh, Director, DRMR, Bharatpur delivered Foundation day lecture and highlighted the mandates of the KVKs and also said that the establishment of this KVK will greatly improve the efficiency of the technology dissemination in the area.

Instructional farm

About 22.0 q seed of mustard var. NRCDR-2 was produced from 5.0 ha.

13 Distinguished Visitors

Name	Designation & Address	Date
Dr B L Jalali	Ex- Director Research,CCS HAU, Hisar	May 6,2014
Dr Deepak Pental	Ex- Vice-Chancellor, Delhi University	Sep 4, 2014
Dr Harvir Singh	Ex- Principal Scientist & Head Crop Protection, DOR, Hyderabad	Sep 4, 2014
Dr M L Jat	Senior Scientist, CIMMYT	Sep 4, 2014
Dr Asha Shivpuri	Ex- Professor & Head, Deptt. Of Plant Pathology, ARA, Durgapura	Sep 4, 2014
Mr. Summer Schwla	Wyoming, USA	Dec 1, 2014
Mr. J W Rancin	USA	Dec 1, 2014
Hoden Hergert	Thermopolis, Wyoming, USA	Dec 1, 2014
Saiqe Albert	Casper, Wyoming, USA	Dec 1, 2014
Justin Hesser	Cheyenne, Wyoming, USA	Dec 1, 2014
Karley Shepperson,	Casper, Wyoming, USA	Dec 1, 2014
Riley Hunter	Wheatland, Wyoming, USA	Dec 1, 2014
Brian Boner	Dorglas, Wyoming, USA	Dec 1, 2014
Cody Ann Bainfer	Chegenne, Wyoming, USA	Dec 1, 2014
Halus Lackwood	Chegenne, Wyoming, USA	Dec 1, 2014
Pierson B Hodgens	Meeteetse, Wyoming, USA	Dec 1, 2014
Cindy Weibel	Chegenne, Wyoming, USA	Dec 1, 2014
Dr Sain Dass	Ex- Director, Directortate of Maize Research, New Delhi	Dec 3, 2014
Dr J P Singh	Ex-Head Deptt of Soil Science, CCS HAU, Hisar	Dec 3, 2014
Dr. Arvind Kumar	Vice-Chancellor, RLBCAU, Jhansi & DDG (Education), ICAR, New Delhi	Feb. 19, 2015
Dr. D M Hegde	Ex- Project Director, IIOR, Hyderabad	Feb. 19,2015
Dr. K.S. Varaprasad,	Project Director, IIOR, Hyderabad	Feb. 19, 2015
Dr. S Ayyappan	Secretary (DARE) & Director General (ICAR),New Delhi	Feb 26, 2015
Dr. J S Sandhu	DDG Crop Science, ICAR, New Delhi	March 3, 2015

14 Personnel

Director's Office	
1	Dhiraj Singh, Director
2	Mrs. Veena Sharma , Personal Assistant
3	Lala Ram, Supporting staff (SSG III)
Scientific Staff	
Agriculture Knowledge Management Unit	
1	Vinod Kumar, Sr. Scientist (Computer Application in Agriculture)
AICRPRM Unit	
2	K.H.Singh, Principal Scientist (Genetics & Plant Breeding)
Crop Improvement	
3	V.V. Singh , Principal Scientist (Genetics & Plant Breeding)
4	Bhagirath Ram, Sr. Scientist (Genetics & Plant Breeding)
5	Arun Kumar, Sr. Scientist (Genetics & Cytogenetics)
6	H S Meena, Scientist, SS (Genetics and Plant Breeding)
7	J. Nanjundan, Scientist, SS (Genetics & Plant Breeding)
8	Priya Medha, Scientist (Genetics & Plant Breeding) on study leave
Natural Resource Management	
1	B.K. Kandpal, Principal Scientist (Agronomy)
2	O.P. Premi , Principal Scientist (Agronomy)
3	S.S. Rathore, Sr. Scientist (Agronomy)
4	Kapila Shekhawat, Scientist, SS (Agronomy)
Plant Protection	
1	Y.P. Singh , Principl Scientist (Agril. Entomology)
2	P.K. Rai , Principal Scientist (Plant Pathology)
3	P.D. Meena , Sr. Scientist (Plant Pathology)
4	Pankaj Sharma, Sr. Scientist (Plant Pathology)
Plant Biotechnology	
1	Ajay Kumar Thakur, Scientist SS (Plant Biotechnology)
2	Binay Kumar Singh, Scientist SS (Plant Biotechnology)
3	Era Vaidya, Scientist (Plant Biotechnology)
4	Prashant Yadav, Scientist (Plant Biotechnology)
5	Reema Rani, Scientist (Plant Biotechnology)
Plant Biochemistry	
1	Ibandalin Mawlong, Scientist (Plant Biochemistry)
2	M. S. Sujith Kumar, Scientist (Plant Biochemistry)
Technology Assessment & Dissemination	
1	A.K. Sharma, Sr. Scientist (Agricultural Extension)

