ANNUAL REPORT

2013 - 14

भाकृअनुप
ICAR

Directorate of Rapeseed-Mustard Research

(Indian Council of Agricultural Research)

Sewar, Bharatpur 321 303 (Rajasthan) India

सरसों अनुसंधान निदेशालय
DRMR
1993
Directorate of Rapeseed-Mustard Research

ANNUAL REPORT
2013–14

Indian Council of Agricultural Research (ICAR) established 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 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.

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

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

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Sewar, Bharatpur-321 303 (Rajasthan), India

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MISSION

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

PREFACE

It gives me immense pleasure and satisfaction to present 21st annual report of the Directorate of Rapeseed-Mustard Research, embodying salient research achievements and development programmes carried out during the year 2013-14. DRMR developed a new high yielding variety "Giriraj (DRMRIJ 31)" of Indian mustard, which has been released for cultivation under timely sown irrigated conditions of Haryana and Rajasthan. Efforts continued to widen the gene pool through interspecific hybridization. Interspecific F_1 hybrids were synthesized through hybridization between *Brassica tournefortii* and *B. rapa* var. yellow *sarson*, resynthesizing *Brassica juncea* through hybridization between various genotypes of *B. rapa* and *B. nigra* and selecting promising plants from segregating generations. Nine Indian mustard strains were identified as thermo-tolerant at seedling stage on the basis of value of heat susceptibility index and yield stability ratio. 491 Indian mustard accessions were characterized for agro-morphological traits to develop core collection and trait specific gene pool for better utilization of genetic resources in breeding programmes. Fifteen independent putative transgenic events of *B. juncea* var. NRCDR 2 were developed with *TvD1* gene via *Agrobacterium tumefaciens*-mediated gene transfer technique. Intron polymorphic markers *At5g41560* and *At2g36360* were validated in two independent bi-parental F_2 populations.

Experiments on soil organic carbon and fertilizer management strategies suggested the combined adoption of mustard straw incorporation + Sesbania green manure and balance NPK which synergistically increased the seed yield. Evaluation of different resource conservation technologies over years revealed that tillage operations (RCTs) and cropping systems significantly influenced the seed yield, production efficiency and economics of mustard. The efficacy of hydrogel was found remunerative at different irrigation scheduling under micro sprinkler irrigation system. The investigations on epidemiology of Sclerotinia rot of Indian mustard revealed that carpogenic infection initiated in 52nd week and continued during 1-3 standard weeks. Total 30 *Alternaria brassicae* isolates were maintained at DRMR.Three DRMR's technologies *viz.*, NRCHB 101, NRCHB 506 and one "Voice Based e-Learning Extension Module for Mustard Cultivation", were licensed through signing MoU for commercialization. During Beej Pakhwara 384 q quality seed of mustard varieties was sold to farmers. A total of 24 instructional episodes were broadcasted through 7 All India Radio stations. Directorate of Rapeseed Mustard Research fetched second prize in 'Rajarshi Tandon Award (2012-13)' for the best official language implementation among the ICAR Institutes in the 'A and B' Region. Five 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; Prof. Swapan Kumar Datta, 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, S.S. Rathore and Lizo Thomas for their conscientious and determined efforts in compiling the programmes and achievements of the Directorate in the present form.

DRMR, Bharatpur
09 June, 2014

(Dhiraj Singh)
Director

ABBREVIATIONS

AAII	Average Aphid Infestation Index
AAO	Assistant Administration Officer
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
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
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
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
RRS	Regional Research Station
RVSKVV	Rajmata Vijayaraje Scindia krishi Vishwa Vidhyalaya
RWC	Relative Water Content
SAC	Space Applications Centre
SAU	State Agricultural University
SDAU	Sardar Dantiwarh Agricultural University
SGM	Sesbania Green Mannure
SKRAU	Swami Keshwanand Rajasthan Agricultural University
SOC	Soil Organic Carbon
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

- Giriraj (DRMRIJ 31), a high yielding variety of Indian mustard (*Brassica juncea* L) developed by DRMR was released for cultivation under irrigated timely sown conditions of zone II (Punjab, Haryana, parts of Rajasthan and Delhi).
- Three DRMR's technologies *viz.*, NRCHB 101 (a high yielding variety of Indian mustard, NRCHB 506 (a hybrid cultivar of Indian mustard) and one Voice Based e-Learning Extension Module for mustard cultivation", were licensed for commercialization with private seed production companies/professional societies.
- Fifteen independent putative transgenic events of *B. juncea* var. NRCDR-2 were developed with *TvD1* gene via *Agrobacterium tumefaciens*-mediated gene transfer technique
- Intron polymorphic markers *At5g41560* and *At2g36360* were validated in two independent bi-parental F_2 populations. Markers were found tightly linked to white rust resistance loci *AcB1-A4.1* and *AcB1-A5.1*, respectively.
- Interspecific hybrids were synthesized through hybridization between *Brassica tournefortii* (2n=20, TT) and *B. rapa* var. yellow *sarson* (NRCYS-05-02) (2n=20, AA).
- Indian mustard strains; BPR-349-9, Urvashi, BPR-541-2, BPR-605-40, Pusa Tarak (EJ9912-13), RGN-48, BPR-549-2, DRMR-729 and DRMR-1918 were identified as thermo-tolerant at seedling stage.
- 491 Indian mustard accessions were characterized for agro-morphological traits to develop core collection and trait specific gene pool in Indian mustard.
- The combined adoption of mustard straw incorporation + Sesbania green manure and balance NPK synergistically increased the seed yield.
- Evaluation of different resource conservation technologies over years revealed that tillage operations (RCTs) and cropping systems significantly influenced the seed yield, stover, biological yields, harvest index, production efficiency, oil content, oil productivity and economics of mustard.
- The efficacy of hydrogel was found remunerative when irrigation scheduling at 0.6 IW/CPE was supplemented with hydrogel.
- Twelve entries *viz.* DRMRIJ 05, JMM 927, RTM 1351, RTM 1359, RTM 314, TMB 29, RTM 2002, RTM 1212, TMB 2030, JMT 04-03, RTM 1355 and T 27 were found highly resistant having the AAII less than 1
- The epidemiology of Sclerotinia rot of Indian mustard (*Brassica juncea* L.) was investigated and the forecasting models were developed.
- Total 30 *Alternaria brassicae* isolates were maintained at DRMR.
- 151.8 q certified seed of wheat and 384 q TL seed of mustard varieties was produced.
- A total of 24 instructional episodes were broadcasted through 7 All India Radio stations.
- A total of 28 research papers, 30 extension folders, 62 popular articles, 5 technical bulletins, 4 books and 4 book chapters/ proceedings were published.
- Resources worth Rs 61.0 lakhs were generated.
- Directorate of Rapeseed Mustard Research was awarded the Second Prize in 'Rajarshi Tandon Award- 2012-13 for the best official language Implementation among the ICAR Institutes in the 'A and B' Region. Five scientists were awarded/recognised by different societies/organisations.

1 DRMR: An Overview

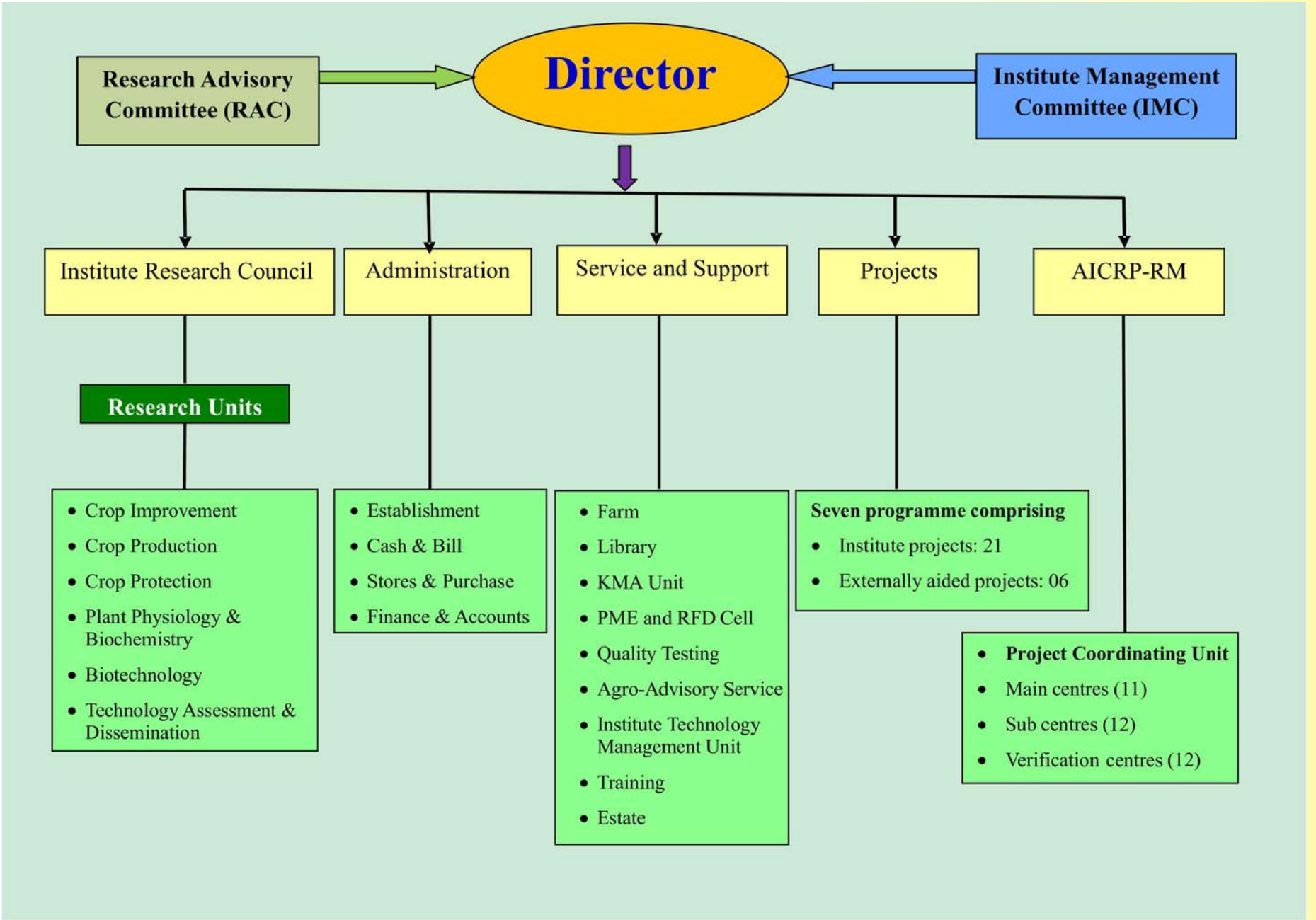
All India Coordinated Research Project on Oilseeds (AICRPO) was established at IARI, New Delhi in April 1967 for the improvement of oilseeds in the country. Setting up separate Project Coordinating Units for various crops during V Plan (1974-79) and on January 28, 1981 for Rapeseed-Mustard at Haryana 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 October 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 has been upgraded as Directorate of Rapeseed-Mustard Research (DRMR) in the XI Plan (2007-12) on Febuary 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 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


Research Advisory Committee (RAC)
Director
Institute Management Committee (IMC)
Institute Research Council
Administration
Service and Support
Projects
AICRP-RM
Research Units
• Crop Improvement
• Crop Production
• Crop Protection
• Plant Physiology & Biochemistry
• Biotechnology
• 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: 21
• Externally aided projects: 06
• Project Coordinating Unit
• Main centres (11)
• Sub centres (12)
• Verification centres (12)

2 Research Achievements

2.1 Genetic enhancement for stress tolerance in Indian mustard

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

Projcet 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)

Contribution and performance of entries in AICRP-RM trials

Seven promising entries have been inducted for multi location testing under AICRP-RM in different coordinated trials during 2013-14. Entry DRMR 150-35 (zone V, rainfed) is being evaluated under rainfed advanced varietal trial in zone V for second year. DRMR 10-40 of *B. juncea* was characterized as drought tolerant at 02 locations. DRMR 81 was identified as salinity tolerant and DRMR 302 recorded high oil content where as DRMR 1679 -100 was found promising for aphid tolerance.

Evaluation of promising entries in station/ advanced trials

In station trial check NRCHB 101 (2140 kg/ ha) recorded maximum yield. In another station trial entries BPR 1069-47 (2134 kg/ha), BPR 683-38 (2119 kg/ha) and BPR 675-39 (2110 kg /ha) performed better than the check RB 50 (2065 kg/ha). In station trial under rainfed conditions, check RH 819 (837 kg/ha) performed better than entries at Bharatpur and entries DRMR 675 -39 (1321 kg/ha) and DRMR 686-3 (1309 kg/ha) performed better than RB 50 (1241 kg/ha) at Jobner.

Evaluation of Half sib progenies for yield components (II selection cycle)

Observations were recorded for siliquae / plant, seed yield /plant, 1000 seed weight on a set of 150 half sib progenies developed for 2nd cycle of selection. Analysis of variance showed significant differences for all the three characters. Heritability was highest for siliquae / plant (66.9%) followed by seed yield/plant (61.6%) and 1000-seed weight (60%). Genetic advance expressed as % of mean was moderate for siliquae/plant and seed yield/plant (29.8% and 35.1 % respectively) while, it was low for 1000-seed weight (8.9%). 12 half sibs for seed yield /plant were selected.

Generation of breeding material

Five F_1s were advanced to F_2 generation. 120 full sib progenies having 30 male groups were developed as per crossing design of NCD 1.

Selection from segregating generations

More than 500 single plants were selected from five F_2 populations, out of them 200 single plant progenies were selected on the basis of 1000-seed weight (>5g) for generation advancement. Out of 361 F_3 single plant progenies, 105 individual plants were selected for generation advancement on the basis of phenotype, earliness, and seed weight. From F_4 generation 65 single plants/bulks were selected for next generation. Selection was made on the basis of phenotype and 1000-seed weight.

Observation nursery

Out of 150 advanced progenies grown in observation nursery along with checks (RB 50, RH 819, Kranti and NRCDR 2), progenies BPR-1187-166-47 (3085 kg/ha), BPR 587-51-111 (2978 kg/ha), BPR-671-60-117 (2879 kg/ha), BPR-645-49-110 (2624 kg/ha), BPR-2-132 (2589 kg/ha), BPR-670-41-105 (2482 kg/ha) recorded more than 10% higher plot yield than the best check (2163 kg/ha). Entries BPR 1191-2-6, BPR 1153-2-15, BPR 1153-1-19, BPR 1292-12-86, BPR 1293-18-91, BPR 1187-1-58 and BPR 671-58-115 were selected on the basis of seed yield.

Half sib progeny development programme

On the basis of phenotype and vigour 250 individual plants were selected from population grown in isolation for third cycle of half sib progeny selection for oil content.

Rainfed

Observation Nursery

Same set of observation nursery (150) was grown under rainfed conditions and promising entries BPR 1191-1-3, BPR 1153-2-13, BPR 1153-3-16, BPR 1153-3-17, BPR 1153-1-20, BPR 1187-2-57 and BPR 1-128 were selected on the basis of seed yield superiority over best check and drought susceptibility Index (DSI) values which were less than 0.5. On the basis of plot yield, progenies BPR 1195-1-1 (1524 kg/ha), BPR 1191-2-16 (1348 kg/ha), BPR 1191-1-7 (1329 kg/ha), BPR 1191-2-2 (1312 kg/ha) and BPR 1191-1-3 (1259 kg/ha) were selected. Genetic parameters were calculated for plant height, main shoot length, fruiting zone length, siliquae/plant, seeds/siliqua, harvest index, seed yield/plant and 1000- seed weight. GCV (36.5%), PCV (40.4%), Heritability (91.2%) and genetic advance (75.6%) were highest for seed yield /plant.

Four F_4 progenies; BPR 1678-268-50, BPR 1678-303, BPR 1678-306 and BPR 1680-327-54 and three F_5 progenies; BPR 1566-2-42 (1507 kg/ha), BPR 1492-1-43 (1347 kg/ha), BPR 5-90 (1312 kg/ha) were selected for high yield.

Maintenance of karan rai lines

Maintained and evaluated lines of *karan rai* having dwarf stature, early maturity, and bold seed.

Half sib progeny development programme

On the basis of phenotype, main shoot length and vigour under rain fed conditions 200 individual plants were selected from population grown in isolation under rainfed conditions for third cycle of half sib progeny selection for drought tolerance.

Genetic studies

An analysis was made to know the patterns of genetic variability and character association, under irrigated and rainfed conditions on 77 advanced progenies (F_6) of Indian mustard . The estimates of heritability under irrigated conditions were of higher magnitude (>50%) for main shoot length, siliquae on main shoot, siliquae length, seed yield /plant and 1000-seed weight where as under rain fed conditions, secondary branches/plant, siliquae on main shoot, siliquae length and 1000-seed weight recorded higher estimates of heritability. Under irrigated conditions, seed yield/plant was positively and significantly correlated with plant height (0.241*), primary branches/plant (0.381*), secondary branches/plant (0.493*), fruiting zone length (0.295*), siliquae/plant (0.562*), biological yield (0.852*) and harvest index (0.613*) while, under rainfed conditions, seed yield /plant was significantly and positively correlated with plant height (0.445*), primary branches/plant (0.443*), secondary branches/plant (0.611*), fruiting zone length (0.505*), siliquae/plant (0.729*), main shoot length (0.410*), seeds/siliqua (0.283*), biological yield (0.774*) and harvest index (0.482*).

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

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

Interspecific cross between *Brassica tournefortii* (2n=20, TT) and *B. rapa* var. yellow *sarson* (NRCYS-05-02) (2n=20, AA)

Interspecific F_1 hybrids were synthesized between *Brassica tournefortii* (2n=20, TT) and *B. rapa* var. yellow *sarson* (NRCYS-05-02) (2n=20, AA), by sexual mating. The F_1s were obtained only when *B. tournefortii* was used as female parent. Morphological, cytological and sequence tagged microsatellite sites (STMS) based molecular analyses were carried out to confirm the hybrid nature of F_1 plants. The percentage success of crossability was 3.7%. The F_1 hybrid plants were medium in height, profusely branched and intermediate to their parents for most of the morphological and inflorescence attributes (Fig.2.1). The leaves were light green in colour with sparsely hairy, petiolate, lobed and lyrately pinnatified. The dentation of leaf margin was noted to be

sinuate-dentate type with obtuse tip and petal colour (pale yellow) was intermediate to the parents. The F_1 plants exhibited enhancement in values of attributes like primary and secondary branches, main raceme length, siliquae on main raceme and siliquae per plant.

Meiotic characteristics of F_1 hybrids

Meiotic analysis of the F_1 hybrids (2n=20) of *B. tournefortii* and *B. rapa* showed a mixture of univalents, bivalents, trivalents and quadrivalents in a total of 82 PMCs analyzed at diakinesis/metaphase I (Fig 2.2). Forty-four PMCs (53.7%) exhibited all 20 chromosomes as univalents. Although occurrence of univalents was frequent, at least one bivalent was observed in 19.5% of PMCs, and maximum of four bivalents were observed in one PMC (1.2%) only. Two and three bivalents were observed in 13.4% and 4.9% of the PMCs analysed, respectively. Bivalents were not aligned at the equatorial plate but were randomly distributed. Conspicuously, few chromosome associations were heteromorphic in nature. Multivalents in the form of trivalents (0-1) and quadrivalents (0-1) were also encountered in few cells. The mode of chromosome association observed was 1IV + 2II + 12I (1.2%), 1III + 1II + 15I (3.7%), 3II + 14I (4.9%), 2II + 16II (13.4%) and 1II + 18I (19.5%).

Unequal distribution of chromosomes at anaphase I was observed in 29.7% of the total cells analyzed. However, a few cells (16.2%) were recorded with normal distribution of bivalents at AI resulting in some fertile pollen grains in the hybrids.

Molecular analysis of F_1 hybrids

STMS marker analysis of genomic DNA was carried out to establish the hybrid nature of the F_1 plants. Amongst the 35 genomic STMS markers used for the study, Ni4-E03, 0l10-C05, 0l11-G11, 0113-G05 and BRMS-042 were found to be polymorphic among the parents. PCR amplification products of STMS markers Ni4-E03, 0l10-C05, 0l11-G11 and 0113-G05, specific to *B. rapa* and *B. tournefortii*, were present in the F_1s in a co-dominant manner.

The F_1 plants of the above cross were back crossed with NRCYS-05-02 (*B. rapa)* and few BC_1 seeds have been obtained.

Patterns of variation in the segregating F_2 derivatives

Agromorphological traits were recorded on 92 and 144 plants from F_2 progenies of two interspecific crosses NRCDR-2 (*B. juncea*) X NRCKR-304 (*B. carinata*) and Kranti (*B. juncea*) X GSC-6 (*B. napus*), respectively. Wide phenotypic variations regarding plant types and metric traits were observed in F_2 populations. The pattern of segregation for plant types showed recovery of *B. juncea* type plants (34.8%) as compared to *B. carinata* type (43.5%), intermediate category (14.1%) and other category (7.0%) in *B. juncea* x *B. carinata* cross. The cross *B. juncea* X *B. napus* showed 54.2% *B. juncea* type as compared to 25.7%, 12.5% and 9.0% of *B. napus* intermediate type and other category, respectively. Few plants were with cluster type bearing of siliquae. The F_2 populations have been advanced to F_3 generations in both the crosses.

Figure 2.1. Comparison of morphological attributesof parent and F1 hybird (a) Leaf; (b) Siliqua; (c) Flower; (P1-B. rapa; P2- B. tournefortii; F1- (B. tournefort x B. rapa).

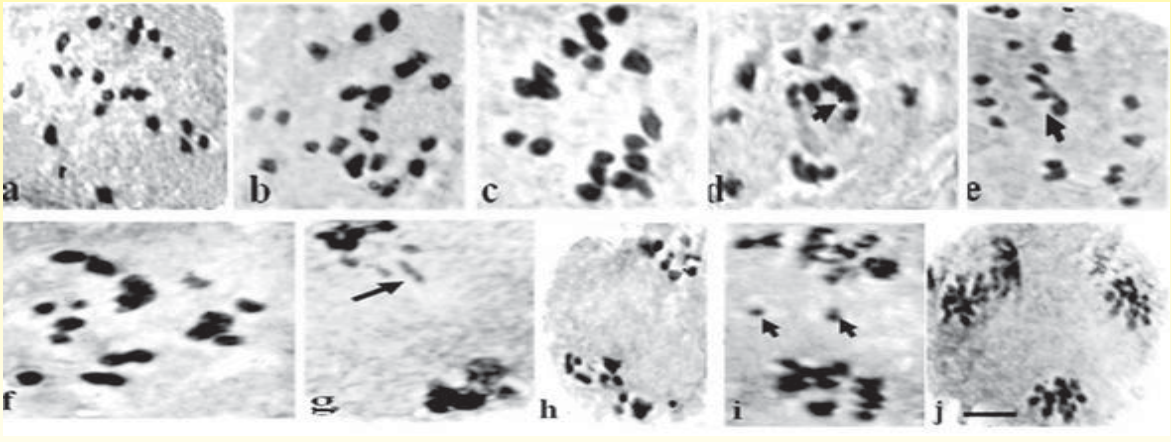


Figure 2.2. Meiotic analysis of F1 hybirds showing chromosome associations at diakinesis/metaphase I and chromosome distribution at anaphase I and II. (a) Metaphase, 201; (b) Diakinesis, 1 II + 181; (c) metaphase I, 211+161; (d) Metaphase I, 1III+1II+151 (marked by arrow); (e) Metaphase I, 1IV + 2II + 12I (marked by arrow); (f) Metaphase I (showing heteromorphic nature); (g) A I, late disjunction of chromosomes; (h) A I, unequal distribution of chromosomes; (i) A I, With laggards (marked by arrow); (j) A II, showing intermixing of chromatids at one pole.

DRMR-CI-14: Genetic and molecular basis of heat tolerance in Indian mustard

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

Associates : S.P. Singh, Senior Scientist (Plant Physiology) and Binay Kumar Singh, Scientist (Plant Biotechnology)

Screening of germplasm for high temperature stress tolerance and productivity

A total of 796 germplasm accessions including 4 checks were evaluated in augmented block design for their *per se* performance with respect to their high temperature stress tolerance at seedling stage. Eighty seeds of each of 796 accessions including four checks were sown in the field under heat stress (26th September) conditions during *rabi* 2012-13 in a single row of two metre length in order to evaluate for high temperature stress tolerance. Among all the accessions tested, only 48 were identified as promising on the basis of per cent population survival at 10 DAS and 25 DAS. The germplasm differed significantly for growth and physiological parameters, *viz.*, population survival % (10 DAS and 25 DAS), membrane stability index (%), excised- leaf water loss (%), relative water content (%), oil content (%), 1000-seed weight (g) and seed yield per plant (g). Adjusted mean values were used to interpret the data. The population survival after 10 and 25 days of sowing ranged from 47.2 to 76.9 % and 35.8 to 55.5 %, respectively. Membrane stability index (%) ranged from 5.3 to 45.5 %. Similarly, excised-leaf water loss (%) and relative water content (%) ranged from 19.6 to 40.3 (%) and 37.9 to 83.8 %, respectively. Germplasm accession DRMR-1574 (19.8), DRMR-1674 (20.7) and DRMR-1777 (25.0) recorded minimum excised-leaf water loss (%), whereas, germplasm accession DRMR-2208 (36.1) and DRMR-1313 (35.3) recorded higher excised- leaf water loss (%) under heat stress conditions. Similarly, germplasm accession DRMR-1313 (83.8), DRMR-2359 (79.7) and DRMR-945 (78.3) retained higher relative water content (%) while, germplasm accession DRMR-1570 (37.9) retained lowest relative water content under heat stress conditions. Oil content ranged from 38.8 % (DRMR-1386) to 43.6 % (check NRCDR-02) under heat stress conditions. 1000-seed weight ranged from 3.9 (DRMR-30) to 6.0 g (DRMR-1662). Germplasm accession DRMR-1674 (20.7 g), DRMR-1626 (19.6 g) and DRMR-2001(17.9 g) produced higher seed yield per plant, whereas, check Urvashi (4.5 g) and germplasm accession DRMR-30 (5.7 g) attained lower seed yield per plant under heat stress conditions.