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

Important Committees

Sl. No.	Committee	Members
1	Priority Setting, Monitoring and Evaluation (PME)	Dr. V.V. Singh, Principal Scientist (Nodal Officer), Dr. Pankaj Sharma, Sr. Scientist, Dr. Vinod Kumar, Sr. Scientist, Dr. Kapila Shekhawat, Scientist, Dr. Ibandalin Mawlong, Scientist, Mr. M.S. Sujith Kumar, Scientist
2	Results-Framework Document (RFD)	Dr. B.K. Kandpal, Principal Scientist/Dr. V.V. Singh, Principal Scientist (Nodal Officer), Dr. Vinod Kumar, Sr. Scientist (Co-Nodal Officer), Dr. Pankaj Sharma, Sr. Scientist, Dr. Ashok Sharma, Sr. Scientist, Dr. Kapila Shekhawat, Scientist, Mr. Shitanshu Kumar, AO, Mr. Sanjay Sharma, STO
3	Institute Technology Management Unit (ITMU)	Dr. Dhiraj Singh, Director (Ex-officio Chairman), Dr. K.H. Singh, Principal Scientist (Member Secretary), Dr. Archana Suman, Principal. Scientist, IARI, Dr. Arun Kumar, Sr. Scientist, Dr. H.S. Meena, Scientist, Dr. Binay Kumar Singh, Scientist, Dr. Kapila Shekhawat, Scientist
4	Institute Purchase Committee (IPC)	Dr. V. V. Singh, Principal Scientist (Chairman), Dr. Vinod Kumar, Sr. Scientist, Dr. B. K. Singh, Scientist, SS Mr. Shitanshu Kumar, AO, Mr. Karan Singh Tanwar, FAO
5	Institute Joint Staff Committee (IJSC)	Dr. Dhiraj Singh, Director (Chairman), Dr. K.H. Singh, Principal Scientist (Member Secretary), Mr. Mukesh Kumar (Member Secretary), Dr. Pankaj Sharma, Sr. Scientist, Dr. Vinod Kumar, Sr. Scientist, Dr. Kapila Shekhawat, Scientist, Mr. Shitanshu Kumar, AO, Mr. P.K. Tiwari, FAO, Mrs. Veena Sharma, PA, Mr. Govind Prasad, TA, Mr. R.C. Meena, TA, Mr. Lala Ram, TA, Mr. Tara Singh, TA
6	Institute Research Committee (IRC)	Dr. Dhiraj Singh, Director (Chairman) Dr. Kapila Shekhawat (Member Secretary) Scientists of ICAR-DRMR (Member)
7	Research Advisory Committee (RAC)	Dr. Deepak Pental, Ex.-VC, Delhi University (Chairman), Dr. Dhiraj Singh, Director Dr. B.K. Kandpal (Member Secretary) Dr. R.S. Malik, Ex-Principal Scientist, IARI, Dr. M.L. Jat, Programme Coordinator, CIMMYT, Dr. Harvir Singh, Ex-Principal Scientist, DOR, Dr. Asha Shivpuri, Professor and Head (Retd), RAU, Dr. J.P. Shrivastava, Professor, BHU, Dr. S.P.S. Karwasra, Ex-Director of Research, CCSHAU, Dr. B.B. Singh, ADG (OP), ICAR, Sh. Harbhan Singh (Non-official Member), Sh. Ramesh Yadav (Non-official Member)

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Panorama

On-Campus Women Training Program

DRMR organized on-campus women training program during 30th June to 5th July, 2014. The training was inaugurated by Dr Dhiraj Singh, Director, DRMR. Dr. Rupender Kaur, demonstrated various recipes of vegetables and meal preparation. She also discussed the importance of balanced diet and healthy ways of cooking to save the nutrients. Dr. A. K. Sharma and Dr. Kapila Shekhawat coordinated the event. More than 10 recipes were also demonstrated under different aspects of meal preparation.