Evaluation of genotypes for high temperature stress tolerance and productivity:

The experiment was conducted at two dates of sowing, *i.e.*, September 28, (under heat stress)

and October 7 (under normal condition) 2012. Two hundred seeds of each fifty three genotypes including two checks were sown in the field on above mentioned dates during *rabi* 2012-13 in complete randomized block design with three replications in two rows of five meter length for high temperature stress tolerance evaluation. The genotypes differed significantly for growth and physiological traits namely; population survival % at 10 and 25 DAS, membrane stability index (%), excised- leaf water loss (%), relative water content (%), water retention capacity of leaves (%), oil content (%), seed yield per plant (g), heat susceptibility index and yield stability ratio.

The percent decrease of population survival was less in BPR-349-4 (96.2), RGN-48 (94.1) and DRMR-541-44 (96.1) at 10 DAS and DRMR-541-44 (89.1) and RGN-48 (88.3) at 25 DAS under heat stress conditions. Membrane stability index under normal and stress condition ranged from 6.9 to 57.8 % and 3.6 to 56.6 %, respectively. Similarly, excised- leaf water loss under normal and stress condition ranged from 14.3 to 34.2 % and 16.7 to 36.8 %, respectively. Strain DRMR 1918 (86.4 %; 1.3), DRMR 729 (80.3 %; 6.1), NPJ-93 (78. 5 %; 1.3) and RB 50 (75.6 %; 11.3) retained higher relative water content, whereas, strain DRMR-675 (42.5 %; 6.9), Maya (47.5 %; 37.1), BPR-605-40 (50.9 %; 9.9) and DFS-45 (54.7%; 32.9) retained lower relative water content under stress conditions. Water retention capacity of leaves under normal and stress conditions ranged from 18.2 to 71.5 % and 15.5 to 62.3 %, respectively. Oil content under normal and stress conditions ranged from 40.5 (DRMR-1918) to 43.6 % (NPJ-112) and 38.8 (NPJ-93) to 42.9 % (NPJ-112), respectively. Strain NPJ-112 (97.4 g), NPJ-124 (41.3 g), NRCDR-601(39.7 g) and DRMR-1350 (35.0 g) recorded higher seed yield per plant under normal temperature condition while genotypes NRCDR-601 (32.6 g), BPR-181-14 (28.2 g) and RGN-12 (27.2 g) recorded higher seed yield per plant under stress conditions. Among the strain BPR-349-9, Urvashi, BPR-541-2, BPR-605-40, Pusa Tarak (EJ9912-13), RGN-48, BPR-549-2, DRMR-729 and DRMR-1918 were identified thermo-tolerant at seedling stage on the basis of value of heat susceptibility index ($\leq$ 0.5) and yield stability ratio (> 80%).

The significant co-efficient of correlation between seed yield per plant and other physiological traits ranged from 0.295* to 0.993**. The seed yield per plant had significant positive correlation with oil content (r=0.295*) under normal temperature conditions. The oil content (%) had significant negative correlation with population survival (%) (r= -0.267*) under heat stress conditions. The relative water content (%) had significant negative correlation with excised-leaf water loss (%) (r= -0.385*) under heat stress conditions. The population survival (%) at 25 DAS had significant positive correlation with population survival (%) at 10 DAS under heat stress conditions.

Hybridization

Twenty eight crosses were made during *rabi* 2012-13 utilizing heat stress tolerant lines of *Brassica juncea* to combine heat tolerance trait in high yield genetic background.

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

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

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

Chromosome doubling in *B. rapa* X *B. nigra* crosses

Fifty two inter-specific crosses generated between various genotypes of *B. rapa* (toria, brown sarson & yellow sarson) and *B. nigra* during 2012-13 were planted in pots during *rabi* 2013-14 for colchicine-induced chromosome doubling in F_1 plants. At two leaf stage each F_1 plant from all inter-specific crosses was treated with 0.2 % colchicine for 3 hours / day for successive 3 days by cotton swab method. The effect of colchicine was observed on initial growth and on various plant parts at later stages. The initial growth of the treated plants was very slow and many of these plants could not survive. Morphological differences have been observed for various traits in surviving plants. Based on visual observations putative colchicine-induced individual plants were tagged. Samples of flower buds from colchicine treated F_1 plants

have been fixed for cytological examinations. Seeds from individual plants were harvested separately.

Generation of inter-specific crosses

In addition to the diploid progenitors *viz.*, *B. rapa* (2n=20, AA) and *B. nigra* (2n=16, BB) the amphidiploid species *B. carinata* (2n=34, BBCC) and *B. napus* (2n=38, AACC) were also included for generation of inter-specific crosses during 2013-14. Following seventeen crosses were generated between various genotypes of *B. rapa* (toria, brown sarson & yellow sarson) and *B. nigra* and 8 crosses were generated between *B. carinata* and *B. napus* genotypes. Parental lines were maintained by sibbing/selfing.

B. rapa var toria X *B. nigra*	BR-23 x SKJ-2, Panchali x BN-2, Parbati x BN-2, Parbati x SKJ-2
B. rapa var yellow Sarson X *B. nigra*	Jhumka x BN-2, Jhumka x SKJ-2, Pusa Gold x BN-2, Pusa Gold x SKJ-2, Ragini x BN-2, Ragini x SKJ-2,YSH-401 x BN-2,YSH-401 x SKJ-2
B. rapa var brown sarson X *B. nigra*	Pusa Kalyani x SKJ-2, KOS-1 x BN-2, KOS-1 x SKJ-2, KBS-3 x BN-2, SKBR-1 x BN-2,
B. carinata x B. napus	NRCKR 304 x NRCGS-1, DRMR 312 x GSC-6, DRMR 312 x NRCGS-1
B. napus x B. carinata	GSC-6 x NRCKR 304, GSC-6 x DRMR 312, GSL-2 x NRCKR 304, GSL-2 x DRMR 312, NRCGS-1 x DRMR 312

Generation of F_1 crosses in *B. juncea*

Nineteen F_1 crosses (RH 749 x NRCDR 2, RH 749 x NRCHB 101, RH 749 x Rohini, RH 749 x TM 118, NRCDR 2 x NRCHB 101, NRCDR 2 x RH 406, NRCDR 2 x TM 118, TM 118 x YRN 6, TM 118 x Rohini, TM 118 x RH 406, YRN 6 x TM 118, WR 2019 x NRCDR 2, WR 2035 x NRCHB 101, Dwarf x TPM 1, Dwarf x NRCDR 2, Dwarf x NRCHB 101, Dwarf x NPJ 112, Dwarf x RH 749 and NPJ 112 x Dwarf) were generated for various traits including high yield & oil content, yellow seed colour, white rust resistance, early maturity and dwarfness.

Selection from segregating generations

More than 250 single plants were selected from 4 F_2 populations. 65 single plants were selected from 55 F_3 progenies of a single cross and 80 single plants were selected from 42 F_4 progenies of 11 crosses

Genetic studies

Line X tester analysis of 36 F_1s involving nine advanced breeding lines and four testers, revealed the operation of both additive and non-additive gene actions with predominance of non-additive gene action in controlling the yield and yield attributing traits in Indian mustard. Four lines *viz.* DRMR 2243, DRMR 2341, DRMR 2486, DRMR 2613 and one tester namely, NRCHB 101 possessed highly significant positive gca effects for seed yield / plant. Significant and positive sca effects were observed for seed yield (12 crosses), 1000-seed weight (14 crosses), oil content (12 crosses), main shoot length (12 crosses), number of siliquae on main shoot (11 crosses), number of seeds/siliqua (11 crosses), siliqua length (five crosses) and number of primary branches (one cross). Seven hybrids exhibited >15% better parent heterosis, highly significant sca effects and higher *per se* performance.

2.2 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)

Associate : J. Nanjundan, Scientist (Genetics & Plant Breeding)

Release of Indian mustard (*Brassica juncea* L) variety DRMRIJ 31 (Giriraj)

One entry DRMRIJ 31 evaluated under All India Coordinated Research Project on Rapeseed Mustard during 2010-11 to 2012-13 expressed it's superiority over the check varieties Kranti, NRCDR 2 and RL 1359. DRMRIJ 31 produced 12.9, 11.4 and 9.7 percent higher seed yield and excelled for oil yield by a margin of 16.0, 13.0 and 11.4 percent over RL

1359 (ZC), NRCDR 2 (LR) and Kranti (NC), respectively, in 19 trials during three year multilocation testing under timely sown irrigated conditions across the zone II. Varietal Identification Committee in its meeting on 6th July 2013 during 20th annual group meeting of AICRP on Rapeseed-Mustard held at SDAU, SK Nagar identified DRMRIJ 31 for release under timely sown irrigated conditions of zone II (Punjab, Haryana, parts of Rajasthan and Delhi). The proposal was submitted for release before Central Sub Committee on Crop Standards, Notification and Release of Varieties, Ministry of Agriculture, Govt. of India. The DRMRIJ 31 has been notified for cultivation in Rajasthan and Haryana in Gazette of India vide S.O.(E) 2817 dated 19 September 2013 as Giriraj (DRMRIJ 31). Average seed yield of DRMRIJ 31 ranged from 2246 - 2757 kg/ha under timely sown conditions. Maturity duration, oil content, 1000-seed weight and plant height ranged from 137-153 days, 38.7-42.5 %, 3.1-6.1 g and 190 - 210 cm, respectively.

Entries inducted to AICRPRM for evaluation

Two hybrid entries DRMRHJ 3809 and DRMRHJ 4109 were inducted to initial hybrid trial (IHT) for evaluation during 2013-14. Three inbred/pureline entries namely, DRMRIJ 13-38, DRMRIJ 118 and DRMRIJ 13-3 were inducted to initial varietal trials for late sown, rainfed and timely sown conditions, respectively. One entry DRMR MJA 35 continued for screening in uniform disease nursery trial for second year testing and one other entry DRMRIJ 11-04 inducted during 2011-12 was repeated for evaluation in initial varietal trial in zone V.

Evaluation of promising entries

262 entries including 124 experimental hybrids and 138 inbred lines were evaluated for seed yield and agronomic traits in seven different experiments of which five station trials were conducted in randomized completed block design and remaining two in augmented block design alongwith appropriate check varieties/ hybrids. In station trial 1, hybrid HJ 3813(2178 kg/ha) yielded at par with best check DMH 1(2114 kg/ha), however 1000-seed weight of HJ 3813 (5.4 g) was significantly higher than that of DMH 1(3.9 g). Station trial 2, consisted of 9 hybrids including 3 from DRMR and 6 from JK Agri-Genetics Ltd under a collaborative hybrid evaluation programme. Highest yielding hybrid JKA-211 (2094 kg/ha) was statistically at par with check DMH 1 (2059 kg/ha) for seed yield, however seed weight of JKA-211 (4.4 g) was higher than that of DMH 1(3.7 g). Station trial 3 consisted of eight inbred/pureline selections and 3 check varieties; NRCHB 101, NRCDR 02 and Kranti. Four entries *viz*., IJ 2-1 (MJA 39/MJR 14), IJ 6-7 (DR7 XHB 101), IJ 1-5 (HB 9914 X HB 9918) and IJ 4-6-2 (IJ 31 X EC 597313) outyielded the best check NRCHB 101 (2104 kg/ha) with a margin of 16.6, 15.9, 14.1 and 11.3 percent, respectively.

In station trial 4, early maturing varieties were evaluated with 2 early maturing check varieties NPJ 112 and NPJ 113 in which check variety NPJ 112 produced higher seed yield 2232 kg/ ha. In fifth trial, seven pureline entries were evaluated with RGN 73, Kranti and Rohini, of which Kranti (2469 kg/ha) was the highest yielding genotype. 108 inbred lines were evaluated in augmented design keeping single row plot of 3 m length. Each block consisted of 18 inbred lines and two checks; DRMRIJ 31 and Kranti. Adjusted mean estimates were computed from statistical analysis and on the basis of adjusted mean, 3 promising entries IJ 12-75 (HB 9914 X HB 9918), IJ 12-124 (NRCHJ 2602-2) and IJ 12-126 (NRCHJ 2602-3) with seed yield of 575 g, 569 g and 529 g per plot, outyielded the best check DRMRIJ 31 (475 g/ plot) by a margin of 21, 19 and 11 percent, respectively. Score for white rust reaction was observed on a 0-9 point scale under natural disease pressure. genotypes IJ 12-02 (ZEM 2 X HB 9916), IJ 12-03 (B33 X VSL5), IJ 12-06 (IJ 31 X EC 597313), IJ 12-14 (selection from QM 16), IJ 12-21 (selection from EC 597311), IJ 12-26 (selection from EC 597320), IJ 12-27 (selection from EC 552573), IJ 12-28 (selection from EC 552574), IJ 12-37 (MJB 27 X PQR 2005-1), IJ 12-39 (ZEM 2 x JGM 1-11), IJ 12-40 (ZEM 2 X (HB 101 X ZEM 2), IJ 12-41 (ZEM 2 X Varuna), IJ 12-43 ((JGM 1-11 XZEM 2) X HB 101), IJ 12-44 (ZEM 2 X HB 101), IJ 12-48 (ZEM 2 X HB 101), IJ 12-50 (selection from NRCDRM 34), IJ 12-51(selection from NRCDRM 62), IJ 12-52 (selection from NRCDRM 73), IJ 12-65

(selection from yellow seeded *B. juncea*) with <1.0 score were selected.

Erucic acid analysis was also get done and four inbred lines *viz*., IJ 12-37 (selection from MJB 27), IJ 12-65 (selection from yellow seeded *B. juncea*), IJ 12-219 ((39-3-2-3 X EC 597313), IJ 12-225 (39-3-2-3 X EC 597313) were identified for low erucic acid. Out of 108 F_1s evaluated in augmented block design in single row plot of 2 m length with 3 checks DMH1, NRCHB 506 and Kranti, two crosses EC 399288 X EC 597309 and DRMRIJ 31 X Kranti outyielded NRCHB 506 by a margin of 64 and 25 percent, respectively. 33 germplasm lines procured from NBPGR, New Delhi were grown with other 42 exotic lines in single row plot of 3 m length in augmented design. Observations were recorded on 50 *Brassica juncea* lines for plant height, main shoot length, siliqua length, beak length and 1000-seed weight. Plant height ranged from 150 (EC 597326) to 265 cm (EC597337); main shoot length from 45 (EC 597342) to 91 cm (EC 564640); siliqua length from 2.6 (EC 597342) to 6.1 (EC 564646); beak length from 0.6 (EC 597342) to 1.3 cm (EC 564646) and 1000-seed weight from 1.1 (JN 004) to 7.1 g (IC 276261).

Generation of breeding material

Conversion of A,B and R lines

Backcrosses were attempted to advance the generation of 18 CMS lines with their respective maintainer lines. Similarly, 9 backcrosses were attempted to advance the generation of restorer lines.

Maintenance of inbred, B and R line

272 inbred lines, 50 germplasm lines and 35 maintainer (B) lines of CMS and of restorer were maintained through selfing.

Selection from segregating generations

Single plant selection was practiced on the basis of phenotype from 19 populations including 12 F_2 crosses of (MJA11 X MJR 4) X 39-3-2-2, MJA 25 X MJR 4 X 39-3-2-2, MJA 34 X MJR 4 X 39-3-2-2, MJA 27 X MJR 9 X 39-3-2-2, MJA 27 X MJR 4 X DRMRIJ 20, MJA 2 X MJR 2 X DRMRIJ 20, MJA 2 X MJR 2 X MJR 2, MJA 2 X MJR 4 X EC 552577, YM 8 X EC 399307, HB 9909 X NUDHYJ 3 X RL1359, HB 9909 X EC 597309, YM 6 X EC 399307; 4 F_3 crosses of 4-9-2 X MJR 2, 4-9-2 X EC 597309, Hyola 401 X NRCYS 05-2, MCB 1-2 and 3 F_4 crosses of 78-1-1-2 X EC 597313, KLM 227 X EC597313 and 39-3-2-3 X EC 597313.

Selection from progenies of interspecific crosses: F_2 progeny of one interspecific cross MJR 3 (*Brassica juncea*) X Pusa Swarnim (*Brassica carinata*) was grown. Variability for pigmentation on stem, leaf characteristics, maturity duration, number of primary branches, determinate siliquae bearing and other yield related traits were observed. Promising plants resembling to *Brassica juncea* and *Brassica carinata* were selected separately, F_1 progeny of two crosses MJR 3 (*B. juncea*) and MCB 1 (*B. carinata*) and of OJA 1 (*B. juncea*) and YSH 401 (*B. campestris* var yellow sarson) were also grown and open pollinated seeds were harvested.

Hybridization

110 crosses were attempted in form of 50 test crosses and one Line x Tester (12 x 5) as given below

Line X Tester (12 X 5)

Lines- EC 597326, EC 597337, EC 597338, EC 597340, EC 597342, EC 597344, EC 564649, JN 010, JN 016, JN 018, JN 028, IJ 31

Tester

RB 50, MJR 9, EC 597313, EC 597341, EC 552577

2.3 Rapeseed-mustard genetic resource management

DRMR CI 6: Management of rapeseed - mustard genetic resources

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

Associates: K.H.Singh, Principal Scientist (Genetics & Plant Breeding) and S.P.Singh, Senior Scientist (Plant Physiology)

Characterization

With an objective to develop core collection in Indian mustard accessions, a total of 491 accessions were characterized along with three

checks, Pusa mustard 25, Maya and RGN 73. The mean, range and coefficient of variation (CV) for different agro-morphological traits are presented in Table 2.1.

Table 2.1: Mean, range and coefficient of variation (CV) for various agro-morphological characters in 491 Indian mustard germplasm accessions

Traits	Mean	Range	CV (%)	Mean of checks		
				Maya	RGN 73	Pusa Mustard 25
Days to initial flowering	50.6	34.0-73.0	7.8	50.5	55.3	40.7
Days to 50% flowering	66.2	51.0-85.0	25.3	66.3	72.9	55.2
Days to maturity	146.2	135.0-155.0	2.5	147.4	148.3	137.9
Plant height (cm)	178.2	107.0-240.0	10.7	178.3	203.7	140.2
Fruiting zone length (cm)	73.41	13.0-149.0	14.0	73.6	86.6	70.6
No. of primary branches	4.9	2.8-8.6	18.3	5.5	5.7	5.0
No. of secondary branches	8.1	2.0-15.0	27.6	9.2	10.0	9.5
Main shoot length (cm)	70.2	45.0-99.0	11.5	69.2	65.9	68.1
No. of siliquae on main shoot	41.9	22.0-58.6	14.7	41.0	42.8	37.8
Siliqua length (cm)	3.8	2.46-5.52	11.7	3.55	3.81	4.26
Siliqua beak length (cm)	0.4	0.32-1.14	18.8	0.5	0.5	0.5
No. of seeds per siliqua	12.1	5.5-17.4	12.7	12.0	13.3	14.1
1000-seed wt (g)	5.1	2.29-8.14	19.8	5.58	5.14	4.94
Seed yield/plant (g)	8.5	1.14-19.76	45.8	10.15	10.85	8.82
Harvest index (%)	16.0	5.00-28.83	33.4	18.47	17.22	17.98
Oil content (%)	40.3	37.32-43.09	2.4	40.36	41.04	40.59

Development of trait specific gene pool in Indian mustard

From the 1377 Indian mustard accessions evaluated during the years 2009-12, 264 accessions were selected for the component traits like plant height (< 170 cm), main shoot length (>80 cm), No. of siliquae on main shoot(>60), siliqua length (>5.0 cm), number of seeds/siliqua(> 17), 1000-seed weight (>7.0 g) and oil content(> 42 %). These accessions were evaluated, for second year, in the crop season of 2012-13 and 73 accessions with better performance (based on two years data) were identified for their use in trait specific improvement programme (Table 2.2).

Table 2.2. Promising accessions identified for different yield component traits

Trait	Range	Promising accessions
Days to maturity	~135 days	DRMR-1787(HUJM-05-01),DRMR-2058(IC520759) and DRMR-2119 (SN99)
Plant height (cm)	< 170	DRMR-1615(DU-10), DRMR-2084(JCR-914), DRMR-20(EC 511481), DRMR-2044(IC 447832) and DRMR-2052(IC 520766)
Main shoot length (cm)	> 80	DRMR-266(EC 182920), DRMR-2055(IC 520768), DRMR-1064(BBM-06-02), DRMR-107(P-83), DRMR-1071(RRN-615), DRMR-1072(RRN-605), DRMR-1082(Kranti), DRMR-1109(IC 266917), DRMR-1690 (B/K/S-42), DRMR-1242(UP II-6), DRMR-1245(P-4), DRMR-1379(UP II-18), DRMR-1619(DU-32), DRMR-1620(IC 267715), DRMR-1674(B/K/S-67), DRMR-1993(IC 312514), DRMR-2063(IC 521376), DRMR-909(Pusa Bold x BJ-1058), DRMR-972(HPLM-06-46), DRMR-1039 (Parasmani-8), DRMR-1073(HUJM-05-02), DRMR-1995(IC 312524), DRMR-

		1327 (P-63), DRMR-681(EC 399288) and DRMR-1346(HP 30)
No. of siliquae on main shoot	>60	DRMR-1374(P-18), DRMR-36(EC 511589) and DRMR-742 (EC511447)
Siliqua length (cm)	> 5.0	DRMR-1034(PRB-2006-5), DRMR-1783(DRMR-1783), DRMR-1829(MRN-J-2001-12) and DRMR-1905(DRMR-1905)
Seeds/ siliqua	>17	DRMR-2152 (IC 571685), DRMR-2122(SN28) and DRMR-2097(SN55)
1000-seed weight (g)	>7.0 g	DRMR-1145 (UP I-24), DRMR-1215(UP II-111), DRMR-1322 (P-11), DRMR-1412(UP II-25), DRMR-1427 (UP II-49), DRMR-1429 (UP II-4), DRMR-1458(UP I-62), DRMR-1596(UP II-21), DRMR-1758 (DRMR-1758), DRMR-2065 (IC 526318), DRMR-473 (NE68) and DRMR-64 (UP I-21)
Oil Content (%)	>42	DRMR-2089 (JCR-996), DRMR-1389 (UP II-119), DRMR-1617(DU-15), DRMR-1675 (B/K/S-19), DRMR-1033 (RK-07-2), DRMR-1067 (RH 0305), DRMR-1105 (IC 266828), DRMR-1845 (sel 23), DRMR-1847 (sel 68), DRMR-1996(IC 312525), DRMR-2024 (IC 355345), DRMR-2116(SN66), DRMR-918 (RCC-4 x Zem-2), DRMR-966 (HPLM-06-35) and DRMR-967 (HPLM-06-36)
Harvest index (%)	>25	DRMR-1618 (DU-25), DRMR-2006 (IC 342778) and DRMR-901(Domo-1)
Total		**73**

Maintenance

A total of 363 rapeseed-mustard accessions were maintained following proper pollination control mechanism.

Acquisition

94 accessions of rapeseed-mustard were obtained from different AICRPRM centers and other institutions.

Distribution

180 accessions were provided to various research organizations/students for their use in research programme.

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)

Fifteen 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 five 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 60% survival rate could be obtained during hardening. Bioassay studies for Alternaria blight tolerance had been carried out for five PCR positive transgenic events by both leaf detachment technique and whole plant bioassay under *in vitro* conditions along with the control (non-transformed) plants. However, no significant difference was observed in both transgenic and control (non-transformed) plants for Alternaria blight tolerance.

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

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

Validation of molecular markers for resistance to white rust

The major application of molecular markers in plant breeding is supporting efficient selection to develop improved cultivars. In our earlier experiments intron polymorphic (IP) markers, *At5g41560* and *At2g36360*, closely linked to white rust resistance loci *AcB1-A4.1* and *AcB1-A5.1* (from Heera and Donskaja-IV, respectively) were employed to evaluate 26 genotypes of Indian mustard, aimed at assessing the efficiency of these markers in marker assisted selection for pyramiding of these loci in some of the popular Indian varieties. Among the tested genotypes NPJ 121, BEC 144, NPJ 127 and JMY 11 showed moderate to high level of resistance. The relationships between the variation of the PCR products of the markers and the disease index (DI) of the tested genotypes were analyzed. During 2013-14, Intron polymorphic markers *At5g41560* and *At2g36360* were also validated in two independent bi-parental F_2 populations other than the ones used for development of markers. Overall, results indicated that the two markers are not genotype specific and provide uniquely divergent loci. Moreover, they are tightly linked to white rust resistance loci *AcB1-A4.1* and *AcB1-A5.1*, respectively.

Marker assisted pyramiding of white rust resistance loci

F_1 hybrids obtained between popular varieties Pusa Bold, Laxmi, Bio-902, Varuna, Maya, Vasundhara, Rohini and NRCDR 2 with white rust resistant genotypes JMY-11 and Heera were advanced to BC_2 stage taking advantage of the off-season nursery at IARI Regional Station, Wellington (TN). At every stage, intron polymorphic (IP) markers, *At5g41560* and *At2g36360*, closely linked to white rust resistance loci *AcB1-A4.1* and *AcB1-A5.1*, respectively were used as a replacement for phenotyping in selecting resistant genotypes. Fresh F_1 crosses were also made between highly resistant east European germplasm Donskaja-IV and Indian mustard varieties Pusa Bold, Laxmi, Bio-902, Varuna, Maya, Vasundhara, Rohini and NRCDR 2.

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

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

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

The long-term effect of soil organic carbon (SOC) and fertilizer management strategies on traditional fallow-mustard system is being evaluated since 2005-06. Continuous adoption of management strategies significantly influenced the mustard seed yield, soil microbial biomass carbon (MBC) and soil dehydrogenase activity. In general Sesbania green manure (SGM) significantly increased mustard seed yield by 22.8 % over control (Table 2.3). Supplementary incorporation of 2.5 t /ha mustard straw before sowing of SGM significantly increased the seed yield by 18.0% over SGM and 44.8% over control. And continuous application of balance NPK (80:17.4:33.3 kg/ha) maintained sustainable higher productivity than deficient doses. The combined adoption of MSI + SGM and balance NPK synergistically increased the seed yield by 107% over suboptimal F1, 29% over optimal F8 and 26.7% over MSI + SGM treatment.