Independence Day

68th Independence Day was celebrated in the Directorate. Dr. Dhiraj Singh, Director ICAR-DRMR hoisted the flag and delivered the Independence Day message. He spoke about the rich cultural heritage of our country and enlightened the audience with many less known facts about India.

Swachh Bharat Abhiyan

In compliance of "Swachh Bharat Abhiyan" of Hon'ble Prime-Minister, 'Swachta campaign' was inaugurated by Director, ICAR-Directorate of Rapeseed-Mustard Research on the birth anniversary of Mahatma Gandhi on 2nd October, 2014. On this occasion, Dr. Dhiraj Singh gave a presentation elaborating issues and aspects of the

campaign. Later, Director with all staff members performed the cleaning of Directorate premises. Cleaning of offices, laboratories, guest house, residential complex and farm area and outside Directorate premises was also performed on weekly basis. The farmers visiting the Directorate were also educated about the Swachta campaign in their daily life and agricultural operations. Various educational activities were organized for the children on the occasion of the Mass Movement of "Swachh Bharat" to bring awareness about cleanliness among them. More than 20 children of the DRMR staff participated in the activities, namely Drawing competition, Poem recitation, Essay writing and Debate/ Extempore with gaiety and fervour.

World Toilet Day

World Toilet Day was observed by the Directorate on Nov 10, 2014. On this occasion, Director ICAR-DRMR highlighted facts related with personal and public hygiene and its importance, diseases caused due to open defecation and challenges and issues before us. Dr. P.K. Rai, Principal Scientist gave an elaborate presentation highlighting different issues related to personal hygiene.

Foundation day

ICAR-DRMR celebrated its 21st Foundation day on October 20, 2014. Director, DRMR, in his foundation day lecture highlighted the journey of achievements and development of ICAR-DRMR ever since its inception and called upon the scientists for adoption of 20 point agenda and strive hard to bring more success to the Directorate. Dr Bhoori Singh and Dr. Fateh Singh, former Principal Scientist, DRMR were the other dignitaries present on the occasion. While addressing the gathering, they appreciated the excellent efforts of directorate being done for technology dissemination through different extension strategies especially capacity building of farmers and extension workers to upgrade their knowledge and skills in scientific cultivation of rapeseed-mustard that has contributed in increasing the productivity

level of rapeseed-mustard not only in Bharatpur district but in the country also. He congratulated the directorate for its association with hundreds of farmers directly and establishing the better linkages with all stakeholders which will be helpful in working for the development of farmers and motivate them to adopt the scientific production technology for enhancing their profitability. A brain storming sessions was also organized on developing Indian mustard cultivars with horizontal resistance against major diseases such as Alternaria blight, Sclerotinia rot, *etc*.

The Directorate also recognized the contributions from its staff during 2012-13 and presented awards in various categories of employees. The best scientist award was given to Dr. Ashok Kumar Sharma, Sr. Scientist, Sh. Govind Singh in the technical staff category, while Sh. Mukesh Kumar and Sh. Tara Singh were awarded in the administrative and supporting staff category, respectively.

Republic Day

The Directorate celebrated 66th Republic Day with great enthusiasm. Dr. Dhiraj Singh,

Director ICAR-DRMR did the honour of hoisting the National flag. Dr. Singh delivered the Republic Day message in which he encouraged everyone to contribute in all possible ways to the country's welfare.

National Seminar on "Strategic interventions to enhance oilseed production in India" organized

The National Seminar on "Strategic interventions to enhance oilseed production in India" was organized jointly by Indian Society for Oilseed Research, Hyderabad and ICAR-DRMR, Bharatpur, during Feb 19-21, 2015, at ICAR-DRMR, Bharatpur. Dr. Arvind Kumar, Vice-Chancellor, RLBCAU, Jhansi & DDG

(Education), ICAR, New Delhi inaugurated the seminar as chief guest. Dr. Singh, while delivering Dr. M.V. Rao Lecture on "Stakeholders access to oilseed technologies towards self sufficiency", said that increased availability of vegetable oils warrants the highest commitment of all stakeholders (farmers, scientists, policy makers, NGOs, KVK private sectors industry, *etc*.). There is urgent need to launch a special mission on oilseeds with greater accountability and commitment to boost the domestic production of vegetable oils in the country and thus minimize the dependency on imports. Dr. Dhiraj Singh, Director, DRMR, Bharatpur in his presentation dealt about the "Rapeseed mustard scenario: Future strategies for enhancing and productivity sustainability". He has presented overall status of Rapeseed and mustard in India at state and district level. He elaborated research status, achievements,

technologies generated and their dissemination. He also discussed about constraints and future prospects of the crop. Dr. K.S. Varaprasad, Project Director, IIOR, Hyderabad presented the "Interventions for enhancing oilseeds production in India". He demonstrated the area, production and yield of oilseed crops and share of different states in oilseed production. He suggested the strategies to enhance the area, productivity and resource use efficiency of oilseed crops.