In general, SGM improved the MBC by 49.5% and dehydrogenase (DH) activity by 11.4% over control (Table 2.4). While adoption of MSI +SGM further improved the MBC by 39.6% and DH by 38.1% over SGM. Contrary to SOC management strategies, the successive refinement in fertilizer levels gradually diminished the MBC and DH. The lower value was recorded when balanced NPK (80:17.4:33.3 kg/ha) was applied to the crop.

Soil dehydrogenase (DH) activity was significantly influenced due to application of

Table 2.3. 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	1339	1478	1617	1756	1756	1811	1840	2145	**1718**
Sesbania (GM)	1828	1967	1995	1995	2189	2244	2300	2356	**2109**
Mustard straw @ 2.5 t/ha + *Sesbania* (GM)	2184	2239	2350	2461	2600	2628	2684	2767	**2489**
Mean	1784	1895	1987	2071	2182	2228	2274	2422	-
CD (P=0.05)	CS: 181, Fertility level: 102, CS x Fertility level: 326, Fertility level x CS: 321								

*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)

Table 2.4. Effect of organic manures & fertility levels on MBC (µg C/g soil) and dehydrogenase activity (µg TPF/g soil/day) at 30DAS.

Treatments	MBC	DH
Organic sources		
Fallow - mustard (control)	114.3	184.0
Sesbania (GM) - mustard	163.8	205.0
Sesbania (GM) + Mustard straw @ 2.5 t/ha- mustard	228.7	283.2
CD (P=0.05)	3.8	6.6
Fertility levels (kg/ha)		
N_{40} $P_{8.7}$ K_0	203.3	250.8
N_{40} $P_{8.7}$ $K_{33.3}$	191.3	240.9
N_{40} $P_{17.4}$ K_0	178.8	233.9
N_{40} $P_{17.4}$ $K_{33.3}$	170.6	226.4
N_{80} $P_{8.7}$ K_0	161.8	222.3
N_{80} $P_{8.7}$ $K_{33.3}$	157.3	218.5
N_{80} $P_{17.4}$ K_0	149.4	200.9
N_{80} $P_{17.4}$ $K_{33.3}$	138.7	198.9
CD (P=0.05)	7.5	4.5
Interaction (Organic sources× Fertility levels)		
CD (P=0.05)	13.0	7.9

different organic and inorganic nutrient management practices. The trend of variation between the treatments with DH activity was recorded similar as was observed in soil MBC. The maximum activity of soil DH was recorded under *Sesbania* (GM) + Mustard straw treatment, which was significantly higher than rest of the treatments. The minimum activity of soil DH was recorded under control, which was significantly lower than rest of the treatments. Soil DH activity was also significantly influenced due to different fertility levels, especially of N application. The highest DH enzyme activity was recorded at 40 kg N/ha, followed by 80 kg N/ha.

A dynamic mustard production system of higher resilience to biotic stresses and changing climate is utmost important for long term sustained productivity. Under this project a long term experiment was therefore initiated in 2005-06 to evaluate the resilience capacity of four oilseed *Brassica* (OSB) production systems of semi-arid tropics. The experiment was refined during 2011-12, keeping three land

use management levels (HML: high management level-100% RDF, MML: medium management levels- 50% RDF and LML: low management levels –no fertilizer) in main plot and six SOC management strategies (SGM, MSI, MSI+SGM, mustard straw mulch – MSM, FYM and vermicompost-VC). Overall, HML significantly improved the mustard seed yield by 19.1% over MML, 69.5% over LML and 88.3 over absolute control. Among SOC management strategies, MSI+SGM was found most resilient and recorded maximum mustard seed yield.

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

Project Leader: Kapila Shekhawat, Scientist SS (Agronomy)

Associate : B.K. Kandpal, Principal Scientist (Agronomy), NS Bhogal, Senior Scientist (Soil Science) and SS Rathore, Senior Scientist (Agronomy)

The RCTs on five mustard systems are being evaluated in permanent experimental plots at DRMR since *rabi* 2009. Five cropping systems, fallow-mustard, green manure-mustard, brown manure-mustard, cluster bean-mustard and pearl millet-mustard were grown under conventional tillage (CT), reduced tillage (RT), zero tillage (ZT) and furrow irrigated raised beds (FIRB) in split-plot design. The tillage operations (RCTs) and cropping systems significantly influenced the seed, stover, biological yields, harvest index, production efficiency, oil content, oil productivity and economics of mustard (Table 2.5).

After 4 years of the experimentation, FIRB produced significantly 28.2% higher seed yield than CT. FIRB was followed by ZT and ZT was at par with RT (Fig.2.3). Highest stover and total biological yield were under FIRB but remained statistically at par with CT and ZT. Soil physic- chemical and biological properties significantly improved under ZT due to continuous retention of residues leading to build up of soil organic matter. The yield enhancement under ZT and RT as compared to CT were achieved through the maintenance of a greater DM accumulation, translocation efficiency and higher sink/source potential during the seed filling stage. Similarly, the highest mustard yields were obtained under green manure- mustard cropping system, cluster bean-mustard system being at par with it. The higher harvest index was obtained under FIRB and ZT among the tillage treatments followed by RT and CT. The production per day (production efficiency) was also higher under FIRB due to higher seed yield. The oil content, however, was found at par in FIRB, RT and CT and significantly lower in RT. The highest system productivity, including the

Table 2.5. Yield, harvest index, production efficiency and oil content of mustard under tillage treatments and various cropping systems during 2012-2013.

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha) (kg/ha)	Biological yield	Harvest index (kg/ha/day)	Production efficiency (%)	Oil content	Oil yield, kg/ha
Tillage operations							
CT	2156^{a}	6673^{b}	8829^{b}	0.24^{a}	15.4^{a}	41.3^{b}	890^{a}
RT	2436^{b}	6491^{b}	8927^{b}	0.27^{b}	17.4^{b}	40.4^{a}	984^{b}
ZT	2533^{b}	6206^{a}	8739^{a}	0.29^{c}	18.1^{b}	41.7^{b}	1056^{b}
FIRB	2765^{c}	6877^{c}	9642^{c}	0.29^{c}	19.8^{c}	41.6^{b}	1150^{c}
Cropping systems							
Fallow-M	2279^{ab}	6433^{a}	8712^{a}	0.26^{a}	16.3^{a}	41.2^{ab}	1111^{c}
GM-M	2697^{d}	6735^{b}	9432^{c}	0.29^{c}	19.3^{c}	41.5^{b}	1036^{b}
BM-M	2496^{c}	6683^{b}	9179^{b}	0.27^{b}	17.8^{b}	41.4^{b}	1115^{c}
CB-M	2693^{d}	6525^{a}	9218^{bc}	0.29^{c}	19.2^{c}	41.2^{ab}	906^{a}
PM-M	2198^{a}	6436^{a}	8634^{a}	0.25^{a}	15.7^{a}	40.9^{a}	899^{a}

yields of cluster bean and pearl millet, was also recorded under FIRB, RT and ZT being at par with the same (Table 2.6). Among the cropping systems, the highest system productivity was obtained under cluster bean-mustard system, pearl millet-mustard system being at par with it. Likewise, the highest mustard equivalent yield was obtained under FIRB, followed by ZT and RT. The highest MEY was obtained under cluster bean-mustard system due to higher market price of cluster bean. The MEY under pearl millet-mustard was significantly higher over other three systems. The highest net returns and B:C ratio were obtained under FIRB, followed by ZT. However, the net returns and B:C ratio obtained under ZT were found at par with RT and significantly lowest yield was obtained under CT. Among the cropping systems, the highest net returns and B:C ratio were obtained under cluster bean-mustard, followed by green manure-mustard. The B:C ratio obtained under brown manure-mustard and pearl millet-mustard were at par with each other.

Table 2.6. System productivity, mustard equivalent yield and economics of Indian mustard under tillage treatments and various cropping system during 2012-13.

Treatments	System productivity	Mustard equivalent (kg/ha)	Net returns yield (kg/ha)	B:C ratio (Rs/ha)
Tillage operations				
CT	2598^{a}	3002^{a}	70,483^{a}	2.80^{a}
RT	2795^{b}	3428^{b}	83,029^{ab}	3.47^{b}
ZT	3078^{b}	3778^{bc}	92,331^{b}	4.21^{bc}
FIRB	3275^{bc}	4149^{d}	1,05,367^{c}	4.55^{c}
Cropping systems				
Fallow-M	2546^{a}	2546^{b}	62,601^{a}	3.05^{a}
GM-M	2931^{b}	2931^{b}	74,141^{b}	3.44^{b}
BM-M	2605^{a}	2605^{b}	69,262^{ab}	3.35^{b}
CB-M	3515^{c}	6451^{d}	1,53,791^{c}	5.06^{c}
PM-M	3090^{c}	3405^{c}	79,197^{b}	3.22^{b}

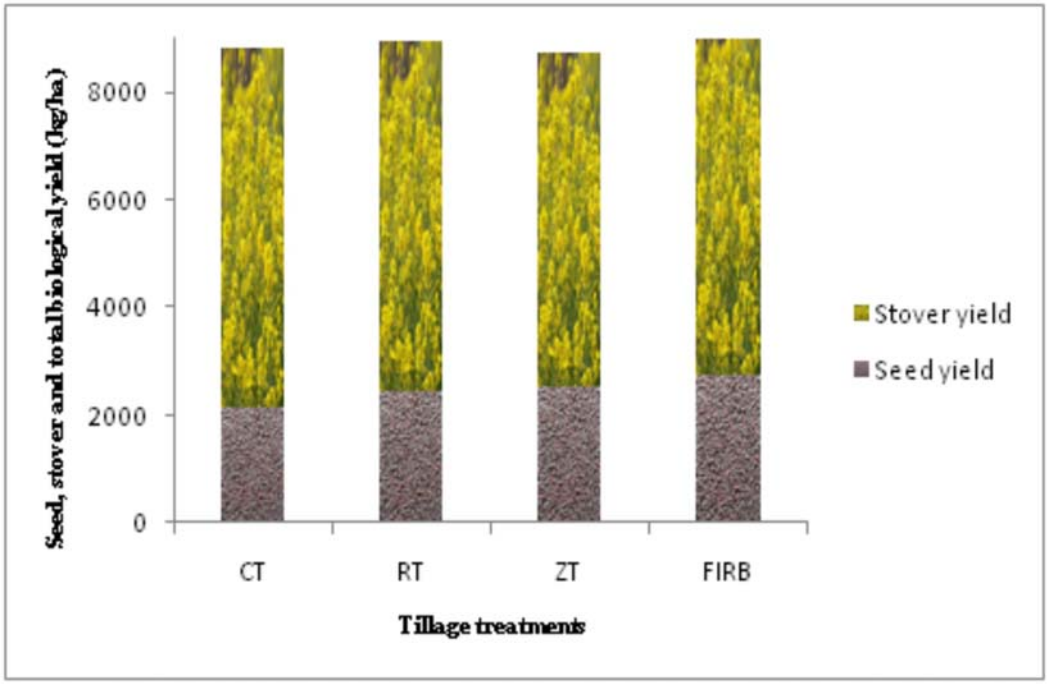


Fig 2.3. Seed and stover yield of mustard under various tillage trearments

The water use efficiency was highest with FIRB under green manure-mustard cropping system. As compared to the CT, the water saving under FIRB was almost 30% higher as the water is applied only in furrows. The residue retention under ZT and RT increased infiltration rate and reduced bulk density. Also, the higher yield obtained under FIRB improved water use efficiency.

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

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

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

The landuse information of more than 550 districts of the country for 5 years (2005-6 to 2009-10) was collected. The OSB covers >1% of gross cropped area in 242 districts from 18 states (Asom-24, Arunachal Pradesh-10, Bihar-15, Chattisgarh-5, Gujarat-6, Haryana-14, Himachal Pradesh- 5, Jammu & Kashmir-15, Jharkhand-17, Madhya Pradesh- 19, Manipur-2, Mizoram- 3, Nagaland- 11, Odisha-2, Rajasthan- 29, Uttar Pradesh- 46, Uttarakhand- 5 and West Bengal- 13). Thematic maps of different landuse attributes were generated using collected information. The average acreage under OSB is more than 1.0 lakh hectares in 11 districts (Sriganganagar, Alwar, Sawai Madhopur, Kota, Bharatpur, Jaipur, Bhind, Tonk, Morena, Bhiwani and Banas Kantha). In 16 districts the area under OSB ranges 0.5-1.0 lakh hectares (Mahendragarh, Murshidabad, Jhunjhunu, Jodhpur, Gwalior, Dholpur, Rewari, West Dinajpur, Bundi, Nadia, Mandsaur, Jalore, Shivpuri, Hisar, Sikar and Agra. While, area under OSB ranges 25-50 thousand hectares in 20 districts and 5-25 thousand hectares in 89 districts (Fig. 2.4). And the acreage under OSB is >25% of the gross cultivated area in 11 districts namely Dibang Valley, Bhind, Morena, Mahendragarh, Rewari, Bharatpur, Gwalior, Tonk, Sawai Madhopur, Alwar and Dholpur.

The 5-years average total OSB production of >1.0 lakh tonnes was recorded in 16 districts (SriGanganagar, Alwar, Bharatpur, Kota, Sawai Madhopur, Bhind, Bhiwani, Jaipur, Morena, Mahendragarh, Banas Kantha, Tonk, Rewari, Murshidabad, Hisar and Jhunjhunu). The total production was 0.5-1.0 lakh tonnes in 18 districts (Fig 2.5). The study revealed fully irrigated OSB production (>90% area) in 84 districts, mainly irrigated (75-90% area) in 57 districts, moderately irrigated (50-75% area) in 38 districts and marginally irrigated (25-50% area) in 45 districts of the country. The overall scenario resulted into higher than national average yield (1.2 t/ha) in 80 districts (Fig 2.6). The thematic maps of important attributes were overlapped and smoothened to generate dominant OSB land utilization types in the country. The OSB was found important crop in 242 districts only. It was identified as main commercial crop in 16 districts, second important commercial crop in 12 districts, subsistence crop in 78 districts and at different levels of commercialization in 136 districts (Fig 2.7.)

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, S.S. (Agronomy)

It is essential to harness full potential of OSB cultivars. Presently, only about one-third of the actual production potential is being realized at farmers' field. Adoption of intensification strategies could enhance the input use efficiencies and average yield of 3 + t/ha at small farms. With this hypothesis field experiments were carried out. The important results are summarized as under:

A. **System of Mustard Intensification:** The OSB var. NRCHB 101 seeded at normal (30 cm x 10 cm) and wide spacing (60 cm x 60 cm) was compared to transplanting. Root trainers were used for raising seed nursery. The pits in the root trainer were filled with a mixture of soil, sand and vermicompost in

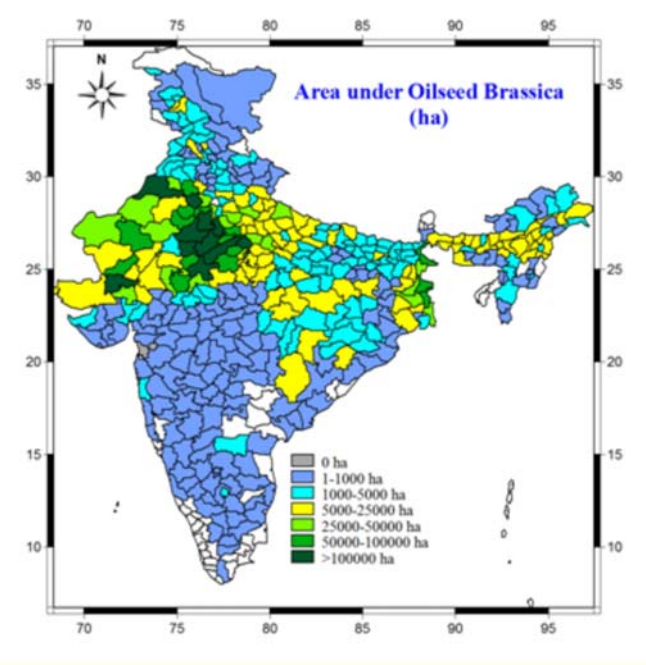


Fig. 2.4. Area (m ha)under oilseed brassica cultivation in different districts of India

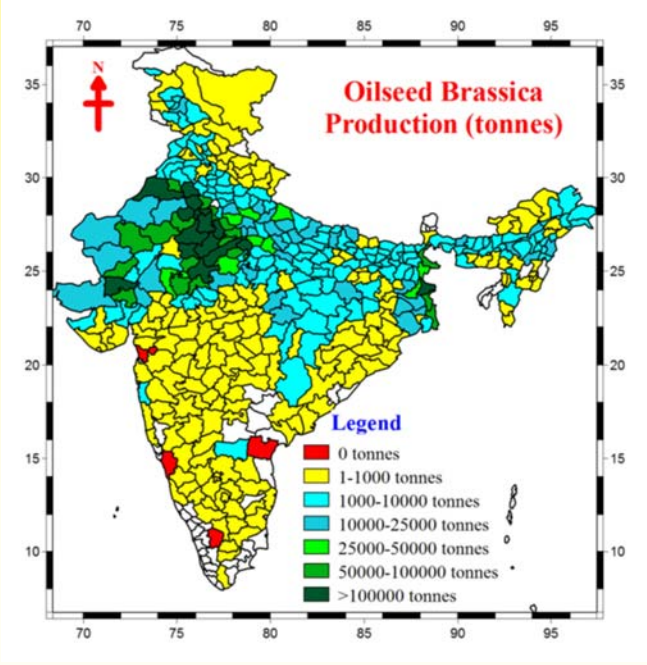


Fig 2.5. District wise oilseed brassica production (mt) status in India (Average value for 2008-2012)

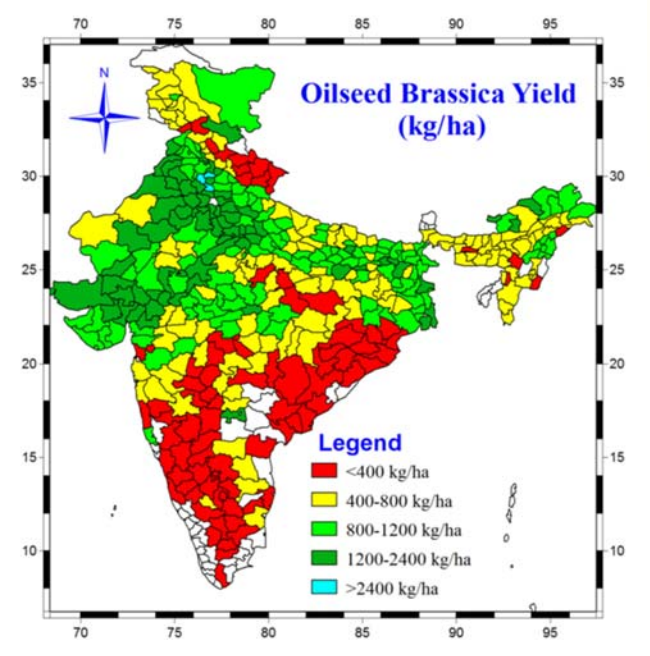


Fig 2.6. Average yield (kg/ha) in different districts.

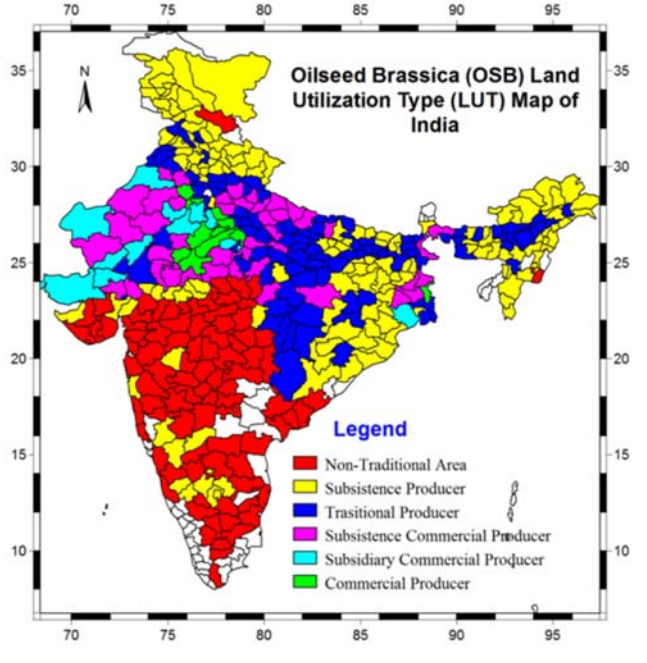


Fig 2.7. Dominant land utilization types (LUT) of oilseed brassica in India

equal proportion (v/v). Four seeds were placed in each pit of the root trainer and covered with vermicompost. After emergence single plant per pit was maintained. The pits (15 cm x 15 cm x 20 cm) at 60 cm x 60 cm spacing dig in the field for transplanting. Recommended fertilizers and vermicompost were mixed in the pits and kept overnight. Finally 13-days old seedlings were transplanted in the field and irrigated the field immediately after transplanting.

The wide spaced crop (WSC) significantly increased primary branches, secondary branches and siliquae per plant over narrow spaced crop (NSC). And transplanting further improved the siliquae/plant over WSC. Overall, WSC significantly improved the seed

yield by 13.8% over NSC (2.58 t/ha). Additional earthing/detopping at 30 DAS of WSC did not influence the seed yield significantly over WSC. However, transplanting significantly increased the seed yield by 18.4% over WSC and by 34.7% over NSC.

B. **Nitrogen requirement for wide spaced crop:** An experiment with different levels of N was undertaken to understand the N requirement of WSC in comparison to normal seeding. All the recommended levels of fertilizers except N were applied basal at both spacing. In normal seeding, N as per treatment was applied basal at last ploughing and top-dressed at 40 DAS in equal proportion. Nitrogen was band placed at 15 and 45 DAS in equal proportion in each WSC treatments. The successive increase in nitrogen level from control (0 kg N/ha) significantly improved the seed yield upto 120 kg N/ha (2.87 t/ha) in NSC and up to 150 kg/ha in WSC (4.59 t/ha) and thereafter the change in seed yield was insignificant (Fig 2.8). The rate of increase in seed yield due to N application (kg/ha) was (20.5- 0.14*N) kg seeds/kg N under NSC and (24.5-0.08*N) kg seeds/kg N under WSC. The regression studies reveal maximum seed yield at 146 kg N/ha under NSC and 306 kg N/ha at WSC while optimum yield at 101 kg N/ha under NSC and 226 kg N/ha under WSC.

C. **Screening of oilseed brassica germplasms for low nitrogen requirement:** OSB demands high amounts of N fertilizer often exceeding 150 kg N/ha to achieve maximum yields due to poor N uptake capability of the crop. Theoretically, the plant should efficiently translocate N to sink (seed) and the soil N balance after the harvest of the crop should remain in dynamic equilibrium in accordance to soil-climate continuum. Since OSB crops have successfully been cultivated in many extreme soil-site conditions and moisture regimes, variability in N uptake and translocation capacity of germplasms must exist. Keeping this hypothesis initially 125 OSB germplasms/ breeding lines/varieties were sown in N deficient soil in a plot size of 1.8 m x 2 m. All the nutrients except N were applied basal at recommended level. The plants were spaced at 60 cm x 60 cm to reduce the intra-species competition. The performance of the germplasms at low N level was assessed on the basis of yield attributes, yield (biological and economic), nitrogen uptake and N partitioning and grouped into three categories. In total 32 genotypes were assessed poor performers, 64 moderate performers and 24 high performers. The lines initially identifies as high performer includes- DRMRIJ 31, 78-1-1-1, DHR 991, EC 399294, EC 399300, EC 399307, GM 2, Rohini, HB 207, HB 9902, HB 9912, HB 9916, IC 212031, NATP 124, QM 16, RGN 55, NRCHB 101, NRCDR 2, NRCHB 506, Pusa Jaikisan, NDRE 7, RL 1359 and BEC 116.

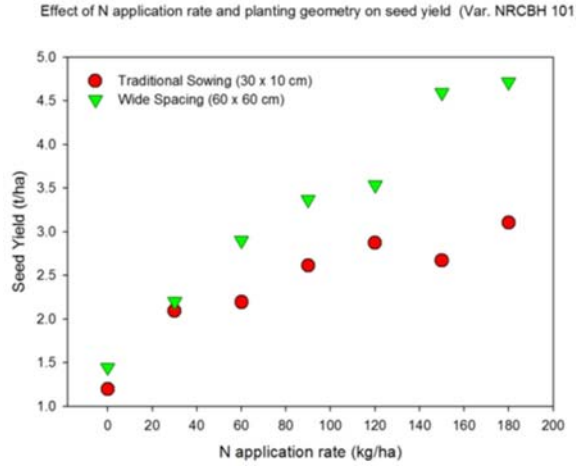


Fig 2.8. Seed yield of OSB (var. NRCHB 101) as influenced by varying N application rates.

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

The efficacy of hydrogel was evaluated at different irrigation scheduling under micro sprinkler irrigation system to Indian mustard. The replicated experiment was conducted in split plot design keeping hydrogel levels (0 and 2.5 kg/ha in main plot and irrigation scheduling (0, 0.4, 0.6 and 0.8 IW/CPE) in sub plots. The main and subplot treatments significantly influenced the seed, biological and oil yield of Indian mustard. In general

application of 2.5 kg hydrogel/ha significantly increased mustard seed yield by 32.3% over no hydrogel. Irrigation scheduling at 0.4 IW/CPE significantly increased the seed yield by 35.0% over no irrigation. Irrigation scheduling at 0.6 IW/CPE improved the seed yield by 70.6% over no irrigation and 26.3% over 0.4 IW/CPE. Further intensification of irrigation scheduling to 0.8 IW/CPE did not influence seed yield significantly over 0.6 IW/CPE. The interaction studies recorded significantly maximum seed yield when irrigation scheduling at 0.6 IW/CPE was supplemented with hydrogel. The combined treatment (0.6 IW/CPE + hydrogel significantly increased the seed yield by 34.1% over no hydrogel and 72.6% over no irrigation. Oil content was exceptionally higher under no irrigation irrespective of hydrogel application but it was maximum under no irrigation with use of hydrogel. The trend in oil yield was similar to seed yield. Maximum oil yield was recorded under 0.8 IW/CPE ratio with use of hydrogel. Production efficiency was higher at IW/CPE ratio 0.8 and 0.6 under use of hydrogel and it was more at every level of irrigation scheduling with use of hydrogel compared to without hydrogel. The production efficiency was minimum when neither irrigation nor hydrogel was applied (Table 2.7).