The participants included majority of stake holders from India oilseed economy which covers the scientist working on different oilseed crops, progressive farmers, persons from oil mills, people from state department of agriculture, media personnel's, policy makers *etc*.

National Science Day

National Science Day was celebrated at ICAR-DRMR on 28th February, 2015 with great enthusiasm as one of the great science festival. The theme of the National Science Day for the year 2015 was "Science for Nation Building". Dr Dhiraj Singh, Director, DRMR delivered the Science day lecture to commemorate the invention of the Raman Effect in India by Sir Chandrasekhara Venkata Raman. He also discussed the activities, efforts and achievements in the field of science for human welfare. The lecture also spread a message about the significance of scientific applications in the daily life of the people.

Inauguration of Basic Science Complex at ICAR-DRMR

Dr. S. Ayyappan, Secretary DARE and DG, ICAR inaugurated the newly built Basic Science Complex at ICAR-DRMR, Bharatpur on 28th Feb., 2015. The basic science complex has marker assisted breeding and transgenic lab, besides physiology and bio chemistry laboratories. He also visited the experimental fields along with Director and scientists. During the interaction meeting held with the staff, Dr.

Ayyappan expressed his contentment for systematic layout of experimental plots and cleanliness of farm. A multi-disciplinary research team effort is needed to address the emerging challenges in the field of rapeseed-mustard and research programmes should address the concerns of farmers to remain relevant, he opined. Scientists should be able to advice farmers about the requisite changes to be brought about in the cropping pattern and cultural practices so that the effects of climate change are mitigated. The stress should be given to efficiently utilize the resources to improve productivity of rapeseed mustard and the quality of services. He appreciated the achievements of the directorate, especially for newly released varieties, seed production programme and technology dissemination through systematic linkages with state departments and effective extension approaches to reach out to large number of farmers that has built up the popularity of the directorate in the country. However, he expressed his concern over the huge import of edible oil and said that rapeseed-mustard crop plays a vital role in the oilseed economy of the country. He called for developing definite road map for the future research and make all out efforts for enhancing the productivity of this important oilseed crop. He advised the scientists to work in a national perspective and carry out focussed targeted research in mission mode approach for achieving self sufficiency in oilseeds production of the country.

Dr. Dhiraj Singh, Director, ICAR-DRMR

assured the Director General that the research work at the directorate will speed up with focusing on improving the production and productivity of rapeseed-mustard, increasing the quality of oil, improving the livelihood security of rapeseed-mustard farmers and to develop varieties of the crop suitable to diverse agro-climatic conditions and situations.

Visit by Dr. J. S. Sandhu, DDG (CS), ICAR-DRMR

Dr. J. S. Sandhu, Deputy Director General of the crop science Division of ICAR visited ICAR-DRMR on March 3, 2015. He visited experimental fields and appreciated the potential of newly released varieties especially RH-749. He also had an interaction with scientists and staff. He said that enhancing production, productivity and quality of rapeseed-mustard crops under climate changes should be the priority of the directorate. He emphasized to undertake the massive research work to address the wide spread problems of Orobanchae in rapeseed-mustard. He also mentioned about the vast scope for productivity improvement of rapeseed-mustard through conventional and biotechnological means. He stressed the importance of enhancing water use efficiency in attaining the targeted production of the crops. He said until and unless developed technology is reached to the farmers, there is no use of it in the laboratory. He expressed his happiness for splendid work done by the directorate for motivating the farmers of the country to adopt scientific production technology for enhancing the productivity through organizing a number of effective extension programmes. Dr. Sandhu, emphasizing the basic need of quality seeds for enhancing productivity, appreciated the joint initiatives taken by ICAR-DRMR, Bharatpur and DUVASU, Mathura to undertake massive seed production programme of new varieties, in over an area of about 100 acres, at the Madhurikund farm of DUVASU, Mathura.

Budget (Rs in lakhs)

Head	Plan		Non-Plan	
	Sanctioned	Utilized	Sanctioned	Utilized
DRMR	167.00	166.33	613.50	596.94
AICRPRM	904.00	902.34	-	-

Resource generation

Head of Account	Amount (Rs)
Sale of farm produce	2203050
Sale of tender forms	69300
License fee	218703
Analytical testing fee	97012
Others	113533
Income generated from internal resource generation schemes	
(a) Training	130000
(b) Guest House	374045
(c) Transport charges	136134
(d) DRMR	87501
(e) RTI	170
Total	**3429448**

16 Results-Framework Document (RFD) 2013-2014

Section 1: Vision, Mission, Objectives and Functions

Vision

Cost effective and eco-friendly rapeseed-mustard farming for edible oil pool.

Mission

Knowledge based crop management technology to stakeholders to enhance rapeseed-mustard productivity for oil quality and farmers' livelihood.

Objectives

1. Genetic enhancement and development of improved cultivars.
2. Development and Identification of appropriate crop production and protection technologies
3. Technology dissemination and capacity building.

Functions

Repository for 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 agro-production and protection technologies for different situation, generation of location specific interdisciplinary information based on multiplication testing and coordination, establishment of linkages and promotion of cooperation with national and international agencies and to extend technical expertise and consultancies.

Section 2: Inter-se priorities among Key Objectives, Success Indicators and Targets

S.No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent 100%	Very Good 90%	Good 80 %	Fair 70 %	Poor 60 %
1.	Genetic enhancement and development of improved cultivars	50	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	12	765	690	612	536	459
				Entries tested under multi-location trials	Number	5	155	140	124	109	93
				Lines identified for unique traits	Number	5	12	11	10	8	*7*
			Development of improved cultivars	Entries contributed for multi location trial	Number	5	105	95	84	74	63
				Varieties identified for release	number	5	5	4	3	2	1
			Seed production programme	Breeder seed produced	Tonnes	6	14.5	13.2	11.6	10.15	8.7
				Truthfully labeled seed produced	Tonnes	12	32.5	29.5	26	22.75	19.5
2	Development and Identification of appropriate crop production and protection technologies	21	Development of new technologies	New technologies tested	Number	11	9	8	7	6	5
				New technologies recommended	Number	10	4	3	**2**	**1**	**-**

3	Technology dissemination and capacity building	18	Demonstrations conducted	Front line demonstrations conducted	Number	10	590	531	472	413	354
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	8	7	6	5	4	3
	Efficient Functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On -time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013
			Timely submission of Results for RFD (2012-13)	On- time submission	Date	1	May 1, 2013	May 2, 2013	May 5, 2013	May 6, 2013	May 7, 2013
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for innovation	On -time submission	Date	2	July 30, 2013	August 10, 2013	August 20, 2013	August 30, 2013	September 10, 2013
	Improving internal efficiency/responsiveness/service delivery of Ministry/ Department	4	Implement Sevottam	Independent audit of implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3: Trend values of the Success Indicators

S.No	Objective	Action	Success indicator	Unit	Actual values for 2011-12	Actual values for 2012-13	Target value for 2013-14	Projected values for 2014-15	Projected values for 2015-16
1.	Genetic enhancement and development of improved cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	500	450	690	700	710
			Entries tested under multi-location trials	Number	175	109	140	142	145
			Lines identified for unique traits	Number	10	10	11	12	13
		Development of improved cultivars	Entries contributed for multi location trial	Number	83	122	95	97	100
			Varieties identified for release	Number	8	5	4	5	6
		Seed production programme	Breeder seed produced	Tonnes	15.2	13.2	13.2	13.3	13.4
			Truthfully labeled seed produced	Tonnes	40.2	27.3	29.5	30.0	31.0
2.	Identification of appropriate crop production and protection technologies	Development of new technologies	New technologies tested	Number	8	10	8	9	10
			New technologies recommended	Number	5	4	3	4	5
3.	Technology dissemination and capacity building	Demonstrations conducted	Front line demonstrations conducted	Number	568	537	531	545	555
		Farmers/ Extension officials training programmes organized	Trainings organized	Number	08	18	6	7	8

	Efficient Functioning of the RFD system	Timely submission of Draft RFD (2013-14) for approval	On -time submission	Date	-	-	May 16, 2013	-	-
		Timely submission of Results for RFD (2012-13)	On -time submission	Date	-	-	May 2, 2013	-	-
	Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
		Prepare an action plan for innovation	On -time submission	Date	-	-	August 10, 2013	-	-
	Improving internal efficiency/responsiveness/service delivery of Ministry/ Department	Implement Sevottam	Independent audit of implementation of Citizen's Charter	%	-	-	95	-	-
			Independent audit of implementation of public grievance redressal system	%	-	-	95	-	-