Economics was calculated on the basis of cost of cultivation, gross returns, net return, and B: C ratio. Gross return includes price of seed as well as crop residue. The MSP of mustard and prevailing market price of mustard residue (Rs. 3000/q) were used for economic analysis. Maximum net returns was estimated from 0.8 IW/CPE ratio with use of hydrogel but it remained comparable to 0.6 IW/CPE irrigation scheduling. No irrigation with use of hydrogel recorded maximum B: C ratio (1.92), followed by the irrigation scheduling at 0.8 (both with and without) and 0.6 IW/CPE ratio irrigation scheduling with the use of hydrogel (Table 2.8).

Land configuration under surface drip irrigation to enhance water use efficiency of Indian mustard

Seven mustard sowing strategies (normal sowing, 30/60 ridge and furrow-RF, 30/90 RF, 60/90BBF, 60/30 flat, 30/60 flat and 60/90 flat) were evaluated to assess their suitability in semi-arid (dry) tropics. Flat sowing at 60/30 and 30/60 flat resulted in maximum seed, biological, oil yield and production efficiency. The significant effect was also observed on harvest index under different land configuration under drip irrigation system. Better growth and yield attributes of Indian mustard (biomass/plant, main shoot length, primary branches, siliqua on primary branches, siliquae on secondary branches, total siliquae per plant, seeds per siliqua on main shoot, seeds per siliqua on main, primary and secondary shoots and 1000 seed weight) under 60/30 and 30/60 planting resulted in higher seed yield

Table 2.7. Seed, biological yield, production efficiency, and harvest index of Indian mustard under Micro-sprinkler irrigation with and without hydrogel (HG)

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Production efficiency (kg/ha/day)	Harvest index
With HG						
0.8	3103^{d}	9713^{bc}	42.42^{ab}	1317^{d}	23.0^{d}	0.32^{cd}
0.6	3115^{d}	9478^{bc}	41.88^{a}	1303^{d}	23.1^{d}	0.34^{d}
0.4	2506^{c}	8536^{ab}	41.92^{a}	1051^{c}	18.6^{c}	0.30^{bcd}
No Irrigation	1805^{ab}	6887^{ab}	43.02^{b}	776^{ab}	13.4^{ab}	0.26^{abc}
Without HG						
0.8	2453^{c}	105666^{c}	42.00^{a}	1030^{c}	18.2^{c}	0.24^{ab}
0.6	2323^{b}	9301b^{c}	42.40^{ab}	985^{b}	17.2^{bc}	0.25^{abc}
0.4	1799^{ab}	8330^{ab}	42.09^{a}	757^{ab}	13.3^{ab}	0.22^{a}
No Irrigation	1384^{a}	5648^{a}	42.67^{ab}	590^{a}	10.3^{a}	0.24^{abc}

Table 2.8. Net return and B:C Ratio of Indian mustard under microsprinkler irrigation with and without hydrogel (HG)

Treatments	Net returns (100% Subsidy)	Net returns (75% Subsidy)	B:C ratio (100 ratio % subsidy)	B:C (75 % subsidy)
With HG				
0.8	95660^{a}	79410^{c}	3.60^{bc}	1.85^{c}
0.6	95307^{ab}	79057^{c}	3.59^{bc}	1.85^{c}
0.4	74197^{c}	57947^{abc}	2.79^{ab}	1.35^{ab}
No Irrigation	49230^{b}	49230^{ab}	1.92^{a}	1.92^{c}
Without HG				
0.8	84450^{a}	68199^{b}	4.05^{c}	1.84^{c}
0.6	76766^{ab}	60516^{abc}	3.69^{bc}	1.63^{ab}
0.4	58130^{cb}	41880^{a}	2.79^{ab}	1.13^{a}
No Irrigation	38631^{c}	38631^{a}	1.95^{a}	1.95^{c}

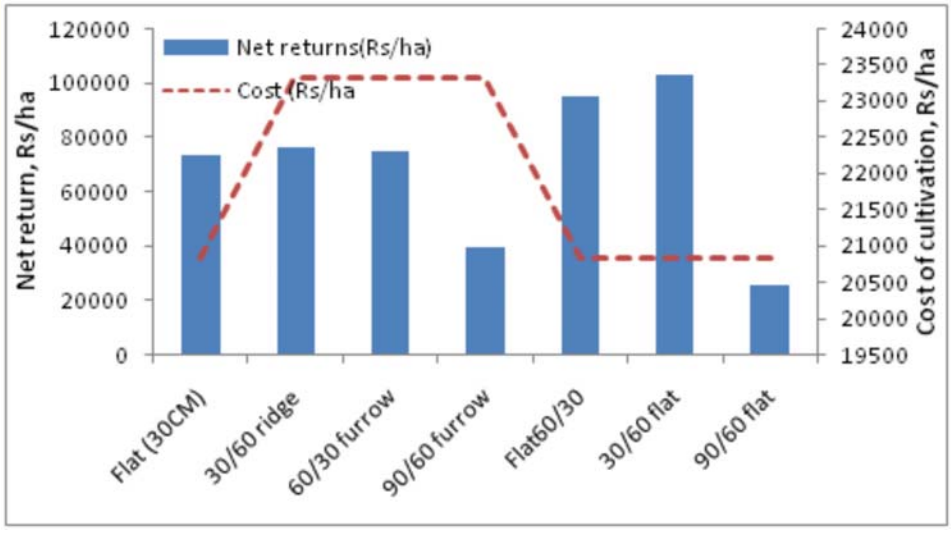


Fig 2.8. Economics of land configuration under drip irrigation system in Indian mustard

than other treatments. Maximum net returns were obtained from flat sowing at 30/60 followed by 60/30. The similar trend was also observed with B:C ratio. Among the ridge and furrow land configuration, 30/60 ridge and 60/30 furrow sowing recorded higher economics and lower cost of cultivation (Fig. 2.8).

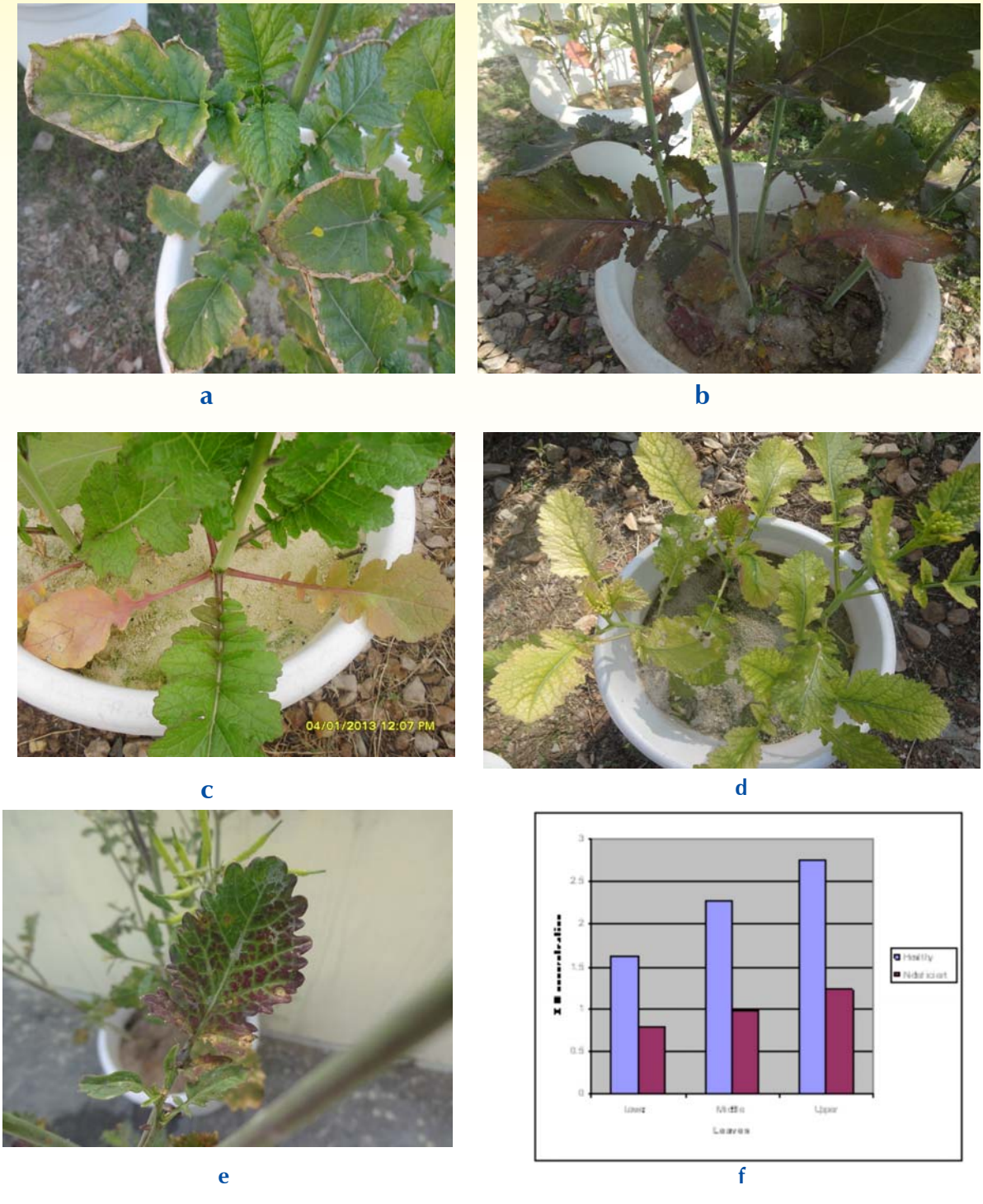
DRMR PHY4: Diagnosis of nutrient deficiencies in Indian mustard

Project Leader : S.P. Singh, Senior Scientist (Plant Physiology)

A sand culture pot experiment was conducted to characterize and validate the visual deficiency symptoms of N, P, K, Fe and Zn in Indian mustard var. NRCDR 2 was sown in plastic pots (45" x 41" size) having contamination free silica sand. Four healthy and uniform plants were maintained in each pot after establishment of plants. The culture solution used for growing the crop was based on the formula used at Long Ashton described by Hewitt (1966) and modified by Agarwala and Sharma (1976). For inducing the deficiency symptoms of N, P and K. The plants were initially raised with complete nutrient solution for 30 days and subjected to nitrogen, phosphorus and potassium deficient solutions as per treatment up to maturity. However, Fe and Zn deficient solutions were used since beginning to develop the deficiencies respectively. A parallel control set complete nutrient solution was also maintained.

Visual symptoms of nutrient deficiency:

a. Nitrogen : Deficiency symptoms of nitrogen in 2013-14 were similar to symptoms observed in 2012-13 (Fig.2.9 a). The N deficient plants initially showed anthocyanin pigmentation in main leaf vein proceeding from leaf-stem junction towards marginal side of the leaves and subsequently moved to minor veins. Gradually fully mature older leaves turned to a light purple colour and finally to uniform purple yellow colour. The symptoms intensified to next upper leaves in similar pattern. In due course the affected leaves dried up and withered.



a b c d e f

Fig. 2.9. Deficiency symptoms on leaves : a. nitrogen, b. phosphorus, c. potassium, d. iron, e. Zinc, f. N content in healthy vs deficient plant

b. Phosphorus : Initially bluish dark patches appearded on the fully matured older leaves of phosphorus deficient plant and gradually turned into pale colour and finally necrosis of upper half leaves (Fig.2.9 b).

c. Potassium : The K-deficient plants showed stunted growth, leaves become small, fleshy, deformed and curled downward. The chlorosis followed by necrosis starts from margins of lower and/ or middle and gradually spread to the inner surface of leaves (Fig.2.9 c).

d. Iron : Uniform interveinal chlorosis of younger leaves was observed in iron deficient plants. As the deficiency progressed leaf became almost white or bleached, however veins remained green. The newly emerging leaves were completely white (Fig.2.9 d).

e. Zinc : The zinc deficiency symptoms initially appeared on 3rd and 4th leaves. The leaves became light yellow to yellow in colour and brown spots were observed with progression of deficiency. Zn deficient plants are stunted and produce small, thin grains (Fig.2.9 e).

2.6. Management of biotic stresses in Indian mustard

DRMR ENT 2: Biological control of major pests of Brassica with special reference tomustard aphid

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

Associate : S.P. Singh, Senior Scientist (Agricultural Entomology)

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

Indian mustard variety NRCDR 2 was sown late in field 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 recorded on 3, 7 and 10th day 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.

Bio-intensive integrated pest management of mustard aphid

The experiment was sown in plot size of 4.2 x 3 m in three replication having cv. NRCDR 2. Ten treatments *i.e. Verticillium. lecanii* @ 10^8 CS/ ml followed by *Coccinella. septempunctata* @ 5,000 beetles/ha, NSKE @ 5% followed by *C. septempunctata* @ 5,000 beetles/ha, NSKE @ 5% followed by *V. lecanii* @ 10^8 CS/ml, *V. lecanii* @ 10^8 CS/ml followed by NSKE @ 5%, Dimethoate @ 1ml/litre followed by *V. lecanii* @ 10^8 CS/ml, Dimethoate @ 1ml/litre followed by *C. septempunctata* @ 5,000 beetles/ha, *V. lecanii* @ 10^8 CS/ml followed by dimethoate @ 1ml/litre, Neem oil @ 2% followed by *C. septempunctata* @ 5,000 beetles/ha, Neem oil @ 2% followed by *V. lecanii* @ 10^8 CS/ml and Control were taken for the spray against the mustard aphid. The maximum mean percent reduction of 97.0% was recorded in the treatment of Dimethoate @ 1 ml/l followed by *Coccinella septem-punctata* @ 5,000 beetles/ha with highest yield followed by *Verticillium lecanii* @ 10^8 CS/ml followed by Dimethoate @ 1 ml/l and Neem oil @ 2% followed by *Coccinella septempunctata* @ 5,000 beetles/ha.

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

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

Associate : S.P. Singh, Senior Scientist (Agril. Entomology)

Screening of germplasm against mustard aphid:

Two hundred twenty four accessions were evaluated to find out the resistance /tolerance against mustard aphid. Each accession was sown in paired row of 3 m length in three replications. Twelve entries *i.e.* DRMRIJ 05, JMM 927, RTM 1351, RTM 1359, RTM 314, TMB 29, RTM 2002, RTM 1212, TMB 2030,

JMT 04-03, RTM 1355 and T 27 were found highly resistant having the AAII less than 1.

Population dynamics of insect pests in rapeseed-mustard:

Six varieties from six species of rapeseed-mustard *i.e.* PCR 7 (*B. juncea*), GSC-6 (*B. napus*), BSH 1 (*B. rapa* var brown sarson), DLSC 2 (*B. carinata*), YST-1(*B. rapa* var yellow sarson) and T-27 (*Eruca sativa*) were sown in three replications in two conditions *i.e.* timely and late sown. The population of insect pests was observed on weekly basis. The highest mustard aphid population in timely sown crop was observed in 7th std. week in GSC 6, 8th std. week in BSH-1 and T 27, 9th std. week in PCR 7, 10th std. week in YST 151 and DLSC 2. 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. 2.10 a).

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 50th std. week under timely sown condition. The pest population again appeared in the 6th std. week and remained active till harvest in the 14th std. week with a peak. The same pattern was also observed in the late sown condition and peak was observed in the 14th std. week (Fig. 2.10 b).

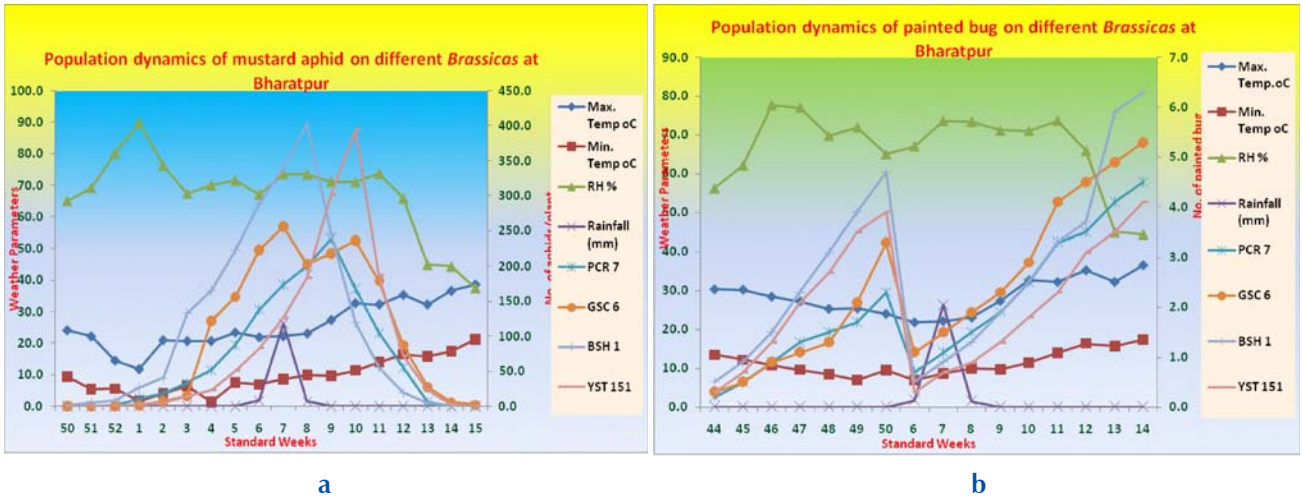
The population of leaf miner was first observed during 51st std. week in all six varieties except PCR 7, GSC 6 and DLSC 2. The peak was attained during 10th std. week in PCR-7, DLSC 2 & T-27 and in 8th std week in BSH-1 and YST 151 while GSC-6 had the peak in 9th std week in timely sown crop. In late sown crop the peak was observed in 9th std. week in PCR-7, T-27, BSH-1 and YST 151 while, in 10th std Week in DLSC 2 and in 14th Std Week in GSC 6.

Honeybee population appeared in different *Brassica* spp. Except *B. carinata* (DLSC 2) in 50th std. week under timely sown condition. The peak was attained during 6th std week in PCR 7 and BSH 1, 7th std. week in GSC 6, T 27 and YST 151 and 9th std. week in DLSC 2. Under late sown condition, honey bee population appeared in 52nd std. week in all species except DLSC 2 (4th std. week) and attained peak in 8th std. week in PCR 7, in 9th std. week in BSH 1 and YST 151, in 10th std. week in GSC 6, T 27 and DLSC 2.

Leaf webber was also observed damaging the timely sown crop specially varieties PCR 7 and GSC 6 and cabbage caterpillar was observed in DLSC 2.

Assessment of yield losses due to insect pests in Brassica crops:

The experiment was sown in plot size of 4.2 x 3 m in eight replications having two *Brassica* species *i.e. B. juncea* (varieties NRCDR 2 and Rohini) and *B. rapa* (BSH 1) under two conditions *viz.* protected and unprotected. In the protected plots weekly spray of recommended insecticide was provided to control the insect pests. The highest yield loss



a b

Fig. 2.10. Population dynamics of (a) mustard aphid, (b) pained bug on different species of *Brassicas*

The biochemical analysis of the inflorescence part of Brassica genotypes revealed that purple mutant, DLSC 2 and T 27 had the higher glucosinolates while phenol content was highest in purple mutant followed by DLSC 2 and T 27 showing the resistance to the mustard aphid. The lectins activity of 4 HU/ml was observed in the inflorescence part of purple mutant, JMM 927, GSC 6, DLSC 2 and T 27. In pods, highest glucosinolates was observed in T 27 followed by purple mutant and DLSC 2 while phenol was higher in purple mutant, DLSC 2 and T 27.

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

The epidemiology of Sclerotinia rot of Indian mustard (*Brassica juncea* L.) was investigated during 2004-05 to 2011-12 and the forecasting models were developed and validated in 2012-13. The carpogenic infection initiated in 52nd std week and continued during 1-3 standard weeks. Disease first appeared after closure of the crop canopy when flowering started. During epidemics, last 8 years mean daily maximum and minimum air temperature was 19.4 and 5.1°C, morning and afternoon RH 95 and 62 per cent, bright sunshine hours 4.9 and rainfall was 1.4 mm (Fig. 2.11) seems favourable for disease development. The R^2 value of the regression analysis between observed and estimated SR prevalence was 0.98.

Germplasm Screening for Sclerotinia rot

Fifty (27 IVT, 14 NDN, 9 breeding line) germplasm lines of *Brassica juncea, B. carinata* and *B. napus* were screened under sick plot at DRMR during 2013-14 season, sown on 28 Oct 2013 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. Rohini and NRCYS 5-2 (susceptible check) in randomized block design with two replications.

Data observed for reaction to the disease indicated that all test lines screened were susceptible. Nine *B. carinata* lines were also screened with artificial stem inoculation technique. DRMR 261 expressed tolerant reaction (lesion size <3.0 cm and disease incidence <10%).

Management of Sclerotinia rot

An experiment on management of Sclerotinia rot was laid out in randomized block design with 8 treatments (including control) *viz.*, seed treatment of *Trichoderma* (8 g/kg) and carbendazim (2g/kg), combinations of seed treatment (ST) and foliar spray (FS) (0.1%) of carbendazim, ST+FS *Trichoderma* and FS *Pseudomonas fluorescens* (10^8 cfu/ml) at flowering stage in four replications on Sclerotinia infested plot. The crop was sown on 28 Oct 2013. Among different treatments, carbendazim ST+ FS provided highest yield (2067 kg/ha) and minimum per cent disease incidence (4.6%) as compared to control (1333 kg/ha and 37.3%).

Variability in morphological growth of *S. sclerotiorum* on different carbon sources

Fungi can use a variety of carbon sources to derive cellular energy. *Sclerotinia* utilizes several

Forecasting models for Sclerotinia rot

Date of planting	Models	R^2	Forecast 2011-12	
			observed	forecast
8 October	$Y=3.93 + 0.002 * Z_{341}$	0.97	28.0	24.3
29 October	$Y= 51.296 + 0.958 Z_{50} + 0.289 Z_{31} -0.164 Z_{41}$	0.98	37.9	32.9
19 Nov.	$Y= 8.276 + 1.6217 Z_{21} + 0.013 Z_{451}$	0.98	18.8	19.6

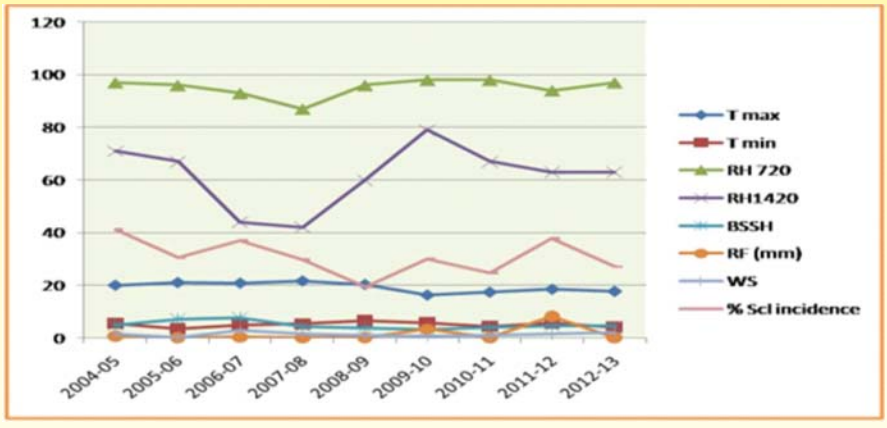
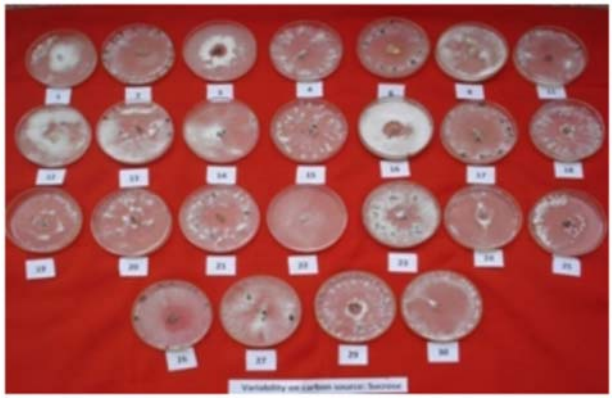
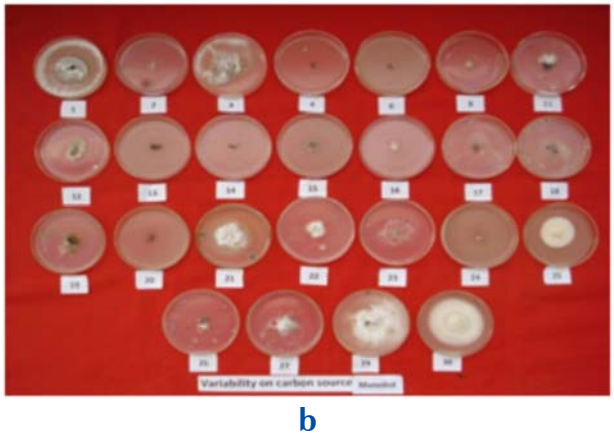


Fig.2.11. Weather variables and per cent Sclerotinia incidence in different years

organic compounds as sources of carbon for both mycelial growth and sclerotium formation. The Czapek dox media was used during the study and different carbon sources were replaced in the media *viz*, dextrose, glucose, maltose, fructose and mannitol.



a



b

Fig.2.12. a. Mycelial growth on sucrose carbon source, b. Mycelial growth on mannitol carbon source

The maximum mycelial growth was of isolate SR 19 (74.5 mm) followed by SR 23 (69.0 mm) while, minimum mycelial growth was in SR 1 (20.5 mm) when sucrose was used as carbon source. In dextrose supplemented medium maximum growth was of isolates SR 15 and SR 24 (72.5 mm each) while, minimum mycelium growth was recorded in SR 22 (20.0 mm). SR 15 and SR 24 also produced maximum number of sclerotia (33 sclerotia each). On media supplemented with maltose as carbon source, SR 4 and SR 15 showed maximum growth (72.5 mm) while, SR 1 showed minimum (20.5 mm) growth. When glucose was used as carbon source, maximum mycelium growth was in SR 4 (70.5 mm). On fructose as carbon source SR 29 showed maximum growth (72.0 mm) while, SR 15 showed minimum (8.5 mm) growth. SR15, SR 19, SR 22, SR 23 and SR 27 did not produce any sclerotia. On mannitol as carbon source, SR-18 produced maximum (70.0 mm) and SR 14 produced minimum (2.0 mm) growth. Mannitol was not found suitable carbon source for isolates SR 2, SR 4, SR 6, SR 12, SR 13, SR 14, SR 15, SR 16, SR 20, SR 21, SR 22 and SR 24. On the basis of mycelial growth as well as number of sclerotia developed, manitol was not found suitable for the growth of *S. sclerotium* (Fig. 2.12. a & b).