Section 4: Description and Definition of Success Indicators and Proposed Measurement Methodology

S.No.	Success indicator	Description	Definition	Measurement	General Comments
1.	Breeding and germplasm lines evaluated	Source material for the improved varieties to be evaluated	Material generated from the basic germplasm and new collections	Number of breeding lines/new germplasm evaluated	
2.	Entries tested under multi-location trials	Breeding lines tested in multilocational testing through AICRP (R-M)	Entries tested by various AICRP(R-M) centres	Number of entries tested	Number depends upon contribution by AICRP partners
3.	Lines identified for unique traits	Breeding lines identified for tolerance to biotic and abiotic stresses and other unique traits	Lines which posses novelty	Number of lines identified	
4.	Entries contributed for multi location trial	Breeding lines tested along with checks in multilocational yield trials through AICRP (R-M)	Entries contributed by various AICRP (R-M) centres	Number of entries contributed	Number depends upon contribution by AICRP(R-M) partners
5.	Varieties identified for release	Breeding lines tested along with checks in multilocational trials through AICRP (R-M) centres and best performing entries compared to checks are identified as new improved varieties for release	Best performing entries is identified	Number of entries/lines identified	
6.	Breeder seed produced	Produce from nucleus and breeder seed is the starting point in seed chain of producing quality seeds for farmers	Breeder seed is the starting point in seed which is multiplied/converted in the foundation/certified seed	Quantity produced (Quintals)	Quantity may vary as per indent from DAC

7.	Truthfully labeled seed produced	Production of truthful level seed of mustard	It is a kind of seed which meets certain standards	Quantity produced (Quintals)	Quantity may vary as per farmers demand
8.	New technologies tested	Certain technologies may be tested under different field conditions	Variety/Crop production and crop protection technology	Number	
9.	New technologies recommended	Certain technologies which are found suitable and economically viable under different field conditions are recommended	Variety/Crop production and crop protection technology	Number	
10.	Front line demonstrations conducted	Trials and demonstrations conducted for technology testing and proving the technology potential production	Frontline demonstration is the field demonstration conducted on farmers field under the close supervision of scientists	Number	Number may vary as per funding from DAC
11.	Trainings organized	Capacity building activities related to knowledge and skill improvement/ development programmes conducted for farmers, extension personnel, student.etc.	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for improving productivity of R&M	Number	Number depends upon funding from different departments

Section 5: Specific Performance Requirements from other Departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	Entries tested under multi-location trials	Testing of entries	Evaluation of entries under different conditions	Number of entries tested as per promotion and contribution by different centres	Less or more number of entries will be tested
State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	Lines identified for unique traits	Selection of unique lines	Identification of unique lines under different conditions	Number of lines identified for uniqness by different centres	Less or more number of lines will be identified
State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	Entries contributed for multi location trial	Contribution of entries	Contribution of entries for evaluation	Number of entries contributed by different centres	Less or more number of entries will be contributed

State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	Varieties identified for release	Identification of varieties for release	Identification of improved strains	Number of varieties identified for released as per proposal submitted by AICRP (R-M) centres	Less or more number of varieties will be released
Central Government	-	Departments	DAC	Breeder seed produced	Indent for quantity of breeder seed	Variety wise indent for breeder seed	Quantity of breeder seed is produced as per the indent	Less or more quantity of breeder seed will be produced
State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	New technologies tested	Testing of new technologies	Evaluation of new technologies under different conditions	Number of new technologies tested by different centres	Less or more number of technologies will be tested
State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	New technologies recommended	Recommendation of technology	Zone wise recommendation of technology	Number of crop production and crop protection technologies recommended	Less or more number of technologies will be recommended

State Government	Assam, Bihar, Jharkhnad, Gujarat, Haryana, Himachal Pradesh, J&K, M.P, Odisha, Punjab, Rajasthan, U.P, Uttarakhand, West Bengal, Chhattisgarh, Manipur, Maharastra	Universities	SAU of respective states	Front line demonstrations conducted	Conduction of Front line demonstrations	Variety and situation wise conduction of Front Line Demonstrations	Number of Front Line Demonstrations conducted	Less or more number of Front Line Demonstrations will be conducted

Section 6: Outcome/Impact of activities of Organization

S.No.	Outcome/impact of Organization	Jointly responsible for influencing this outcome/impact with the following departments/ ministry (ies)	Success indicators	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1.	Enhanced rapeseed-mustard productivity	SDA, DAC and SAUs	Increase in productivity	Percent	0.5	0.7	1	2	3
2.	Enhanced farmer's income	CACP, State Govt., Deptt. of Commerce	Improvement in farmers income	Percent	1	2	3	6	10

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institutes

Name of the Division: **Crop Science Division**

Name of the Institution: **Directorate of Rapeseed-Mustard Research, Sewar, Bharatpur**
RFD Nodal Officer of the RSC : **Dr. B.K.Kandpal**

S.N	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
1.	Genetic enhancement and development of improved cultivars	50	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	12	765	690	612	536	459	**735**	**96**	**11.52**	**106.5**	Availability of more germplasms from gene bank
				Entries tested under multi-location trials	Number	5	155	140	124	109	93	**177**	**100**	**5.0**	**126.4**	Breeding line with wide variation under multilocation trials during 2012-13 were repeated during the year.
				Lines identified for unique traits	Number	5	12	11	10	8	*7*	**11**	**90**	**4.5**	**100**	
			Development of improved cultivars	Entries contributed for multi location trial	Number	5	105	95	84	74	63	**140**	**100**	**5.0**	**147.4**	Re-evaluation of some breeding strains and more strains identified for multi-location trials from AICRP-RM centres.
				Varieties identified for release	Number	5	5	4	3	2	1	**4**	**90**	**4.5**	**100**	
			Seed production	Breeder seed produced	Tonnes	6	14.5	13.2	11.6	10.15	8.7	**21.12**	**100**	**6.0**	**160**	Cultivation of many recent

			programme													varieties in minimum viable area resulted more production of breeder seeds. In addition the production depends on indent from DAC and SAU's
				Truthfully labelled seed produced	Tonnes	12	32.5	29.5	26	22.75	19.5	**38.30**	**100**	**12.0**	**129.8**	Special efforts has been made to produce more TFL seed to ensure quality seed to farmers.
2	Development and Identification of appropriate crop production and protection technologies	21	Development of new technologies	New technologies tested	Number	11	9	8	7	6	5	**10**	**100**	**11.0**	**125**	Identification of more genotypes in AVT-I under normal sown conditions increased the number of technologies tested.
				New technologies recommended	Number	10	4	3	**2**	**1**	**-**	**7**	**100**	**10.0**	**233.3**	Wide variation in weed flora across the OSB production zones resulted into generation of 5 different location specific weed control recommendations.
3	Technology dissemination and capacity building	18	Demonstrations conducted	Frontline demonstrations conducted	Number	10	590	531	472	413	354	**597**	**100**	**10.0**	**112.4**	Additional FLDs conducted by KVK-Bansur

																(Alwar) of this Directorate surpassed the targets.
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	8	7	6	5	4	3	**19**	**100**	**8.0**	**316.7**	Extra efforts to train the farmers from non-traditional but potential areas under ATMA project resulted into 3-fold increase in target.
	Efficient Functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013	**May 4, 2013**	**100**	**2.0**	**100**	
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1, 2013	May 2, 2013	May 5, 2013	May 6, 2013	May 7, 2013	**April 27, 2013**	**100**	**1.0**	**100**	
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	**100**	**100**	**2.0**	**100**	
			Prepare an action plan for innovation	On-time submission	Date	2	July 30, 2013	Aug. 10, 2013	Aug. 20, 2013	Aug. 30, 2013	Sept. 10, 2013	**July 23, 2013**	**100**	**2.0**	**100**	
	Improving internal efficiency/responsiveness/service delivery of Ministry/ Department	4	Implement Sevottam	Independent audit of implementation of Citizen's Charter	%	2	100	95	90	85	80	**100**	**100**	**2.0**	**100**	
				Independent audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	**100**	**100**	**2.0**	**100**	