Effect of different dilutions of partially purified toxin(s) produced by *S. sclerotiorum*

Toxin study

Fungal pathogens are known to synthesize various kinds of secondary metabolites which play a key role in pathogenesis.

Bioassay of partially purified toxins produced by *S. sclerotiorum* was carried out on mustard, tomato, chilli, brinjal and okra with toxin produced by *S. sclerotiorum* that were cultured on six different carbon sources. Among six different carbon sources and three different

dilutions, the maximum wilting and chlorosis of mustard leaves was observed on sucrose followed by dextrose. The partially purified toxin showed the gradual increase in symptoms from 12 to 24 hours. On tomato twigs the partially purified toxins resulted in maximum wilting and chlorosis (5.0) at 2:8 (DDW: PPT) reported after 24 hours on sucrose. The carbon source played important role in toxin production, when partially purified toxin was observed on brinjal leaves sucrose followed by glucose produced maximum wilting and chlorosis. On chilli leaves among different carbon sources produced toxin at highest dilution 2:8 gave maximum expression of wilting and chlorosis symptoms while mannitol gave minimum expression of symptoms which may be due to effect of carbon source. The effect of partially purified toxin when observed on okra leaves it was found that the wilting and chlorosis gradually increased after 12 hours and reached maximum at 24 hours. Maximum wilting and chlorosis was in highest dilution concentration of sucrose.

Effects on Seed germination and seedling vigour

Seeds of susceptible cultivars of Indian mustard cv Rohini were soaked in different dilutions of partially purified toxin separately for 4 hr. The different dilutions of toxin retarded the germination of the seeds. Per cent inhibition in germination ranged from 16.0 to 36.0. The toxin also affected root and shoot length. Maximum per cent inhibition of root (48.0%) and shoot (45.0%) length of toxin treated seedlings after 7 days was found with dilution 2:8 of *S. sclerotiorum*.

Variability for disease reaction against *Sclerotinia sclerotiorum* on different species of Brassica

Disease reaction after stem inoculation with *S. sclerotiorum* on nine different species of Brassica were observed after 3 weeks. In terms of per cent infection *B. juncea* cv Rohini expressed maximum per cent infection (90.0 %), maximum lesion size was in isolate SR 4 and SR 10 (25.1 cm) while, minimum in SR 20 (3.6 cm). However among different cultivated *Brassica* species *B. carinata* was having slight tolerance to Sclerotinia rot. Per cent infection ranged from 18.2-59.0 %. The lesion size was maximum in isolate SR 3 (3.8 cm) while, it was minimum (0.3cm) in SR 14. Isolates SR 04, SR 06, SR 18 showed maximum infection in *B. rapa var toria* (91.3 %). Lesion size was largest in SR 24 (39 cm) and lowest in SR 22 (5.5 cm). *B. rapa var yellow sarson* (NRCYS 5-2) showed maximum sensitivity in infection with SR 21 (91.6 %). Lesion size was maximum in SR 25 (36.7cm) and minimum in SR 15 (4.5 cm). In *B. nigra* (BN-1) SR 17 showed maximum per cent infection (83.3) and lesion size minimum in SR 7 (1.9 cm) and maximum in SR 10 (29.8 cm). While in *B. napus* (GSC6) lesion size was largest in SR 20 (11.5 cm), smallest in SR 13 (0.5 cm) and infection was maximum in SR 2 (80.1 %). *Eruca sativa* (T-27) was most sensitive to all different geographical isolates and showed maximum infection in SR 2 (94.8 %). *B. rapa* var brown sarson (KOS 1) had maximum infection in SR 3 (83.3 %). Among different cultivated species of Brassica and *B. alba* tested against different isolates of *S. sclerotiorum*, *B. alba* did not show infection. However the lesion size ranged from 0.3 to 1.9 cm (Fig. 2.13)

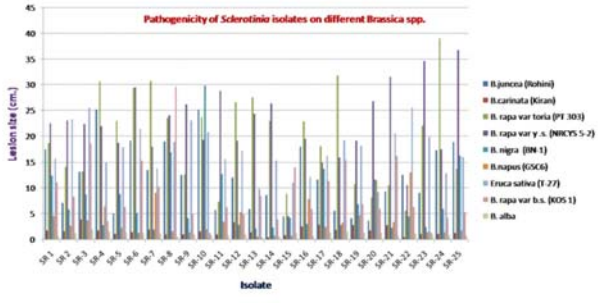


Fig.2.13. Pathogenicity of Sclerotinia isolates on different Brassica spp.

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

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

Associate : Pankaj Sharma, Senior Scientist (Plant Pathology)

Epidemiology

First symptoms of Alternaria leaf blight (ABL) disease in 22nd October sown crop were observed on Jan 09 (78 DAS) and on Feb 05 (105 DAS) in cv. Varuna and NRCDR 2, respectively of Indian mustard. Higher disease severity both on leaves and pods was observed

in December 03 followed by November 26 sown crop, as the crop coincided with the favourable weather conditions for disease development. Young plants below 35 days did not show disease development on the leaves. Cultivar Varuna appeared to be more susceptible as compared to NRCDR 2.

Characterization of tolerance to Alternaria blight in *Brassica juncea*

Management of this disease is a challenge for plant pathologist due to unavailability of resistant sources against the pathogen. Keeping in view, a total of 23 genotypes of different *Brassica* species were characterized for Alternaria blight tolerance under artificial conditions in field for two consecutive years (2011-12 and 2012-13). Among the test genotypes, DRMR-2800 (5.3%), DRMR-2805 (6.0%), DRMR-2807 (7.0%) and DRMR-2806 (8.0%), were found promising with higher level of tolerance against Alternaria blight recorded on leaves, as compared to susceptible check Rohini (28.0%) at 90-100 days after sowing. Genetic diversity study using SSR markers revealed a high level of similarity (90%) between accessions DRMR-11-2805 and DRMR-11-2806 as compared to other genotypes. Based on the ANOVA, heritability (h^2) values ranged from 0.58 (seeds/siliqua) to 0.99 (seed yield/plant) while the genetic advance (GA) varied from 3.7 % (oil content) to 106.1% (seed yield/plant).

Genetic Characterization through SSR and Protein Profiling in Indian mustard against Alternaria blight (*Alternaria brassicae*)

The polymorphism was exhibited by SSR primers among all the genotypes. In our studies, *B. alba* showed least similarity (68%) with others genotypes and the accessions DRMR-11-2805 and DRMR-11-2806 showed 90% similarity. Protein fragments of various molecular weights were separated in *Brassica* species. Individual protein fragments were considered as allele/loci. Overall 81% of similarity between genotypes was observed but among these *B. alba* showed less similarity (42%) with *Brassica juncea*.

Alternaria blight management

An experiment was conducted to evaluate new fungicides and bioagents for the management of Alternaria blight in Indian mustard. Data revealed significant reduction in Alternaria blight on leaves by foliar spray of mancozeb and seed treatment and foliar spray of propiconazole over control. Minimum disease severity was recorded in mancozeb ST+ FS (8.6%) followed by foliar spray alone by mancozeb (12.9 %) and foliar spray of propiconazole (15.4 %).

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 experiment, the sowing was done at 3 dates *i.e.* October 25, November 09, and November 24, 2012. The disease was noticed quite late, during the 2nd week of January and progressed very slowly up to the 1st week of February. A sharp increase in disease was observed during 3rd week of February on both early and late sown crop. Light precipitation received in the month of February and 90% RH during morning hours might have favored rapid spread of the disease. No significant correlation was observed between the soil moisture and disease index. Staghead formation was very rare and was noticed in late sown crop only. Also, the disease severity on pods was maximum in late sown crop as compared to timely sown crop. The maximum disease index (62.2%) was observed in late sown (24th November, 2012) crop whereas, the minimum disease index (38.8%)

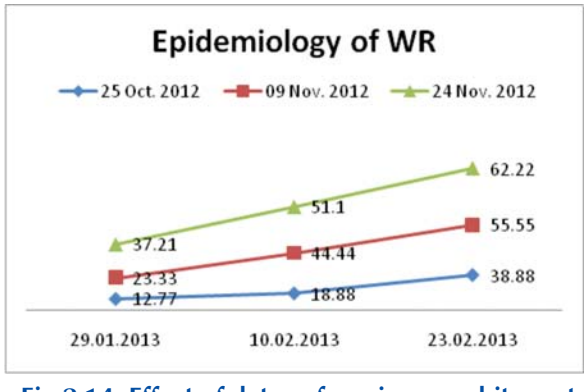


Fig.2.14. Effect of dates of sowing on white rust disease index

was observed in timely sown (25st October, 2012) crop. However, on 09th November sown crop the disease index was 55.5% (Fig. 2.14).

In white rust management experiment, no significant differences were observed among the treatments used. The disease pressure varied among the treatments from 15.5 to 46.7 %. Under management study, Maximum (48.1 %) reduction in disease index was observed with foliar spray of carbendazim (0.1 %) followed by ST (Apron SD 35@ 6g/kg seed) + foliar spray of Quintal (0.2 %) and seed treatment with Apron SD 35 (@ 6g/kg seed) + foliar spray of Folicur (0.1 %). Minimum reduction in disease index (Fig. 2.15) was recorded with foliar sprays of *Pseudomonas fluorescence* (15.6 %) and *Bacillus subtilis* (17.7 %).

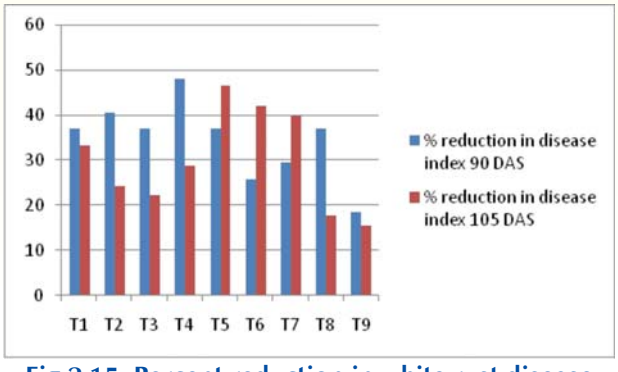


Fig.2.15. Percent reduction in white rust disease index with different treatments

T_1= Seed treatment with Apron SD 35@ 6g/kg seed; T_2= Foliar spray of Quintal@ 0.2%; T_3= Foliar spray of Folicur @ 0.1%; T_4= Foliar spray of Carbendazim @ 0.1%; T_5= T_1+T_2 ; T_6= T_1+T_3; T_7= T_1+T_4; T_8= Foliar spray of *Bacillus subtilis* (10^9 cfu); T_9 = Foliar spray of *Pseudomonas fluorescence* (10^9 cfu).

Among 80 segregating lines of rapeseed-mustard screened for resistance to WR at Bharatpur and Wellington, BPR-1480-410a-SPS-1(1), BPR-1480-427b-SPS-1(1), BPR-1480-425A-SPS-1(1) and BPR-1512-444A-SPS-1(1) were found resistant to white rust at Bharatpur but showed susceptibility at Wellington. BPR-1480-419d-SPS-1(1) was found tolerant to Alternaria blight at Bharatpur. EC 399313, JM-11, DMH-1 and EC 399296 gave differential reaction to Bharatpur and Hisar isolates of *A. candida* NRCDR 515, GSL 1 and PBC 9221 gave resistant reaction to both the isolates of *A. candida*.

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)

Associates : Lijo Thomas, Scientist, SS (Agril. Economics), Vinod Kumar, Senior Scientist (Computer Application)

Adoption pattern of recommended mustard technologies and perception of farmers for non-adoption

For the purpose of the study, a sample of 25 mustard growing farmers from each of the selected 10 villages, namely; Babain, Murwara, Haithaini, Unchagaon, Paharsar, Gadoli, Ekta, Vijaypura, Kasot and Gamdi of Bharatpur district of Rajasthan (a total of 250 respondents) were interviewed randomly during the crop season 2012-13.

All the recommended mustard production practices/technologies were broadly classified in three groups *viz.* crop management practices, crop nutrition practices and plant protection practices. The responses of respondent farmers were recorded for two aspects *viz.*, knowledge and adoption of different recommended practices of mustard production technology. The data were collected from the respondents through interview, focused group discussion, metrics, triangulation, etc. on these aspects based on the following criteria:-

i) Knowledge: When farmer has complete information including mode of application of recommendations about a technology, its cost, its availability, relative profit, *etc.*

ii) Adoption: Farmers used the full technology continuously on a full scale as recommended by research system.

Regarding crop management practices, the study reported that 94.0 per cent respondents had the knowledge of sowing time of mustard crop followed by 92.0 per cent respondents having the knowledge of high yielding varieties.

The adoption level of timely sowing (78%) was also high, however, low than the knowledge level because sowing was depended on rainfall and available soil moisture as majority of respondents sow the seed in conserved moisture. The high level of knowledge also led to high adoption (80.8%) of high yielding varieties. It was also worthy to note that about 60 per cent farmers, adopting high yielding varieties were using varieties of private sector and 30 per cent farmers were using varieties of public sector. The 10 per cent farmers were using varieties purchased from fellow farmers or open mandi. Majority of farmers reported that they didn't have access to or information about the seed of new varieties released by the public sector. Some farmers reported that number of varieties of public as well as private sector are at par in performance but private sector with better marketing campaigning, strategies, better grading, packing, local availability, *etc*. than public sector led to wide adoption of private sector varieties.

It was also interesting to note that 88.0 per cent respondents had the knowledge of proper seed rate but adoption level was only 12.0 per cent. Respondents reported that they had to put higher seed rate due to fear of poor germination in high temperature at the time of sowing and damage of crop by painted bug at early stage. Despite having high knowledge (82.0%) of recommended irrigation management, the component was adopted by only 68.0 per cent respondents due to dependency of some respondents on other fellow farmers for irrigation water. The knowledge about sowing method was had by 78.0 per cent respondents and adopted by 66.6 per cent respondents. About 76.00 per cent respondents had the knowledge about harvesting & threshing. However the recommended practices of harvesting & threshing were adopted by only 46.0 per cent respondents due to non availability of labourers and threshers.

The knowledge of weed management and thinning was held by 64.0 and 46.0 percent respondents, respectively. However, there was poor adoption of weed management practices only by 28.0 per cent respondents. Among all the crop management practices of mustard production, thinning was not being adopted by the respondents. Only 3.60 per cent reported that sometimes they did the thinning. Majority of respondents reported that the intensive labour investment in these two components prevented them not to adopt these practices.

The low knowledge level (32.0%) was found about frost and only 4.0 percent sometimes adopted the management practices of frost like burning of residues and waste materials in the study area. There was poor knowledge (28%) and adoption (18%) level regarding proper field preparation due to set perception of the respondents.

Regarding crop nutrition practices of mustard production, the level of knowledge and adoption of recommended doses of different nutrients/fertilizers was very low indicated imbalance use of fertilizers in study area. It was interesting to note that majority of respondents had knowledge about the importance of different nutrients in mustard production but they did not have the knowledge of recommended doses, proper method of use, *etc*. The application of fertilizers should be based on soil testing. However, majority of respondents using the fertilizers as per their knowledge and experiences of getting responses from applied doses of different kind of fertilizers specially nitrogenous and phosphate fertilizers without soil testing due to one or other reasons.

It was found that the highest knowledge was in case of phosphate fertilizers by 32.0 per cent respondents but adoption of recommended doses was higher by 44.0 per cent respondents. Similarly, knowledge of recommended dose of nitrogenous fertilizers was low (24.0%) but adoption was slightly higher (38.0%) than the level of knowledge possessed. It might be thought how it was possible that adoption was higher than knowledge possessed by a respondent. It might be because of that respondents were using these fertilizers for long times and as per their experiences of getting response of different levels of doses of the fertilizers in their own field, they were using the doses of these fertilizers which had also been recommended.

The knowledge and adoption of F.Y.M. were had by 26.0 and 12.0 per cent respondents,

respectively due to limited/non-availability of F.Y.M. in the area. The knowledge of sulphur was possessed by 22.0 per cent respondents and component was adopted by only 18.0 per cent respondents. About 20.0 per cent respondents had the knowledge about green manuring which was adopted by 14.0 per cent respondents. The knowledge about Zinc, PSB, Azotobacter and Boron was possessed by only few respondents which were 12.0, 10.0, 9.2, and 8.0 per cent respondents, respectively. The 6.0 per cent respondents sometimes used the zinc and PSB culture, while, none had adopted Azotobacter and Boron in study area.

Among recommended plant protection practices of mustard production, it was observed that 66.0 per cent respondents had the knowledge of summer deep ploughing but adoption was very low (18%). The knowledge and adoption of seed treatment was reported by 64.0 and 44.0 per cent respondents, respectively. It was also noted that knowledge of destruction of crop residues & affected plants/parts was had by 38.0 per cent, but the practice was adopted by only 6.0 per cent respondents.

The study also found that respondents had very poor knowledge about soil treatment, dusting/ spraying of insecticides and fungicides ranged from 22.0 to 36.0 Per cent and these plant protection practices were also not adopted by majority of the respondents (adoption level ranged only from 8.0 - to 12.0 per cent respondents)

Important reasons for non-adoption of recommended technology

The lack of knowledge & motivation, lack of resources, low net returns, non-availability of required inputs locally, high cost of inputs/ machinery, non availability of labourers, non-availability of required/suitable equipments, non-availability in time and inferior quality of required inputs (seeds, fertilizer, pesticides, etc.), lack of assured irrigation, lack of soil/ plant analysis facility and fear of losses due to adoption of new technology/recommendations were perceived important constraints/ reasons by majority of the respondents as responsible for non adoption of recommended mustard production technology.

DRMR ECT-7: Assessment of Technology, Risk & Returns in Rapeseed-Mustard Cultivation

Project Leader : Lijo Thomas, Scientist, SS (Agril. Economics)

Associate : A.K. Sharma, Senior Scientist (Agril. Extension)

The ex-post analysis of varietal technology using economic surplus approach was done under the project. The results obtained indicated that the investment in varietal development efforts were fully justified given the stream of benefits arising out of varietal replacement over the years. This strengthens the argument for higher investments for the development of improved varieties. The quantification of production risk in rapeseed-mustard cultivation was undertaken with a view to develop region specific risk profile of the crop. The quantification of risk involved in the cultivation of RM and its competing crops at the state level revealed that the risk associated with the cultivation of RM is more than that of wheat. Using the time series data obtained from CACP, the cost and returns from rapeseed-mustard cultivation in major states were analyzed to study the trends in gross profits, implicit price of produce, relative competitiveness *etc*. The returns to investment from rapeseed-mustard were compared with wheat, the major competing crop. It was found that RM crop gave better returns on investment. However, it should be noted that the gross returns were higher from wheat cultivation in comparison to RM cultivation. The analysis of district wise data on area and productivity of RM across the country revealed the existence of opportunities for enhancement of rapeseed-mustard production in the country through strategic interventions. The need to accord higher priority to the strategic research component emerged from the study. Region specific approach was recommended for major producing states of RM in the country. The level of productivity required to make the mustard crop competitive with respect to its major competing crops was computed. The better risk profile of wheat is one major reason for the preference of wheat crop even when the returns to investment are higher for RM crop. The structure of cost of cultivation of RM studied

using secondary data showed that the quantity of fertilizers and machine labour has shown a significant increase over the years whereas the animal labour use in cultivation has become almost negligible. The change in structure of the use of inputs and the resultant cost structure has implications for the efforts in enhancing the energy efficiency of rapeseed-mustard cultivation.

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

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

The scientific work of the researchers or research institutes is generally assessed by the quality of resulting research publications. Therefore, need arises to maintain information on publications in an organized and accessible manner. We implemented an Agricultural Publications Information System prototype named as DRMRPubinfo for the documentation of research publications and evaluation of performance of institutions involved in agricultural research. This prototype, which supports a wide range of publication types, is designed to meet the specific requirements of agricultural research institutions and has features like advanced search option, extraction of publications statistics based on a variety of visual queries, *etc*. For filtering and effective searching, metadata formats suitable for describing scientific publications have been used in creating the database. Several workflow procedures maintain data quality and the system allows to the researchers/users to enter the publication data in the database themselves. Public search facility has also been provided for searching records, dynamic browsing of publication lists and exporting the contents to various formats for creation of reports. This DRMRPubinfo prototype can serve as a versatile tool for monitoring progress and facilitating evaluation of research quality at the individual and institutional levels. The system has been developed using open source platform LAMP.

Updation and maintenance of web site

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

Externally funded projects

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

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

Associate : J. Nanjundan, Scientist (Genetics & Plant Breeding)

The major activities accomplished under DUS Testing during the year 2012-13 were evaluation and maintenance of rapeseed-mustard varieties.

Evaluation: DUS Testing of two candidate varieties, 08 varieties of common knowledge, one farmers' variety alongwith 26 reference varieties of *Brassica juncea* was performed following DUS Test guideleines. Observations on leaf colour, flower colour, time of flowering, maturity period, number of leaf lobes, leaf length, leaf width, length of petals, width of petals, main shoot length, plant height, siliqua length, siliqua beak length, siliquae number on main shoot, siliqua density on main shoot, leaf hairiness, leaf lobes, dentation of margin, siliqua angle and siliqua surface texture were recorded and report on DUS characteristics on candidate varieties was communicated to PPV & FRA.

Maintenance: One hundred twenty varieties including Indian mustard (82), karan rai (06), toria (12), yellow sarson (12), brown sarson (02) and gobhi sarson (06) were maintained through appropriate mating system:

ICAR seed project on Seed Production in Agricultural Crops

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

Associates : Incharge Farm and A.K. Sharma, Senior Scientist, Agricultural Extension

Seed Production

151.8 q certified seed of wheat and 259 q TL seed of mustard varieties was produced during 2012-13. In addition 124.26 q TL seed of

mustard varieties NRCDR 2 and NRCHB 101 was produced at farmer's field under participatory mode.

DRMR NP 2a

ICAR-NPTC: Development of aphid resistant transgenic Brassica

Project Leader : Ajay Kumar Thakur, Scientist, Senior Scale (Biotechnology)

Associates : P.K. Rai, Principal Scientist (Plant Pathology), Y.P. Singh, Principal Scientist (Entomology)

During 2013-2014, twelve independent putative transgenic events in *B. juncea* var. Pusabold had been developed with chickpea (*Cicer arietinum*) *lectin* gene via *Agrobacterium tumefaciens*-mediated gene transfer technique. Molecular characterization of the putative transgenic plants was carried out by PCR using *npt-II* gene specific primers. Three out of twelve putative transgenic events were found to be PCR positive. The PCR positive transgenic shoots are being multiplied and maintained on selective shoot regeneration medium containing 20 mg/l kanamycin and 250 mg/l cefotaxime.

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

Generation advancement of recombinant inbred lines (RILs)

F_5 seeds of RILs {Rohini x PHR-2 (QTLs mapping for Altrenaria tolerance) and Rohini x PBR-97 and Rohini x RH-819 (QTLs mapping for drought/ heat tolerance)} were harvested. Further, F_5 seeds of cross combinations Rohini x PBR-97 and Rohini x RH-819 were raised for generation advancement and to observe the draught related traits in augmented design with suitable check in 2 row of 4 m length with 45 cm row to row and 15 cm plant to plant spacings. Also, F_5 population of Rohini x PHR-2 were raised in single row of 3 m length keeping 45 x 15 cm row to row and plant to palnt spacings, respectively for generation advancement as well for Alternaria blight reaction. Isolates of *A. brassicae* were maintained through sub-culturing.

Out Reach Programme on Diagnosis and Management of Leaf spot diseases of Field and Horticultural crops

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

Associate : Pankaj Sharma, Senior Scientist (Plant Pathology)

Maintenance of *Alternaria brassicae* repository

Total 30 *Alternaria brassicae* isolates were maintained at DRMR, Bharatpur under this project. It was found first time that the cultures could be maintained on natural media *i.e.* Brassica broth and tomato broth with suitable carbon sources.

Tomato extract agar in dark

This natural media was used for the suitable growth and comparative study of *Alternaria brassicae*. Sucrose (20 g/l) was added as a carbon source. Radial growth was measured on 7th day after inoculation. Average radial growth of 29 isolates was 25.13 mm however the isolate BAB-29 showed maximum growth 41.75 mm and isolate BAB-20 grew least with 12.75mm growth. Results indicated that the tomato extract agar media was better for the growth and the maintenance of *Alternaria brassicae* cultures. The results also represented the existence of variability among the isolates. Physiological characters were varied among the *Alternaria brassicae* isolates.

Brassica leaf extract agar in Dark

The growth condition for the pathogen was 25^{o}C without light. Sucrose was used as a carbon source in media. The average growth of all isolates was 18.9 mm, whereas, the maximum growth was in isolate BAB-39 (35.6 mm) and minimum growth was of isolate BAB-54 (16.0 mm).

Effect of light/ dark on mycelial growth of *Alternaria brassicae* isolates

An experiment was conducted to observe the effect of light on mycelial growth and variability among the 25 isolates of *A. brassicae.* Varied growth observed in the different isolates showed the existence of variability among isolates. Surprisingly the results indicated that some isolates grew well in light but some other isolates showed good growth in dark. Minor increase in growth was observed due to light but reverse effect was also observed in dark. Maximum mycelial growth due to light was recorded in isolates BAB-45, BAB-09, BAB-06, BAB- 43 and BAB-41. However, the maximum growth due to darkness was recorded in isolates BAB-08, BAB-54, BAB-40 and BAB-20 (Fig 2.16).