Procedure for computing the Weighted and Composite Score

Total Composite Score: 98.52

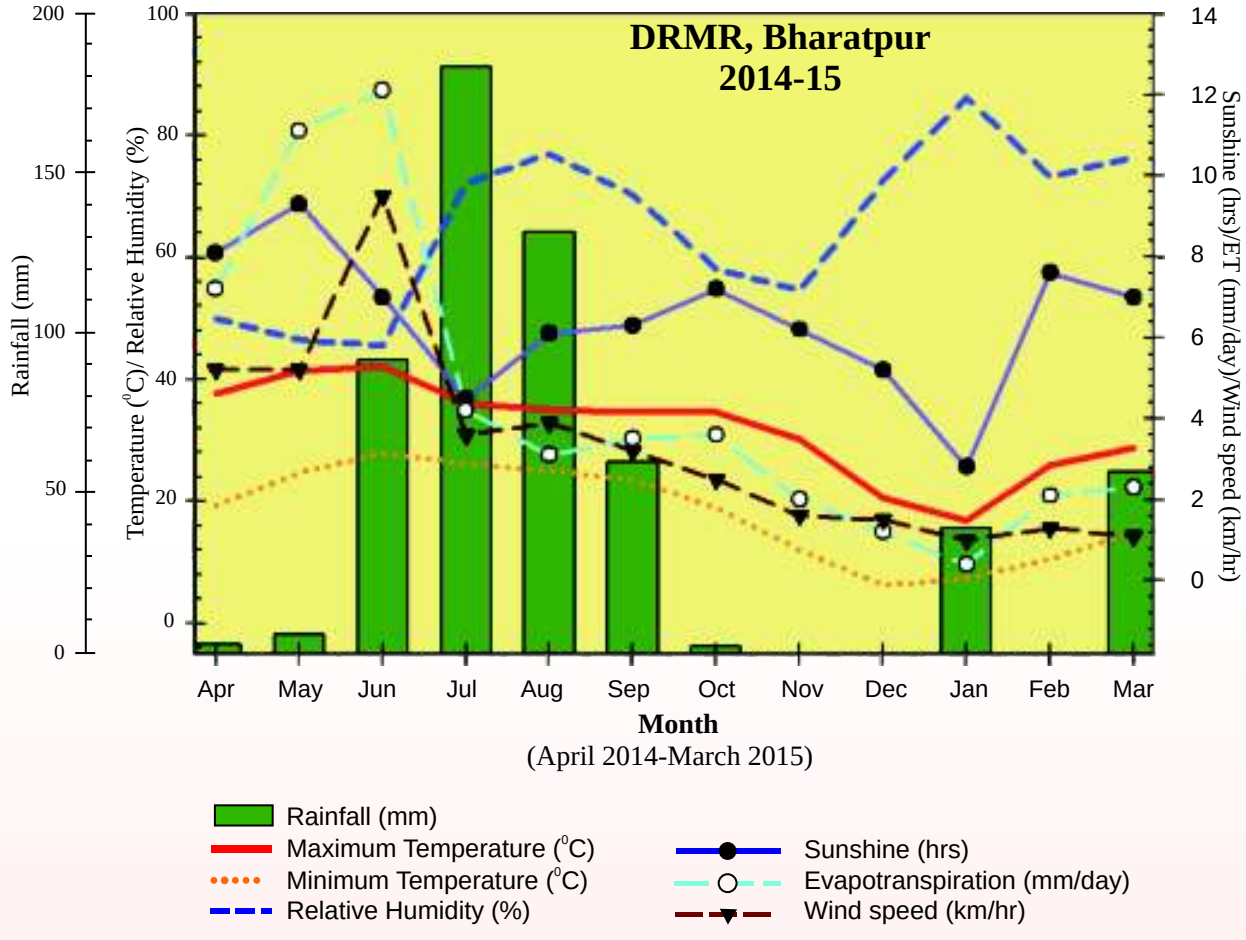
Rating : Excellent

1. **Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100**
2. **Total Composite Score = Sum of Weighted Scores of all the Success Indicators**

17 Meteorological Data

Overall it was a good monsoon year with total 574.4 mm of precipitation was received in 37 rainy days. The monsoon became active in last week of June and remained active throughout July, August and September. The monsoon withdrew in the last week of September leaving sufficient conserved moisture for subsequent mustard crop and 41.7 mm rainfall was received from Oct-Feb during crop season. But 57.0 mm rain fall occurred in the month of March at crop maturity and harvesting stage caused yield losses.

Throughout the cropping season the mean monthly temperature remained favorable for rapeseed-mustard production. However, minimum daily temperature reached <6.2°C during last week of Dec. 2014. The evaporation losses ranged from 0.4-12.1 mm/day during the year and 0.4-3.6 mm/day during *rabi* season. The average sunshine during crop season was 2.8-7.2 hours.



हर कदम, हर डगर
किसानों का हमसफर

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