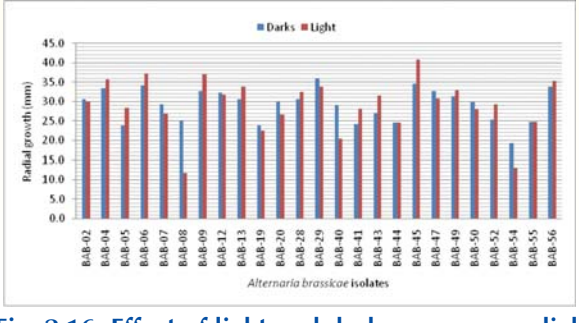


Fig. 2.16. Effect of light and darkness on mycelial growth of *Alternaria brassicae* isolates

Effect of different carbon sources on growth of *A. brassicae* isolates using Elliot s Agar

An experiment was conducted using 25 *A. brassicae* isolates on Elliot's agar media with different carbon sources including Sucrose, Dextrose, Maltose, D-Mannitol, and Fructose to find out the favourable carbon source for the growth of *A. brassicae* and variability among the isolates. Elliot's agar media supplemented with fructose and maltose were found suitable for vigorous growth of *A. brassicae* followed by Sucrose, Dextrose and D-Mannitol, while minimum growth rate was observed in dextrose. Sporulation was maximum in media having maltose as carbon source indicating that vigorous growth of cultures is supported by more sporulation carbon source. Maximum sporulation was observed in BAB 13 followed by BAB-12 and BAB-50 isolates on Elliots's medium. The result showed the existence of variability among *A. brassicae* isolates based on mycelial growth, morphology, cultural growth on different carbon sources in media. The physiological characteristic and sporulation was examined on the basis of different carbon sources *viz.*, Dextrose, Sucrose, Fructose, D-Mannitol and Maltose (Fig 2.17).

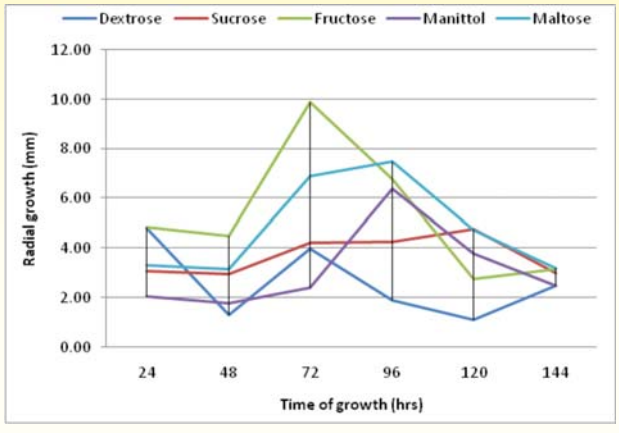


Fig. 2.17. Effect of different carbon sources on growth of Alternaria brassicae

Total seed protein profiling of Alternaria blight resistant promising lines

The objective of total seed protein profiling of Alternaria blight and white rust resistant lines was to examine the variability among *Brassica* species and find out the specific protein responsible for resistance. The total seed protein was extracted and applied in to 1.5% SDS gel. SDS-PAGE analysis of total protein, however, did not reveal much variation between the studied genotypes.

Induced mutagenesis for isolation of Alternaria blight resistant mutant in *Brassica juncea*

The success of induced mutations in crop improvement has been considered by some workers that induced mutagenesis underpins plant functional genomics. Isolation of Alternaria resistant mutation would help to develop Alternaria resistant varieties and to uncover distinct signaling pathways, enzymes and key regulatory factors involved in pathogenesis of Alternaria. Total 200g of each of four varieties of Indian mustard were get irradiated with gamma rays to induce mutation before sowing at BARC, Mumbai. M_1 generation was obtained by harvesting an individual plant for further screening against the Alternaria blight disease.

3 Transfer of Technology

DRMR Facilitates formation of Farmer Interest Group (FIGs) in two villages

As a part of the concerted efforts taken by the directorate to promote technology adoption in mustard cultivation, DRMR formed 2 Farmer Interest Groups (FIGs) comprising 60 farmers each in 2 villages, Ekta and Nyeotha of Bharatpur district for adoption of scientific cultivation of mustard. The FIGs work as a farmers collective group to facilitate transfer of technology and to motivate the farmers to adopt improved technology in cultivation of mustard. The extension activities of the directorate are made more effective through the mediation of FIGs which act as a catalyst in bringing about desired behavioural change in mustard farmers.

The members of the FIGs were provided on and off campus intensive training and skill up-gradation on several aspects of improved production technology for mustard farming. The importance of technology adoption and its potential impact on productivity was conveyed to the farmers through a series of meetings organized by DRMR during 2013-14 as a part of its support to the FIGs. Apart from training the farmers on core aspects of mustard production technology, skills were also imparted on allied agricultural activities like biogas production, integrated pest management, *etc.* through visit of DRMR experimental farm and demonstration units. The technology introduced to the farmers through the training and lectures were also demonstrated to them in their own village through technology demonstration plot.

DRMR at the door of the farmers through Sarson Farm School

For effective transfer of rapeseed-mustard technology and to provide on the spot solution of the problems faced by the farmers in adoption of scientific technology, DRMR reached out to the farmers through Sarson Farm Schools during 2013-14. During 2013-14, 4 villages namely Gamdi, Ekta, Sahapur and Jhangirpur of Bharatpur district were covered under Sarson Farm School programme. This innovative collaboration with ATMA has enabled the directorate to expand its reach among the rapeseed-mustard farmers in the district for effective transfer of technology.

Scientists play a crucial role in ensuring that the environment and all resources contribute to the farmers' learning experiences. A technology demonstration on complete package of practices of mustard was laid out in one hectare area of an achiever farmer in each field school to show the production potential of the scientific technology and serving as is the primary resource for learning for all participating farmers. Each farm school provided comprehensive training on rapeseed-mustard cultivation and other related issues of crop production to 25-30 participants through demonstration, lectures, focused group discussion, agro-ecosystem analysis, *etc.* A minimum of 6 interactive sessions spaced over the entire crop growing season at regular interval were conducted for each Sarson Farm School.

DRMR organized Model Training Course (MTC)

DRMR organized a Model Training Course (MTC) on "Advances in seed production, processing and certification in rabi field crops" during January 6-13, 2014 sponsored by Directorate of Extension, Ministry of Agriculture, Govt. of India.

The prime aim of MTC was to augment the participants' knowledge on technical, organizational, institutional and economic aspects of seed production/ processing and certification of rabi field crops to have a team of trained extension / development personnel regarding the advances in seed production/ processing and certification of rabi field crops and also capable enough to exploit the management practices for their effective transfer to the farmers.

The DRMR staff as well as invited speakers from other ICAR institutes/SAU served the faculty for the programme.

A total of 22 Extension personnel from State Department of Agriculture of Assam (4), Odisha (2), Chhattisgarh (1), Uttar Pradesh (5), Madhya Pradesh (2), Rajasthan (2), Haryana (3), Andhra Pradesh (2) and Kerla (1) participated in the MTC

Visitors Advisory Services

Under the Services, 41 interaction meetings and counselling sessions on rapeseed-mustard cultivation were organized or coordinated for visiting groups from Rajasthan, Uttar Pradesh, Madhya Pradesh, Himachal Pradesh and Gujarat consisting of 1654 stakeholders including 989 farmers, 231 farm women, 68 extension personnel, 339 students and 27 school teachers The visiting groups were educated/ trained through lectures, visits to technology park, experimental fields, museum and also provided literatures.

Mustard Production Technology Transfer through All India Radio

The DRMR sponsored the Sarson School on AIR programme for undertaking transfer of technology through the use of this evergreen medium of mass communication. A total of 24 instructional episodes were broadcasted through each of the 7 All India Radio stations (Jaipur, Alwar, Kota, SwaiMadhopur & Jhalawar in Rajasthan and Mathura & Agra in Uttar Pradesh) located in major mustard growing region of the country. The radio broadcast received wide popularity among the mustard farmers in the region and emerged as the fulcrum of the transfer of technology efforts of the directorate.

Success Story

Development of Voice Based e-learning Extension Module for Mustard Cultivation

DRMR has designed and developed a "**Voice Based e-Learning Extension Module for mustard cultivation*f* under the name of** "Sune Sunyen: Peet Kranti Layein" (E-Sarson Shiksa Programme) through which farmers can listen to the advice from scientists about crop production and management at their will. The module contains 10 lessons covering the entire package of practices on rapeseed-mustard cultivation.

The e-learning module developed has gained wide popularity and acceptance within the first rapeseed-mustard cropping season since its development. The technology was developed to address the low level of knowledge about the improved production technology, which is often described as the cause for persistence of

high levels of yield gap and low productivity in the farmers field. The technology is complementary to the existing pedagogy for dissemination of farm technologies through kisan goshtis, kisan melas, advisory services, distribution of literature etc. The e-learning module containing ten sections has evoked keen interest from different agencies for distribution to the farmers.

The CD containing the second edition of e-lesson was released by Shri Shivraj Singh Chouhan, Chief Minister of Madhya Pradesh on Feb 22, 2014 in Morena (MP) during the four day farmers fair organized by Department of Farmers Welfare and Agriculture Development, Morena (MP) under ATMA. The initial batch of more than one thousand CDs was distributed during the farmers' mela. Department of Farmers Welfare and Agriculture Development, Morena, Government of Madhya Pradesh has also come out with a plan to distribute the e-lesson to thousands of rapeseed-mustard farmers in the district.

The CDs of e-lesson have also been given to farmers directly from the directorate. About 3400 units have already been distributed among the farmers during 2013-14. Taking into consideration, the indirect secondary spread of the e-lesson through farmer to farmer transfer, the new technology is expected to reach more than two lakh farmers during the first year of its deployment.

This initiative is in furtherance of the efforts of the Directorate of Rapeseed Mustard Research in providing extension services to rapeseed-mustard farmers through constant innovations and imaginative use of available technology. It is hoped that this innovation will be a significant landmark in delivery of extension services which can play a vital role in bridging the yield gap and motivate extension personnel for the development of similar products for other crops.

DRMR organizes the 20th Sarson Vigyan Mela

The Directorate of Rapeseed Mustard Research organized the 20th Sarson Vigyan mela during 22-24, February, 2014. The format of this much awaited annual event of the directorate has undergone a significant makeover this year with the farmers fair held for three days duration for the first time. The Sarson Vigyan mela was inaugurated by Dr. Arvind kumar, Deputy Director General (Education) ICAR. During his inaugural address, Dr. Arvind Kumar said that the nation is facing a severe shortage in domestic availability of edible oils, which is presently met through costly imports. He exhorted the oilseed farmers to enhance the self sufficiency in edible oil production to ensure the nutritional security in the country. The function was chaired by Dr. Dhiraj Singh, Director DRMR. In his welcome address Dr. Singh emphasized upon learning and transfer of technology. The farmers responded with enthusiasm and participated in the mela in huge numbers. The first day of the mela recorded a footfall of more than 1500 farmers from various parts of Rajasthan and nearby states.

On the second day of the mela, a training cum awareness programme on the provisions of Protection of Plant Varieties and Farmers Rights Act, 2001 was organized. The various aspects of the act applicable to the farmers and their implications were explained during the programme. More than one thousand farmers visited the mela during the second day. Awareness programme on seed and seed production aspects was organized during the third day. Quality seed production techniques and its importance were explained to the farmer trainees. On all the days of the mela, crop competition was held in which farmers participated in large numbers. Kisan Goshtis and other competitions for the farmers were also organized during the three day farmer fair.

The winners of the crop competition and *kisan Prashnotharis* were also awarded.

Frontline Demonstrations

Ninety five demonstrations (FLDs) on three components *viz;* varietal, thio urea, sulphur through SSP were laid out in different villages of Bharatpur and Alwar districts 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 with 2 improved varieties developed by DRMR *viz.* NRCDR-02 and NRCHB -101.

Institute Technology Management

Institute Technology Management Unit (ITMU) in coordination with Institute Technology Management Committee (ITMC) is looking after the management of technologies developed by DRMR. Primary responsibilities of ITMU involve preparation of database of potential technologies, assessing the potential for commercialization, protection of technology under respective IPR legislation, refinement, maintenance and commercialization of technologies under public-private partnership mode. In this endeavour, six high yielding varieties/hybrid including NRCHB 506 (hybrid), NRCDR 02, NRCHB 101, DRMR 601 and Giriraj (DRMRIJ 31) of Indian mustard and NRCYS 05-2 of yellow sarson were identified as "technology ready for commercialization". Consequent upon interactions and negotiations, three varieties/hybrid of Indian mustard *viz*., NRCDR 02, NRCHB 506 and NRCHB 101 have been commercialized through licensing to four different private sector seed companies; JK Agri- Genetics Pvt. Ltd, Signet Crop Sciences India Pvt. Ltd, Bayer Bioscience Pvt. Ltd and Bioseeds Research India for seed multiplication and marketing. In addition one voice based E Learning module "Sune Sunayen: Peet Kranti Layein", has also been commercialized through licensing for further multiplication and distribution to three firms/professional societies; Haldhar Times, Krishi Bharti and Society of Extension Education. Efforts were also put to protect varieties under protection of plant varieties and farmers rights act (PPV & FRA) 2001. Three applications have been filed in respect of these varieties developed by DRMR in addition to 31 varieties developed by different AICRPRM centres. In response protection of plant varieties and farmers rights authority (PPV & FRA) has issued certificates of registration of 12 varieties *viz*., Maya, Basanti, RCC-4, Neelam, KBS-3, YSH 0401, Vasundhra, RH 0119, Swarn Jyoti, RB 50, GSC 6 and OCN-3. Remaining varieties are under process of registration.

4 Education and Training

Trainings Imparted

Name of the Student	Name of the Guide	Title of Dissertation
Ms.Anjali Sharma	Dr Pankaj Sharma, Senior Scientist, Plant Pathology	Patho-biological investigations of Stem rot (*Sclerotinia sclerotium*) of Oilseed Brassica.
Ms. Veena Kr. Mittal	Dr. Arun Kumar, Senior Scientist, Cytogentics	Cellular and molecular evidences of synthesis of interspecific hybrids between *Brassica tournefortii* and *Brassica rapa* through sexual hybridization
Mr. Deepchand Saini	Dr. (Mrs.) Manju Bala, Senior Scientist, Biochemistry	Biochemical evaluation of rapeseed-mustard Genotypes and NIRS calibration for estimation of protein content in intact seeds
Mr. Brajesh Kumar	Dr P D Meena Senior Scientist, Plant Pathology	Variability of *Alternaria brassicae* (Berk.) Sacc. Isolates based on growth characteristics on different carbon sources and crude protein profiling.
Ms. Renu Sen	Dr. S P Singh,Senior Scientist, Plant Physiology	Physiological basis of salt tolerance in Indian mustard at germination and early seedling growth.

Trainings Attended

Participants	Training Programme	Duration	Institute
Dr. Arun Kumar Dr. J. Nanjundan	Management of Plant Genetic Resources	September 16-25, 2013	NBPGR, New Delhi
Dr H S Meena Dr. Binay Kumar Singh	Advanced 'Omics' Techniques for Improvements in Plant and Human Health	Nov. 15- Dec. 05, 2013	IARI, New Delhi
Dr. K H Singh	NAIP sponsored Management Development Workshop on Technology Management for Researchers	27-31 January 2014	NAARM Hyderabad
Dr. Y P Singh	Bio-informatics: *Invitro* to *Insilico* approaches in Entomology	18 November -01 December, 2013	NBAII, Bangalore
Sh. U C Sharma	Training programme on Establishment Rules	17-21 June, 2013	ISTM, New Delhi
Dr. (Mrs.) Kapila Shekhawat	Training programme on Climate change : Scenario, Impact on Agriculture and strategies for mitigation	February 18- March 10, 2014	SKRAU, Bikaner

Seminars at DRMR

Speaker	Topic	Date
DRMR		
Dr. Ajay Kumar Thakur	RNAi technology and its application in crop management	April 2, 2013
Dr. Vinod Kumar	Developing web based agricultural research publication information system using meta data description concept for research documentation and performance evaluation	April 4, 2013
Dr Binay Kumar Singh	Wither Genomics?	April 15, 2013
Dr V V Singh and Sh. Sanjay Kumar	An Introduction to Result Framework Document	May 3, 2013
Dr K H Singh	All India Coordinated Research Project on Rapeseed -Mustard: Accomplishments and Challenges	May 15, 2013

Dr Arun Kumar	Molecular cytogenetics	May 30, 2013
Dr. Bhagirath Ram	Breeding for Stress Tolerance in Crop Plants	June 15, 2013
Dr J Nanjundan	Evolution of Brassica Genomes	June 29, 2013
Mrs. Priyamedha	Breeding for Quality in Crop Plants	July 19, 2013
Dr H S Meena	Quality Seed Research and Growth of Indian Seed Sector	July 30, 2013
Dr. Vinod Kumar	E- procurement: opportunity and challenges	August 14, 2013
Dr. Ajay Kumar Thakur	G M crop Regulatory systems in south Asia	September 30, 2013
Dr J Nanjundan	Management of Plant Genetic Resources	September 30, 2013
Dr. Dhiraj Singh	Response of sulphur application on Rapeseed-Mustard	December 30, 2013
Dr Y P Singh	Bio-informatics: *Invitro* to *Insilico* approaches in Entomology	January 9, 2014
Dr. Arun Kumar	Problem formulation for identifying protection goals relevant to the environment risk assessment of GE plants in India	January 9, 2014
Dr. Binay Kumar Singh	Advanced Omics techniques for improvements in plant and human health	January 9, 2014
Dr. Y P Singh	Emerging Trends in Eco-friendly insect pest management	March 26, 2014
Guest		
Prof. B N Singh	International Agricultural research systems	April 12, 2013
Dr. P K Chonkar	Former Professor and Head, Division of Soil Science, IARIExcellence in Science: Perception of those who have excelled	May 14, 2013
Dr. (Mrs.) Abha Agnihotri		October 14, 2013
Dr. P R Verma		January 27, 2013
Dr. D P Singh	Abiotic stress in Crop Production: Lessons from past, Present Status and Future Strategies	March 27, 2013
Dr. R K Choudhury	DUS Testing: Principles and Applications	March 28, 2013

Library Services

Particulars	No.	Detailed description
Journals	47	*Agricultural Reviews, Agronomy Journal, Annals of Agricultural Research, Annals of Agri. Bio-Research, Annals of Biology, Brassica, Current Science, Indian Farming, Indian Journal of Agricultural Science, Indian Journal of Agronomy, Indian Journal of Biotechnology, Indian Journal of Entomology, Indian Journal of Cytology and Genetics, Indian Journal of Ephidology, Indian Journal of genetics and Plant Breeding, Indian Journal of Plant Genetic Resources, Indian Research Journal of Extension Education, Indian Journal of Plant Physiology, Indian Science Abstracts, Journal of Asian Agri. History, Journal of Biological Control, Journal of Bio-Science, Journal of Communication Studies, Journal of Genetics, Journal of Intellectual Property Rights, Journal of Interacademia, Journal of Mycology and Plant Pathology, Journal of Oilseeds Research, Science and Culture.*
Newsletters	95	From various government, ICAR, SAU and other organizations
Annual reports	65	From various government, ICAR, SAU and other organizations
Other reference materials	70	From various government, ICAR, SAU and other organizations
Books	203	Latest books, encyclopedia, dictionaries, Hindi books, etc.

5 Awards and Recognition

DRMR felicitated for outstanding work in Hindi

Rajbhasha Sansthan, New Delhi awarded DRMR with Karyalya Deep and Karyalaya Darpan for outstansing work in Hindi and Annual Hindi Magazine Sidhharth Sarson Sandesh, respactively. These awards were provided during 74th Diamond Jubilee Celebrations held on 24 - 26 April, 2013 at Solan, Himachal Pradesh. Dr. Vinod Kumar, Sr. Scientist, Shri JL Sharma, AAO and Shri US Rana, CTO of DRMR participated in this workshop & received the awards. An article written by Dr. Vinod Kumar, was also awarded with 3rd Prize.

DRMR was conferred Rajarshi Tandon Award

Directorate of Rapeseed Mustard Research received the Second Prize in 'Rajarshi Tandon Award- 2012-13 for the best official language Implementation among the ICAR Institutes in the 'A and B' Region. The award recognizes outstanding contribution in promoting the use of official language in office communications and other related activities.

Dr. Dhiraj Singh: The contributions of Dr Dhiraj Singh, Director, DRMR in the field of rapeseed-mustard research and development in India were recognized by the Society for Rapeseed-Mustard Research, Bharatpur by conferring him its prestigious "**Dr P.R.Kumar Outstanding Brassica Scientist 2012-13*f*,** award.

Dr. Ashok Kumar Sharma: Dr. Ashok Kumar Sharma, Senior Scientist, Ag. Extension, DRMR, Bharatpur was awarded by District Administration, Bharatpur for his significant contribution in transfer of technology of rapeseed-mustard among the farmers. The award was presented by Hon'ble Education Minister, Govt. of Rajasthan, Sh. Braj Kishore Sharma on Independence Day (15-8-2013) at Bharatpur.

Dr. K.H. Singh, Principal Scientist (Genetics & Plant Breeding) and **Dr. Vinod Kumar,** Senior Scientist (Computer Application) were conferred with **Fellow** of Society for Rapeseed-Mustard Research, Bharatpur.

Dr. Pankaj Sharma: Senior Scientist, Plant Pathology was awarded Fellow of Indian Society of Mycology and Plant Pathology (FISMPP), MPUAT, Udaipur.

Dr. N.S. Bhogal, Senior Scientist (Soil science), **Dr. S. P. Singh,** Senior Scientist (Plant Physiology), **Dr. Arun Kumar,** Senior Scientist (Genetics & Plant Breeding) and **Dr. P.D. Meena,** Senior Scientist (Plant Pathology) received **Best Poster Presentation** awards during second national Brassica conference held at PAU, Ludhiana.

Promotion/ Transfer of staff

Personnel	New position	From
Promotion		
Dr. Vinod Kumar, Senior Scientist	Senior Scientist (PB-4)	04-10-2013
Dr. Lijo Thomas, Scientist	Scientist, SS	08-01-2013
Sh. H.P. Meena, Senior Technical Officer	Asstt. Chief Technical Officer	01-01-2013
Sh. Ram Narayan, Senior Technical Officer	Asstt. Chief Technical Officer	05-05-2013
Sh. Ram Singh, Technical Assistant	Senior Technical Assistant	22-09-2012
Sh. Umesh Chandra Sharma, Assistant	Asstt. Administrative Officer	14-10-2013
Sh. Pankaj Pathak, LDC	Upper Divisional Clerk	02-11-2013
Selection		
Dr. Dhiraj Singh, Head OilseedsCCS HAU, Hisar	Director, DRMR, Bharatpur	19-9-2013
Dr. J.S. Chauhan, Director	Asstt. Director General (Seed), ICAR, New Delhi	09.7.2013
Dr. Bhagirath Ram Senior Scientist (PB-3)	Senior Scientist (PB-4)	21-06-2013
Dr. Manju Bala, Senior Scientist	Senior Scientist (PB-4), CIPHET, Ludhiana	08-08-2013
Sh. J.L. Sharma, AAO	AO, CARI, Izatnagar	27-8-2013.
Transfer		
Dr. S.P. Singh, Senior Scientist	Senior Scientist,NBPGR, New Delhi	31-08-2013
Sh. Kumararaja P., Scientist	Scientist, CIBA, Chennai	11-6-2013
Dr. K.N. Meena, Assistant Technical Officer, IARI, New Delhi	Assistant Technical Officer DRMR, Bharatpur	02-09-2013

6 Linkages and Collaboration

DRMR Collaborates with Agricultural Technology management Agency (ATMA)/ Department of Agriculture / NGOs

DRMR organized 13 capacity building programmes for farmers and extension personnel of 3 to 7 days duration sponsored by PD, ATMA, Morena (27 Sept- 01 Oct 2013 & 3-7 March 2014), Gwalior (22-26 Oct 2013), Shivpuri (16-20 Dec 2013) & Bhind (26-30 Dec 2013) of MP; Tonk (02-06 Sept 2013), Swaimadhopur (1-5 Jan 2014) & Karoli (1-5 Jan 2014) of Rajasthan; Haridwar (14-16 Nov 2013) of Uttarakhand; Jamtara (25-28 Nov 2013) of Jharkhand; Department of Agriculture, Kokrajhar (5-11 Feb 2014) of Assam and 2 NGOs namely; CmF, Jaipur (17-19 Sept 2013) & SRIJAN, Bundi (23-25 Sept 2013) of Rajasthan.

A total of 342 farmers and 23 extension personnel of respective districts were provided extensive training about scientific production technology of mustard and agriculture management through these programmes.

The main objective of these programmes was to improve the knowledge and skill of participants about scientific production and protection technology of rapeseed-mustard and motivate them to adopt these technologies. The training modules included field preparation, improved varieties for different situations, crop management, integrated nutrients, disease, pest management, protection of plant varieties and farmers rights act, organic farming, use of ICT, bio technology, future trading, marketing, agriculture management practices, recent advances made in rapeseed-mustard research, *etc.*

Besides, 29 training programmes of one day each sponsored by PD ATMA, Bharatpur were also organized for providing training about improved production technology of Mustard to 1740 farmers of different villages of Bharatpur district of Rajasthan during 22-24 Feb 2014.

DRMR Signs MoU for Enhancing Rapeseed-Mustard Productivity in Tripura and Manipur under NEH component project

Directorate of Rapeseed-Mustard Research (DRMR), Bharatpur has signed 2 Memorandum of Understanding (MoUs) with the Department of Agriculture, Government of Tripura and the Directorate of Research, Central Agricultural University, Imphal, Manipur to undertake capacity building and provide technology solutions for enhancing production and productivity of rapeseed-mustard in the Tripura and Manipur state. The MoUs will be in force for duration of four years starting from 2013-14. The memorandum forms a part of the activities carried out under the NEH component: Enhancement of Rapeseed-Mustard Production in Tripura and Manipur.

In order to implement the project, DRMR supplied seeds of Indian mustard variety NRCHB 101 to concerned department/ university for conducting the cluster demonstrations during 2013-14 under the project NEH component in Tripura and Manipur.

A two day launching workshop cum training programme was organized during 23-24 November, 2013 at *Pragna Bhawan*, Agartala. The programme was inaugurated on 23 rd November, 2013 by Dr. Dhiraj Singh, Director, DRMR. Dr Baharul Islam Majumder, Joint Director Agriculture (Research), Department of Agriculture, Government of Tripura welcomed the initiatives of the directorate and expressed his hope that significant increase in productivity could be harnessed through this collaborative venture. The training programme for middle level field functionaries also organized during the workshop. The training programme focused on the potential of rapeseed-mustard crop in the state and imparted knowledge on improved varietal selection and crop management practices to exploit the full potential of the crop.

The workshop also had an interaction session with Dr. V K Bahuguna, Principal Secretary Agriculture, Government of Tripura. This programme under the NEH component will identify suitable rapeseed-mustard varieties for Tripura and conduct frontline demonstrations to convince the importance of technology adoption among the farmers. DRMR will undertake necessary steps to ensure the availability of sufficient quantity of quality seeds of the desired varieties to enhance the productivity of rapeseed-mustard in the Tripura state.

DAC join hands with DRMR for demonstrating benefits from Technology and Institutional Support

The Department of Agriculture, Government of India in collaboration with Directorate of Rapeseed-Mustard Research, Bharatpur launched a project for demonstrating the potential impact of technology adoption backed by adequate institutional support on production and productivity of rapeseed-mustard during *rabi* season 2013-14. The project entitled *"DAC-DRMR collaborative project on Enhancing Rapeseed-Mustard Productivity through Inclusive Technology Package and Institutional Linkage"* envisions to bring 250 hectares of land under intensive rapeseed-mustard cultivation with complete adoption of recommended technology package including choice of variety, use of agrochemicals and crop management practices. The project shall strive to demonstrate the scope for enhancing rapeseed-mustard productivity through varietal replacement complemented with inclusive technology package and provision of close institutional support for cultivators.

The village Ekta Gram Panchayth of Bharatpur district of Rajasthan was selected for the project and 250 beneficiaries were selected from the project location. The beneficiaries were provided the seeds of improved variety (NRCDR-2) and required fertilizers and chemicals. The project provided the initiative for technology adoption and sought to absorb the technology risk for the initial adoption and transfer the necessary skills for continued adoption of technology. The project envisages a permanent change in the behaviour of the farmers through demonstration of the superiority of improved technology, intensive extension efforts, production support and institutional linkage.

Three training programmes were completed under the project in which more than 90 participants were trained on improved rapeseed-mustard cultivation practices. The project used a participatory approach in all the activities and the project team works in close coordination and consultation with the farmers group formed in the project location. The linkage between DAC and DRMR has brought a change of attitude among the farmers towards technology.

On 25th January, 2014, Dr. J S Sandhu, Agriculture Commissioner, Government of India, visited the villages where the DAC-DRMR collaborative project on *Enhancing Rapeseed-Mustard Productivity through inclusive technology package and Institutional linkage* is currently in operation.

DRMR-KVK Linkage Programme

The DRMR has sought to leverage the grass-root level reach and credibility of KVK,s for technology transfer through it's collaborative DRMR –KVK linkage extension programme. Under this programme, the KVK's from states like Rajasthan, Uttar Pradesh and Madhya Pradesh shall be partners of DRMR for dissemination of improved production technology of rapeseed-mustard.

Under this initiative, a crop cafeteria of rapeseed-mustard displaying varieties released from DRMR shall be developed in a suitable area within the KVK campus, which shall facilitate the evaluation of these varieties by the farmers who visit the KVK and will spread awareness about the variety. DRMR will facilitate the process by supplying 100 g of seed material of each of these varieties to the KVKs during each cropping season, apart from providing technical guidance and support. Further, the directorate has also committed to provide resource persons for trainings conducted by the KVKs on rapeseed-mustard crop production. To promote the cropping system approach to secure the livelihood of farmers, the linkage programme shall also explore the possibility of promoting Soybean-Mustard cropping system, especially in parts of Madhya Pradesh.

7 All India Coordinated Research Project on Rapeseed-Mustard

Directorate of Rapeseed-Mustard Research Bharatpur successfully organized 20th annual group meeting of AICRP on Rapeseed-Mustard during July 5-7, 2013 at Sardar Dantiwada Agricultural University, Sardarkrushinagar. Dr. K. Sreedharan, Vice Chancellor, SDAU, SK Nagar, presided over the inaugural session. Dr. S.K.Datta, DDG (Crop Science) and Dr. D.P.Singh, Chairman, RAC, DRMR, Bharatpur graced the occasion as Chief guest and Guest of honour, respectively. Dr. R. M. Chauhan Director Research SDAU welcomed the dignitaries, delegates and media personnel. The session started with prayer followed by lighting of lamp by dignitaries. Dr. R.M.Chauhan, Director Research, SDAU, SK Nagar formally welcomed the dignitaries and participants.

Dr. J.S.Chauhan, Director, DRMR, Bharatpur presented the research highlights of AICRP on Rapeseed-Mustard during 2012-13. In his presentation, he expressed concern over decline in area under rapeseed-mustard cultivation. Presenting the research highlights, he informed that 781 new accessions were collected, four genetic stocks were registered, 177 yield trials were conducted in plant breeding to evaluate 157 entries and 19 entries were promoted. 34 proposals of extant varieties for registartion with PPV & FR Authority, New Delhi were submitted.

Sri U.D.Singh, Managing Director, Gujarat State Seed Corporation in his address mentioned that due to cotton based cropping system there is decline in area under mustard in Gujarat. He highlighted the importance of good quality seed and high yielding varieties and stressed upon increasing varietal replacement.

Dr. D. P. Singh, Consultant Farmers' Commission, Haryana and Chairman RAC, DRMR, Bharatpur in his address, described the strategy for better crop management by applying the FYM and balanced fertilizers to improve the organic matter in soil. Citing the example of intercropping of mustard with chickpea, he informed that mustard can extract moisture from deeper layers of soil and survive under moisture stress conditions. Further, he stressed upon Orobanche management, resource conservation technology, water saving devices, watershed management, precision farming and use of ridge maker for better management and judicial use of resources.

Later on eight publications including seven from DRMR, Bharatpur and one from SDAU, SK Nagar were released by Dr. S.K.Datta, DDG (CS), Dr. K. Sreedharan, V.C., SDAU, SK Nagar, Sri U.D.Singh and Dr. D.P. Singh, Consultant Farmers' Commission followed by award ceremony. Best Performing Main and sub AICRPRM Centres awarded for the year 2010-11 were; PAU, Ludhiana and RRS Bawal, respectively and for 2012-13; GBPUAT, Pantnagar and ARS Sriganganagar, respectively.

Dr. S.K.Datta, DDG (CS) emphasized upon making the crop more remunerative to capture the area by quoting the example of increase of area under maize in West Bengal. He also pointed out the huge gap between existing potential and realized yield at farmers' field and suggested to fix region wise targets for yield. He pointed out to identify the factors limiting the yield and then address those factors to enhance the yield. The need for transgenic approach needs to be adopted to address the issues of biotic stresses like aphid and weeds. Dr Datta also expressed concern over huge import of edible oil.

Dr. K. Sreedharan, Vice Chancellor SDAU, SK Nagar extended thanks to DDG (CS) for selecting the SDAU as venue for annual group meeting. In his address, he emphasized upon nutritional as well as food security and suggested for value addition in these crops to utilize the available protein in seed meal.

Eleven sessions including presentation of reports wherein all PIs presented the progress report of 2012-13 of their respective disciplines,

technical programme formulation, technology dissemination and impact analyses, presentations in key areas and plenary were held during the meeting. Various issues related to different disciplines were discussed at length. Technical programmes for the year 2013-14 were also formulated for various disciplines. Varietal Identification Committee under the Chairmanship of Prof. S.K. Datta, Deputy, Director General (Crop Science), ICAR, considered 4 proposals including 3 of Indian mustard and 01 of gobhi sarson (*B. napus*) and identified all 4 varieties for release. About 125 scientists/personnel associated with rapeseed mustard research and development in the country participated in this meeting. With the plenary session chaired by Dr. D.P.Singh Consultant Farmers' Commission Haryana and Chairman RAC, DRMR, Bharatpur, the meeting was successfully concluded on 7th August, 2013.The discipline wise highlights of the programme were as follows:

Crop Improvement

A total of 6,417 accessions comprising toria (694), Indian mustard (4,747), yellow sarson (461), gobhi sarson (103), brown sarson (65), karan rai (203), taramira (107), *Brassica tournefortii* (03), *Sinapis alba* (03), *B. caudatus* (04), *R. caudatus* (02), *B.nigra* (14), *B. oleracea* (06), *Raphanus sativa* (01), *Crambe spp* (02), *Lepidium spp* (01) and *Camellina spp* (01) were maintained through appropriate mating systems at Bhubaneswar, Dholi, Hisar, Kanpur, Morena, Pantnagar, S.K. Nagar, Sriganganagar, IARI, New Delhi, Navgaon, Ranchi and Jobner. Another 781 new accessions comprising Indian mustard (503), toria (47), yellow sarson (63), brown sarson (06), *B nigra* (40), *B rugosa* (92) and taramira (30), were collected. Further, 1,499 accessions consisting of 1046 Indian mustard, 115 toria, 174 yellow sarson, 17 gobhi sarson, 41 brown sarson, 06 karan rai and 100 taramira were evaluated. On the basis of germplasm evaluation, promising accessions were identified for earliness in toria at Bhubaneswar, Pantnagar and Dholi; tolerance to aphid & drought in toria, earliness and aphid tolerance in Indian mustard at Bhubaneswar and tolerance to Alternaria blight at Dholi. Four genetic stocks including three of Indian mustard (*B.juncea*), BPR 549-9 (INGR13016), BPR 540-6 (INGR13027); NUDH-YJ-6 (INGR13015); one white flowered (WF) yellow sarson (INGR13028) of *B rapa* var *yellow sarson*, a yellow sarson genotype with white flower, were registered.

91 crosses were attempted in toria, 48 in yellow sarson and 588 in Indian mustard, 21 in gobhi sarson, 45 in taramira at Hisar, Kanpur, Morena, Ranchi, Pantnagar, Dholi, IARI, Navgaon, S.K.Nagar, Chatha (Jammu) and Jobner to improve seed yield, earliness, seed size, disease/pest resistance, quality and oil content. Selection of superior plants/bulks at different centres was practiced in toria, yellow sarson and Indian mustard.

122 strains of toria were tested at Kanpur, Hisar, Morena and Dholi. Yield superiority was up to 32.5 % over Bhawani at Morena. In yellow sarson, 39 strains were tested at Kanpur and Dholi and yield superiority up to 27.3 % over the check Swarna was recorded at Dholi. In Indian mustard, 1305 strains were evaluated at 9 centres in 125 trials with yield superiority up to 51.9 % over the check JM 4 at Morena. 09 strains of taramira were evaluated at Jobner and yield superiority up to 17.6 % over the check, RTM 314 was reported.

Against the indent of 109.67 q breeder seed of 80 rapeseed-mustard varieties and two parental lines of hybrid, NRCHB 506, 211.23 q breeder seed including carry over was produced, indicating a surplus availability of 102.76 q.

Thirty two yield trials consisting of toria (13 strains), yellow sarson (11 strains), Indian mustard (123 strains), gobhi sarson (05 strains) and taramira (05 strains) were conducted at 177 locations across the 5 agro climatic zones of the country. A total of 18 strains comprising 02 of toria, 13 of Indian mustard and 03 of taramira have been promoted to advance stage testing.

Crop Production

Seven experiments on various crop production aspects of rapeseed-mustard were conducted at 24 cooperating centres across the 5 zones. In 2nd year of Long term fertility experiments,

crop initially responded up to 100%N and 100%NP application. The beneficial effect of supplementary fertilizers was observed at HSR (FYM, Zn and S) and PNT (FYM) only. Under drought management experiments, the foliar spray of agro-chemicals successfully mitigated impact of terminal drought in rapeseed-mustard as seed yield increased by up to 45% due to 1% urea, 55.5% due to 0.05% thiourea and 62.8% due to 1% KNO_3 spray at 50% flowering + 50% pod filling stages. In weed management studies, the herbicides 1 kg a.i/ha isoporteuron 75WP at 30 DAS, 0.15 kg a.i./ha oxyfluorfen 23.5EC (PE), 1 kg a.i./ha pendimethalin 30EC (PE), 0.75 kg a.i./ha pendimethalin 38.7CS (PE), 0.75 kg/ha trifluralin 48EC (PPI), 0.06 kg a.i./ha quizalofop 5EC (PE), 0.06 kg a.i./ha clodinafop 15WP (25-30 DAS) and 0.09 kg a.i./ha oxadiargyl 80WP (PE) were found effective against weeds depending upon the weed flora at respective centres and significantly reduced yield losses.

26 districts across 11 states in 5 zones were surveyed for weed flora in rapeseed-mustard crops. The most common weeds include *Chenopodium album, Cynodon dactylon,Anagalis arvensis, Cyperus rotundus, Phalaris minor, Melilotus alba, Convolvulus arvensis, Fumaria parviflora, Euphorbia helioscopia, Polygonum hydropiper, Asphodelus tenuifolius, Avena fatua/ ludovicinia, Medicago denticulate, Vicia sativa, Carthamus oxycantha, Parthanium hysterophorus, Ranunculus arvensis, Rumex acetosella/sp.*and *Tridax procumbens*.

Strain DRMRIJ 31 produced 11.5% significantly higher seed yield than the best check at NAV and remained at par with at other centres in Zone II under timely sown irrigated conditions. However, RL 1359 was superior by 11.2% than the best check at HSR. Under timely sown irrigated conditions of Zone III, the quality mustard strain LES 43 remained at par with the best check at KPR. Seed yield of strain SKM 301 under timely sown irrigated conditions of Zone IV was higher (7.9%) at JOB than the best check. While seed yield of SKM 815 remained at par at SKN and JOB. The *Brassica napus* entry GSC 101 under timely sown irrigated conditions recorded >10% significantly higher seed yield than the best check at CHT, DLK and KNG.

Crop Protection

Diseases

During 2012-13, moderate to severe incidence of AB was recorded at LDH, FZB and PNT, and white rust at HSR, FZB, PNT and MOR. Severer incident of DM was observed at cotyledonary stage at FZB and PNT. PM severity was very low at most of the locations except MOR (10-60%). SR incident was also low at most of the centers. Moderate incidence of bacterial rot (BR) was recorded at HSR and FZB.

GSC 101(*B. napus*), RTM 1355 (*E. sativa*), RMT 08-2, RMT 08-6 and PTE 2008-02 of *B. rapa* var.*toria* were tolerant to WR. GSC 101 and RTM 1355 also showed resistant reaction to downy mildew under natural as well as artificial inoculated conditions.

DRMR 312, DRMR 316 and DRMR 100 of *B. carinata*; DRMR MJA-35 of *B. juncea*; PYS 2007-10 and PYS 2008-5 of *B. Rapa* var. *yellow sarson* and PT 2006-4, RMT 10-10 and RMT 10-7 of *B. rapa* var. *toria* showed resistant reaction to WR under natural conditions. DRMR 316 and DRMR 312 also showed resistant reaction to DM.

PPBN 2 and PPBN 3 of *B. napus* and PPBR 2 of *B. juncea* had resistant reaction to WR under natural and artificial conditions. They also gave resistant reaction to DM whereas, PPBR 2 gave resistant reaction to PM under natural conditions.

DRMR 261, MCB 1, DRMR 243 and DRMR 270 of *B. carinata* showed resistant reaction under artificial inoculated conditions and to downy mildew under artificial and natural conditions.

BSH 1 of *B. Rapa* var. brown sarson, NUDB 26-11 of *B. napus* and BCS 4, NPC 16, NPC 20 and NPC 21 of *B. carninata* were found resistant to WR under natural and artificial conditions. These strains also showed resistant reaction to DM at cotyledonary stage under natural and artificial conditions.

PT 2010-11 of *B. rapa* var. *toria*; CNH 11-13 and HNS 1001 of *B. napus*; RTM 1351 and RTM 1359 of *E. sativa* and YSWB 2011-10-1, YSWB 20229/2-11, YSWB 2012/9, YSWB 2014/3-12, YSKM 12-1, YSKM 12-2 and PYS 2008-5 of *B.*

rapa var. yellow sarson showed resistance to WR. RTM 1351 of *E. sativa* also showed resistance reaction to PM. HNS 1001, CNH 11-7 and CNH 11-13 of *B. napus* showed resistant reaction to DM.

Reaction of 14 rapeseed-mustard genotypes was recorded against 4 isolates of *Albugo candida*. Genotype GSL 1, EC 414293, EC 399301, Basanti, DMH 1 and EC 399296 gave differential reaction to WR isolates at HSR, PNT,LDH and BPR. Genotypes GSL 1, EC 414293 and EC 399301 also gave differential reactions to different isolates collected from Pantnagar.

Pathogenic variability was observed among 11 isolates of *A. brassicae*, collected from different hosts of *A. brassicae*. Isolate collected form ornamental rai was most virulent and caused infection on all the 11 species tested. Isolates collected form *E. sativa* and Domo yellow were also virulent and caused infection to most of the species except *S. alba* and *E. sativa.*

Pathogenic variability of *S. sclerotiorum*, isolated from different species of Brassica, was assessed on *B. juncea* cv. Rohini. All the isolates were found virulent and caused infection. Disease incidence ranged from 20-99% by the isolates collected from Marigold and *B. juncea*, respectively.

Pests

Weather conditions were moderate for the development of insect-pests. Strains RGN 58 (SBG 125), DRMR IJ 05 (SBG 13), DRMR 1679-100 (SBG 14), PRO 5111 (SBG 26), NPJ 161 (SAG 24), RH 932 (SAG 29), JMM 927 (SBG 23) (*Brassica juncea*); DLSC 1 (SAG 34) (*B. carinata*); RTM 1351 (SBG 147), RTM 1359 (SBG 149), RTM 1355 (SAG 40), RTM 315 (SBG 150), TMB 29 (SBG 151), RTM 2002 (SBG 152), TMB 2030 (SBG 153), T 27 (SBG 148) and RTM 1212 (SBG 148) (*E. sativa*) were found promising having the AAII < 1. The highest yield losses were observed in BSH 1 at BPR (38.3%), HSR (15.5%), KPR (75.6%), SKN (25.6%), and DOL (28.5%) but at LDH NRCDR 2 (16.3%), at NAV RRN 505 (34.0%), at BER Binoy (80.6%) suffered higher yield loss due to insect pests.

Low to moderate population of mustard aphid was reported from most of the centres up to 3rd to 13th standard week with peak during 5th to 8th std. week. Moderate to high population of painted bug was found active from 44th to 1st std. week and again 7th to 13th std. week at HSR while at BPR it was from 47th to 50th std. week and again 6th to 14th std. week.

Significant higher seed yield and effective aphid control was observed under the insecticidal treatments. Dimethoate 30 EC @ 1 ml/l was most effective and resulted in maximum yield at NAV, BPR and KPR. The higher IBCR was found in acetamiprid 20 SP @ 0.15g/L (BPR, NAV and SKN), dimethoate 30 EC @ 300g ai/ha (BER and KPR) and imidacloprid 17.8 SL @ 20 g ai/ha at HSR.

Dimethoate @ 1ml/l followed by *C. septempunctata* @ 5000 beetles/ha at (LDH, BPR and SKN), dimethoate @ 1ml/l followed by *V. lecanii* @ 10^8 CS/ml at KPR, NSKE@ 5% followed by *C. septempunctata* @ 5000 beetles/ha at BER, neem oil @ 2% followed by *V. lecanii* @ 10^8 CS/ml at HSR and *V. lecanii* @ 10^8 CS/ml followed by dimethoate @ 1ml/l at NAV was found most effective and provided maximum yield.

Plant Physiology and Biochemistry

Sixty two genotypes of Indian mustard (*Brassica juncea L*) were evaluated for high temperature tolerance at seedling stage on the basis of electrolyte leakage and seedling mortality after heat stress. Genotypes TM 106 (Phy 1) and 44 S 31 (Phy 57) showed < 20% mortality and relatively less electrolyte leakage (< 40%) at KPR. In general, shading reduced photosynthesis, seed yield and total biomass at all the locations. Genotypes PBR 378, BPR 549-9 and DRMR 549-49 exhibited < 20 % reduction in seed yield at BPR and KPR. Sixty four genotypes were evaluated for drought tolerance under field conditions. LES 47, DRMR 10-40, RH 0948 showed < 20 % reduction in seed yield/plant at BPR and KPR, while the genotypes RH 0749, BPR 540-6, RH 0735, RGN 323 and PRL 2010-10 had < 20 % reduction in seed yield/plant at BPR and LDH.

The high oil content was recorded in strains MCN (E) 12-1 (NPJ 172) and MCN (E) 12-14 (DRMR 302) of *B. juncea* at KPR and LDH; NCN 12-1 (CNH 11-7) and NCN 12-4 (HNS 1001) of *B. napus* at HSR and LDH; TCN 12-8

(RAUDT 10-33) of *B. rapa* var.toria at DOL, HSR, KPR, PNT and TCN 12-11 (PT 2010-10) at KPR, LDH, MOR and PNT Strain YSCN 12-6 (YSKM 12-2) of *B. rapa* var yellow sarson at DOL, KPR, MOR and PNT. All the strains of quality mustard evaluated under IVT and AVT had high glucosinolate content. Among IVT entries NUDB YJ-10, Pusa Mustard 21 (QC), LES 46, LES 47 and RLC 2 had < 2% erucic acid. Among the AVT strains LES 43 and Pusa mustard 21 had < 2% erucic acid at two centers while LES 45 had < 2% erucic acid at all the three centres. Seed meal of 60 varieties of rapeseed-mustard was used to estimate total phenol, ascorbic acid, fibre and phytic acid and tocopherol content at KNG, LDH,BPR,KPR and PNT. At all the centers phenol content was reported lowest in different strains of *B. rapa* and highest in strains of mustard. Mean fibre content ranged from 8.6 ± 0.4 to 17.5 ± 0.3. Varieties EJ 20 of *B.juncea* and Sheetal of *B. napus* showed high ascorbic acid (386.8 mg/100g) content at BPR. Strains of *B. rapa* showed highest phytic acid content while lowest was reported for strains of *B.juncea*. Tocopherol content ranged from 46.3 (NDYS 2 of *B. rapa* var.yellow sarson) to 204.2 mg/100g (DRMR 541-44 of *B. juncea*) at LDH. Mustard oil was blended with sesame, groundnut and rice bran oils. Among the blends, mustard: sesame (30:70), showed SFA: MUFA: PUFA ratio of 1:3:1, while other two blends mustard: groundnut (30:70) and mustard: rice bran (30:70) also showed values near to the recommended ratio.

Technology Assessment

Twenty four cooperating centres conducted 537 FLDs on rapeseed (154) and mustard (383) in 67 districts across 16 states of the country. Rajasthan had maximum FLDs (105) followed by Uttar Pradesh (91). There were 196, 222 and 119 FLDs on the whole package (WP), varietal component and other component technology (CT), respectively under irrigated as well as rainfed conditions. Under rainfed conditions, the maximum average yield from the WP for Indian mustard, toria, gobhi sarson, karan rai and brown sarson, respectively, was 1,156, 1,251, 1,280, 1,491 and 886 kg/ha. The maximum yield gap between realizable and realized yield was 53.1%, 65.3%, 77.8%, 66.6% and 34.5%, respectively, with maximum additional net monetary return (ANMR)/ha of Rs 6,362, Rs 11,520, Rs 11,270, Rs 13,146 and Rs 3,494, respectively. The maximum average yield from the WP under irrigated conditions for Indian mustard, toria, yellow sarson and gobhi sarson was 2,600, 1,924, 1,760 and 2,086 kg/ha, yield gap of 37.6%, 25.3%, 54.2% and 9.0% and ANMR/ha Rs 9,838, Rs 5,790, Rs 9,730 and Rs 4,957, respectively.

A total of 69 FLDs with 10 component technologies for Indian mustard were carried out by different centres. Among all the components, line sowing demonstrated by Dholi centre had maximum average yield of 2,860 kg/ha. However, maximum yield increase of 29.6% was recorded with painted bug management demonstrated by Bawal centre that accrued maximum ANMR of Rs 14,610/ha with additional cost of Rs. 890/ha. Zero tillage, aphid management, sowing method and seed rate component in toria, club root disease management in gobhi sarson and recommended fertilizer and proper plant protection with improved variety of taramira gave 42.6%, 27.5%, 27.1%, 12.2%, 28.2% and 25.5% yield enhancement over FP, respectively.

The following recommendations were made:

- Varietal identification Committee identified four varieties including three (LET 36, LES 43 and DRMRIJ 31) of Indian mustard and one (GSC1) of gobhi sarson for release.
- Strengthening of national crossing programme involving donors for biotic and abiotic stresses.
- Intercropping of mustard + maize (1:1 or 1:2) at Bhubaneswar and Dholi; wheat + mustard (9:1) at Varanasi, Kanke and Nagpur and mixed cropping of wheat + mustard (90:10%) at Chatha proved more remunerative than sole crops. However, sole wheat at Kanpur and Morena were more rewarding than intercropping.
- Seed treatment with *Azotobactor* + PSB each 250g in formulation / ha-seed along with 100%NP resulted in 2.0 to 14.7% higher seed yield in comparison to 100%NP at Morena, Varanasi, Hisar,

Kota, Shillongani, Jobner, Bhubaneswar, Khudwani, SK Nagar and Kanke).

- The process of registration of rapeseed-mustard varieties under PPV & FRA should be expedited by the AICRPRM centres.
- Promising identified genotypes (indigenous/exotic) should be supplied to the needy AICRPRM centres for their effective utilization.
- Technology used in FLDs should be clear and thoroughly described along with complete package in the report for their further effective dissemination.
- 50% FLDs allotted to the centers should be conducted with the varieties recommended for their respective zone. In case of component technology demonstrations, minimum 4-5 FLDs must be conducted on one component by the center.
- Precise cost estimation of the demonstrated technology is very important for adoption. All the centres should properly record the total cost of cultivation including cost of input material and human labour for all demonstrations along with farmers' practices.

8 PUBLICATIONS

Research papers

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In addition 30 extension folders and 62 popular articles were also published.

9 Research Programmes and Projects

Programme/ Project code	Name of Programme / Project Programme	Leader/PI
Programme :1	**Genetic enhancement for stress tolerance in Indian mustard**	**V V Singh**
DRMR CI 10	Population improvement for high productivity and oil content in Indian mustard under normal and moisture stressed conditions	V V Singh
DRMR CI - 12	Widening of gene pool in *Brassicas* through Interspecific and Intergeneric hybridization	Arun Kumar
DRMR CI14	Genetic and molecular basis of heat tolerance in Indian mustard	BhgirathRam
DRMR CI- 15	Re-synthesis of Indian mustard (*Brassica* juncea L. Czern. & Coss.)	H S Meena
Programme :2	**Breeding for yield and quality enhancement in rapeseed-mustard**	**K H Singh**
DRMR CI – 5	Development of hybrids in Indian mustard	K H Singh
Programme :3	**Programme: Rapeseed-mustard genetic resource management**	**J Nanjundan**
DRMR CI6	Augmentation, Characterization, Evaluation , Rejuvenation and Maintenance of Rapeseed- Mustard Germplasm	J Nanjundan
Programme:4	**Biotechnological interventions to improve rapeseed-mustard productivity**	**P K Rai**
DRMR BT-1	In vitro plant regeneration and genetic transformation o *Brassica juncea* L. Czern. & Coss. with an antifungal defensin gene	A K Thakur
DRMR BT-4	Genetic analysis of white rust resistance loci of Indian mustard and their marker assisted introgression to some of the popular Indian cultivars	B K Singh
Programme:5	**Enhancing resource use efficiency and abiotic stress management for resilient rapeseed-mustard production system**	**B K Kandpal**
DRMR PHY-4	Diagnosis of nutrient deficiencies in Indianmustard through visual symptoms and plant analysis	S P Singh
DRMR CP-6	Enhancing soil resilience in mustard based systems through integrated crop management practices	O P Premi
DRMR CP:11	Evaluation and Standardization of RCT's for mustard based cropping systems under semi-arid conditions of Rajasthan	Kapila Shekhawat
DRMR CP13	Characterization and classification of soil-site conditions to delineate rapeseed-mustard production zones	B K Kandpal
DRMR CP14	Long term fertility experiment to study changes in soil quality, mustard productivity and sustainability	NS Bhogal
DRMR CP15	Efficient water management in *Brassica juncea*	S S Rathore
Programme 6	**Management of biotic stresses in Indian mustard**	**Y P Singh**
DRMR ENT-2	Biological control of major pests of *Brassicas* with special reference to mustard aphid	Y P Singh
DRMR ENT-3	Pest-plant interaction of major pests of *Brassicas*.	Y P Singh

DRMR PP-1	Management of *Sclerotinia* rot in Rapeseed-Mustard	Pankaj Sharma
DRMR-PP 3	Management of *Alternaria* Blight in Rapeseed-Mustard	P D Meena
DRMR PP-5	Epidemiology and management of white rust	P K Rai
Programme: 7	**Technology assessment and dissemination**	**A K Sharma**
DRMR CA-1	Development of application software for rapeseed-mustard information management.	Vinod Kumar
DRMR ECT – 4	Participatory extension for dissemination of rapeseed-mustard technology	A K Sharma
DRMR AE-3	Assessment of Technology, Risk & Returns In Rapeseed-Mustard Cultivation	Lijo Thomas
Externally Funded Projects		
DRMR EA 2	Characterization of rapeseed–mustard varieties for distinctness, uniformity and stability (DUS) testing	K H Singh
DRMR EA 4	ICAR seed project on seed production in agricultural crops	V V Singh
DRMR EA 7	Intellectual property management and transfer/ commercialization of agricultural technology scheme	K H Singh
DRMR NP 2a	ICAR-NPTC: Development of aphid resistant transgenic Brassica	A K Thakur
DRMR NP 2b	ICAR-NPTC: Brassica functional genomics for Alternaria blight and drought/ heat tolerance	P K Rai
DRMR NP 5	Diagnosis and management of leaf spot diseases of field and horticultural crops	P D Meena

10 IRC and IMC Meetings

Institute research council meetings

DRMR organized its 23rd Institute Research Council (IRC) meeting on Sept. 27-28, 2013 under the chairmanship of Director, DRMR. Scientists presented the findings of the year 2012-13 and proposed technical programme for 2013-14. Emphasizing cross disciplinary thinking among scientists Chairman asked for missionary efforts to upscale variety seed replacement and generation of farmer participatory technologies together. The Chairman suggested keeping all F_2 population and segregating progenies from forthcoming crop season onward so that concerned scientists along with team can use the information jointly. The pre-breeding objectives should be clear and strengthened to ensure generation of good genetic material. The Chairman suggested maintaining single pedigree register for the benefits of all the breeders, live cafeteria of promising rapeseed-mustard varieties and economic assessment of all production-protection technologies before dissemi-nation. The Director reaffirmed his full support to scientists for the cause of science and effort to make DRMR world leader in rapeseed-mustard research. He expressed full confidence in the capabilities and potentials of scientists and ensured constraints free and well-coordinated working environment to all in the Directorate.

Institute management committee

16th Institute Management Committee meeting was held on May 10, 2013 under the chairmanship of Dr. J S Chauhan, Director. The committee discussed different agenda, small equipment and facilities required for the ongoing research and made suitable recommendations for approval of the council.

IMC	
Director, DRMR, Bharatpur	Chairman
Joint Director of Agriculture, Directorate/ Dept of Agriculture, Govt of Rajasthan, Bharatpur (Raj)	Member
Joint Director of Agriculture, (Oilseeds), Dept of Agriculture, Govt of Madhya Pradesh, Bhopal	Member
Dr Govind Singh, Director Research, SKRAU, Bikaner (Raj.)	Member
Smt Sushma Singh, M M 4/45 Vinaykhand, Gomati Nagar, Lucknow	Member
Dr AN Sharma, Principal Scientist, Directorate of Soybean Research, Indore	Member
Dr AL Singh, Principal Scientist, Directorate of Groundnut Research, Junagadh	Member
Dr BD Sharma, Principal Scientist, Soil chemistry/fertility, CIAH, Bikaner	Member
Dr Arjun Lal, Head, Germplasm Exchange, NBPGR, New Delhi	Member
Dr BB Singh, ADG (O&P), ICAR, New Delhi	Member
Sh KS Tanwar, Finance & Account Officer, DRMR, Bharatpur	Member
Assistant Adm Officer, DRMR, Bharatpur	Member Secretary

11 Participation in Conferences, Meetings, Seminars, Symposia and Workshops

Events	Venue	Period	Participant
Brain Storming Session on "Methodological Issues in Extension Researches: Way Forward"	Zonal Project Directorate, Zone-VI, CAZRI Campus, Jodhpur	April 26, 2013	A K Sharma Pankaj Sahrma
Annual Zonal workshop of KVK Zone VI held at	RARI, Durgapura, Jaipur.	May 2-4, 2013	Pankaj Sharma
Workshop of IARI National Extension Programme with different Institutes/ SAUs	IARI, New Delhi	May 8, 2013	A K Sharma
Plant Genome Saviour Community Award Function, organized by PPV&FRA	NASC, New Delhi,	May 22, 2013	J Nanjundan
International Conference on Impact of Technological Tools on Food Security under Global Warming Scenario	Shobhit University, Meerut,	May 11-12, 2013	SS Rathore, Bhagirath Ram, B K Singh, Arun Kumar, H S Meena
XX Annual Group Meeting of AICRP-RM	SDAU, SK Nagar (Gujarat)	July 5-7, 2013	JS Chauhan, YP Singh, B K Kandpal, PK Rai, VV Singh, KH Singh, P D Meena, SS Rathore, AK Sharma, Pankaj Shrama, SP Singh, J Nanjundan
Meeting on Performance of seed minikits distributed under ISOPOM scheme during XI Plan	Krishi Bhawan, New Delhi	July 30 , 2013	KH Singh
Zonal Research and Extension Advisory Committee meeting	ARS, Navgaon (Alwar)	Aug12, 2013	BK Kandpal, KH Singh, AK Sharma, Pankaj Sharma
VIII *review meeting of ICAR Seed Project*	*NBPGR, New Delhi*	*Aug 26-27, 2013*	V V Singh
Attended the training programme on management of Plant Genetic Resources	NBPGR, New Delhi,	Sept 16-25, 2013	J Nanjundan
South Asia Biosafety Conference',	New Delhi	Sept, 18-19, 2013	Ajay Kumar
8th National Conference of KVKs	UAS, Bangalore	Oct 23-25, 2013.	Pankaj Sharma
Mid-term meeting of RFD Nodal Officers	*ICAR, Krishi Bhawan*	*Oct 29, 2013*	V V Singh
Workshop on 'Intellectual Property and Commercialization in Biotechnology	Amity University, Noida (UP)	Nov 13, 2013	Dhiraj Singh, V V Singh, HS Meena

Launching workshop cum training programme "NEH Component: Enhancement of Rapeseed-Mustard Production	Agartalla, Tripura	Nov, 23-24, 2013	Lijo Thomas
Indo-Canadian meeting on prioritization of research areas for collaboration in the field of genomics	Krishi Bhavan, New Delhi	Nov 28, 2013.	Dhiraj Singh, KH Singh, Ajay Kumar
Workshop on Problem formulation for identifying protection goads relevant to the environment risk assessment of GE plants in India	NASC complex, New Delhi.	Dec 19-20, 2013.	Arun Kumar
National Symposium on Emerging Trends in Eco-friendly insect pest management"	Tamilnadu Agricultural University, Coimbatore during	Jan 22-24, 2014.	Y P Singh
Monitoring of DUS Test centres at DRMR Bharatpur	CSAUAT Kanpur	Febr 5-6 , 2014	KH Singh
2nd National Brassica Conference on Brassicas for Addressing Edible Oils and Nutritional Security	PAU, Ludhiana,	Feb 14-16, 2014	Dhiraj Singh, BK Kandpal, NS Bhogal, OP Premi, PD Meena, SS Rathore, Bhagirath Ram, Vinod Kumar, Arun Kumar, HS Meena
Conference on Innovation Ecosystem -Indian Perspective organized by National Research Development Council	University of Petroleum and Energy Studies, Dehradun, Uttarakhand	Feb,27-28, 2014	Lijo Thomas
8 review meeting of DUS test centres and Projects at organized by Protection of Plant Varieties and Farmers Rights Authority	UAS Dharwad	Feb 28- March 1, 2014	KH Singh
Annual breeder seed review meeting	Durgapura, Jaipur	March 7, 2014	KH Singh
35 All India Rabi Seminar on Oilseed Crops	COOIT	Mar 8-9, 2014	Lijo Thomas

12 Workshop, Meetings, Seminar, Short Course and Trainings Organized

Short Course on Advances in Seed Production and Processing of Rabi Oilseeds

DRMR organized a 10 days ICAR sponsored short course on "Advances in seed production and processing of *rabi* oilseeds" during Dec 4-13, 2013. In this training programme, 13 participants from eight states (Arunachal Pradesh, Asom, West Bengal, Odisha, Chhattisgarh, Uttar Pradesh, Rajasthan and Maharashtra) participated. Total 26 lectures, 10 practical-cum-field demonstrations and 03 field visits to seed production fields, seed processing plant and seed store were organized. During these lectures, participants were given chance for interaction and clarification of their doubts and queries. Major topic covered were; history of seed industry in India, scenario of oilseed seed production, weed, disease, insect pest management in rabi oilseeds, advances in hybrid seed production, different varieties/ hybrid of rapeseed-mustard, terminator seed technology, field inspection: procedure and standards in rabi oilseeds, advances in seed processing and seed storage, Protection of Plant Varieties and Farmers' Rights Act (PPVFRA); Seed certification- procedure and important agencies and determination of quality parameters in seed production, *etc.* These topics were covered by resource persons from DRMR, Bharatpur, IARI, New Delhi, CCSHAU, Hisar, MPUA&T, Udaipur, SKN Agriculture University, Jobner (Jaipur) and Seed certification agency, Bharatpur. Dr V V Singh, Pr. Scientist (Plant Breeding) was Course Director of this Short course programme.

DRMR ˘KVK Interface Workshop Organized at Bharatpur

The Directorate of Rapeseed-Mustard organized the first DRMR-KVKs Interface workshop on 06th June,2013 at Bharatpur. The workshop was conducted to evaluate the technology demonstrations conducted by various KVKs during the crop season 2012-13 and to sensitize the KVK functionaries from major rapeseed-mustard growing regions about the improved technology practices available for the crop. Project Coordinators and SMS from several KVKs representing the states of Rajasthan, Uttar Pradesh, Madhya Pradesh and Haryana attended the workshop. This initiative was undertaken to bring about the better coordination between DRMR and KVKs.

The performance of DRMR varieties in Front Line Demonstrations conducted by the KKVs at Kumher, Dausa, Bansur, Alwar, Kotputli and Sawai Madhopur was presented in the workshop. The success of the demonstrations and the potential for yield enhancement has raised the awareness about these varieties. The workshop discussed the major production constraints faced during the last crop season. Critical deliberations on the ways and means to increase the adoption of improved varieties and technologies by the farmers were taken up during the workshop. The strategies to overcome the production constraints faced during the last cropping season were also discussed.

Research˘Extension-Industry-Farmers Interface Meeting organized at DRMR

The Directorate of Rapeseed Mustard Research organized the Research –Extension-Industry-Farmers Interface Meeting on 26th September, 2013 at DRMR, Bharatpur. The theme of the

meet was "*Linkages for Enhancing Productivity of Rapeseed-Mustard*" which was selected in keeping with the broad objective of the meet. This will enable to speed-up the process of transferring research outputs from the lab to technological and practical applications of immediate use to the farming community. The meeting brought together, the various stakeholders in rapeseed-mustard development to discuss the problems faced by each constituent in fulfilling their mandate and explored the possibilities for developing fruitful linkages in rapeseed-mustard research and development. The participation from all the stakeholder communities of the rapeseed-mustard economy made the meet a platform for mutual understanding and exchange of innovative ideas. Apart from the scientists of DRMR, representatives from agro-chemical industries, private agricultural research organizations, seed manufacturers, agro-input delivery agencies, public sector seed distribution agency, non- governmental agencies involved in developmental activities in rapeseed-mustard crop sector and representatives from research and administrative sections of the state agricultural department participated in the programme.

Addressing the participants, Dr. Dhiraj Singh, Director, DRMR said that the directorate shall strive to become the leading centre at the national and international level in all matters pertaining to the rapeseed-mustard research and development. The emerging threats of multi nutrient deficiency in the soil, challenges related to climate change, the need to conserve natural resources *etc.* are areas where the directorate would look forward to make its contribution.

Speaking on behalf of the oilseed-processing industry, Sh. Krishan Kumar Agarwal, Vice President of Mustard Oil Producers Association of India (MOPA), gave an outline of the economy wide trends in edible oil imports and its financial implications. He underscored the mutual dependence between oilseed farmers and the oilseed-processing industry and said that the industry will have to take a more proactive role to promote technology adoption by the farmers. The president of the Bharatpur Chamber of Commerce, Sh. Goyal welcomed the initiative by the directorate to bring different stakeholders together and expressed his hope that the industry can contribute constructively to achieve higher productivity in rapeseed-mustard.

13 Tribal Sub-Plan

As per the guidelines of Planning Commission for Tribal Sub Plan to channelize the flow of outlays and benefits from the general sectors in the central ministries/deptt for the development of Scheduled Tribes at least in proportion to their population for reduction in poverty & unemployment, creation of productive assets and human resource development, DRMR is also implementing the TSP since 2011-12 with schemes to develop agriculture and allied activities that provide a source of livelihood and human resource development of tribal farmers of selected targeted area of the country.

Keeping in view of success of the Tribal Sub Plan being implemented by DRMR continued the programme with same universities for 2013-14. DRMR signed 4 MoUs for the year 2013-14 with CAU, Imphal, Manipur (Out lay of Rs. 56.59 lakhs), BAU, Kanke, Ranchi, Out lay of Rs. 13.61 lakhs), AAU, Jorhat, Asom (Out lay of Rs. 12.10 lakhs) and RVSKVV, Gwalior, Madhya Pradesh (Out lay of Rs. 10.31 lakhs) for augmenting rapeseed-mustard production for sustainable livelihood security of tribal farmers in selected districts of their jurisdiction. The participatory varietal selection, organizing FLDs, 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 the activities carried out under the TSP to promote technology adoption and productivity enhancement in rapeseed-mustard cultivation.

During 2013-14, TSP was implemented in 17 districts of 4 states *viz.*, Senapati, Imphal East, Imphal West, Churachandpur, Thoubal & Bishnupur districts of Manipur, East Siang, Weat Siang & Papum Pare districts of Arunachal Pradesh, Kolasib district of Mizoram; Ranchi, Lohargaga & West Singhbhum districts of Jharkhand; Dhemaji district of Assam and Jhabua, Dhar & Badwani districts of Madhya Pradesh.

Capacity building of tribal farmers

DRMR organized 3 training programmes for capacity building of the tribal farmers and dissemination of improved technology of rapeseed-mustard among them. Training programmes were organized jointly with RVSKV, Gwalior (22-24 December 2013), CAU, Imphal (13-15 February 2014) and BAU, Ranchi (18-20 February 2014) under the aegies of Tribal Sub- Plan of DRMR and AICRP-RM.

Under tribal Sub Plan, efforts are being made to popularize rapeseed-mustard cultivation in selected tribal areas of North-East region, Jharkhand and Madhya Pradesh. The training programmes were organized for development of knowledge and skills of tribal farmers for encouraging them to adopt the rapeseed-mustard cultivation as rice-mustard cropping pattern instead of keeping the land fallow after rice cultivation. Farmers were also motivated to grow mustard in place of wheat keeping in view of low water requirement and more profit. The major objective of the programme was to enhance the income of tribal farmers by enhancing farm productivity. Directorate has been doing intensified and sustained efforts for the benefit and upliftment of tribal farmers in the tribal areas under this programme. The major activities under the programme included developing small water harvesting structure frontline demonstrations of improved

technology in tribal areas, distribution of implements/ equipments to tribal farmers and training of tribal farmers to promote technology adoption and productivity enhancement in rapeseed-mustard cultivation.

Monitoring of TSP project

Dr. Dhiraj Singh, Director, DRMR visited Imphal during 5- 7 February, 2014 and witnessed large scale demonstration on Zero tillage cultivation of rapeseed-mustard. He also attended the Farmers' Field Day on 6th February, 2014 as Chief Guest at Poiroupat, Imphal East District, Manipur. A total of 286 progressive farmers including 98 farm-women from the project site participated in the field

day and farmers-scientists interaction programme. Director, DRMR along with Sh. Shamu Kabui, Director (Agriculture), Government of Manipur, Dr. M. Rohinikumar Singh, Director of Research, CAU, Imphal, Dr. M. Premjit Singh, Director of Extension Education, CAU, Imphal, Dr. J. M. Laishram, Dean, College of Agriculture, CAU, Imphal and Dr. Bhagirath Ram, Sr. Scientist, DRMR attended the Farmers Field Day and witnessed the bumper crop of rapeseed-mustard cultivated under zero tillage in an area of 338 ha. Dr. Dhiraj Singh stressed on evaluation of high yielding varieties of Indian mustard and yellow sarson in farmers' field and identification of suitable short duration genotypes for rice fallows of North-eastern Hill region. Further he advised the tribal farmers of Manipur for using zero till seed drill in mustard field for maintaining proper plant population and enhancing yield. He also witnessed the bumper crop of Indian mustard variety developed by DRMR NRCHB-101 grown in 76 ha under zero tillage cultivation at Khumbong, Imphal West, Manipur on 7th February, 2014.

14 Krishi Vigyan Kendra, Gunta-Bansur (Alwar)

On and off-campus trainings

Nine on campus trainings including three sponsored from ATMA, were organised at KVK on different aspects *viz.* Scientific production technology for mustard, clusterbean, Insect and disease management in kharif crops, Insect and disease management in mustard, IPM in cucurbitaceous crops and Improved cultivation of mustard. Total 326 farmers participated in these trainings.

Eight off campus trainings were conducted in different villages during cropping season and provided the knowledge to farmers on different aspects of improved package practice of crops, plant protection and animal nutrition. A total 260 farmers and farm women were benefitted by these trainings.

Front Line Demonstrations

During Kharif 2013, ten FLDs in 4.0 ha on cluster bean var. RGC 1002 and 10 FLDs on green gram var. SML 668 were conducted in 4.0 ha area. Average yield in clusterbean was 12.1 q/ha while in local check it was 8.8 q/ha. The per cent increase in yield was 27.2 and B:C ratio was 1:1.7. Farmers liked this variety for short duration (85-90 d) and good yield. A field day was also organised on cluster bean at village Bhupseda.

Average yield in green gram was 6.3 q/ha while in local check it was 4.0 q/ha. The per cent increase in yield was 36.5 and B:C ratio was 1:1.02. Farmers liked this variety for short duration and good yield but frequent rains caused *Cercospora* leaf spot and yellow vein mosaic. A field day was also organized on green gram at village Santhalpur.

In Rabi 2013-14, forty FLDs in 20.0 ha were conducted on mustrad var. NRCDR-2. 15 FLDs of AICRP-RM were also conducted in 6.0 ha. The maximum and minimum yield was 25.5 and 16.0 q/ha, respectively. Average yield was 19.4 q/ha while in local check it was 14.2 q/ha with an increase of 36.6 per cent. B:C ratio was 1:2.23.

Farmers appreciated the performance of the variety for its good number of branching and pods. A field day was also organized on mustard at village Kanpura.

Other Demonstrations

In Rabi 2013, for nutritional security, packets vegetable seeds were provided to 50 farm women for their kitchen garden. One off campus training was also conducted on nutritional management at village Motuka.

Demonstrations on mineral mixture were also given to the 50 farmers covering 110 animals. One off campus training and one de-worming campaign were also conducted at village Kanpura.

On Farm Trial (OFT)

One OFT on Sclerotinia rot management was conducted at five farmer's field. Four treatments were tested during the experiment. The results of OFT revealed that seed treatment and foliar spray of carbendazim, low soil

moisture during December end to January first fortnight, gave the maximum yield (17.8 q/ha) and B:C ratio 1:1.96 as compare to farmers practice (12.6 q/ha and B:C 1:1.16).

Krishak and night Gosthi

A total five krishak gosthi were organized in different villages *viz*. Aospur, Chandoli, Motuka, Chula and Kanpura. A total 183 farmers and 23 farm women were benefited by these gosthis. One night gosthi was organized in village Kanpura in which 60 farmers were benefited.

Other Demonstrations

Ten lectures were delivered in different farmer meeting, kharif and rabi abhiyan programmes, seven film show were also organized for trainee farmers, one farmer scientist interaction meeting was organized, 29 diagnostic visits were also conducted, and one exhibition of KVK was organized during Krishi mela of ATMA, Alwar. Advisory to farmers were also given over telephone and their visit to KVK. With all above activities 3382 farmers and 733 farm women were benefitted.

One day Parthenium awareness and eradication programme was organized on KVK.

Scientific Advisory Committee (SAC) meeting

First scientific advisory committee meeting of KVK was organized in collaboration with KVK Kotputli on 13 March 2014.The meeting was chaired by Dr P.N. Kalla, Director Extension Education, SKARU Bikaner. Chief guest was Dr Sangram Singh, DEE, SKN Agriculture University, Jobner. Dr Pankaj Sharma, Incharge KVK presented the progress report (2012-14) and action plan (2014-15). Dr. Kalla appreciated the work done by the KVK. During the meeting 45 officers of agriculture, line departments and progressive farmer and farm women participated.

Foundation day

KVK organised its 3nd Foundation day on 28.3.2014. Chief Guest Dr. Y.P. Singh, Principal Scientist, DRMR delivered Foundation day lecture. Dr. Singh on the occasion highlighted the mandates of the KVKs and said that establishment of this KVK will greatly improved the efficiency of the technology dissemination. Dr. Pankaj Sharma, Senior scientist and Incharge KVK welcomed the guests and presented the annual progress report of last one year. 30 progressive farmers from different villages participated in the programme.

Publications

Twenty one popular articles were published. All extension activities were covered and timely published in print media (104 no. press release) and also telecasted on ETV news channel as well as Annadata programmes.

Instructional farm

2.0 ha farm land was ploughed, prepared and sown with mustard crop var NRCDR 2.

15 Distinguished Visitors

Name	Designation & Address	Date
Dr B N Singh	Ex- Director ResearchBirsa Agril. Uni. Kanke	April 12,2013
Dr V S Tomar	Vice ChancellorJNKVV, Jabalpur	April 22,2013
Dr P K Chhonkar	Ex- Prof. & Head, Division of Soil Science, IARI, New Delhi	May 14, 2013
Dr Abha Agnihotri		Oct. 14, 2013
Dr N Gopalakrishnan	ADG (Commercial cropsICAR, New Delhi	Oct. 20, 2013
Dr J S Sandhu	Agricultural CommisionerGOI, New Delhi	Oct. 20, 2013 Jan. 25, 2014
Dr J B Chaudhary	Ex- Vice-Chancellor HAU, Hisar & GBPUA&T, PantnagarChairman, RAC, DRMR, Bharatpur	Dec. 14, 2013
Dr P R Verma	Retired Oilseed PathologistAgriculture and Agri-food Canada, Saskatoon	Jan. 27, 2014
Dr S K Datta	DDG (CS)ICAR, New Delhi	Jan. 28, 2014
Sh Prabhu Lal Saini	Minister for Agril, AH & Horti.Govt. Of Rajasthan	Feb. 15, 2014
Dr S Ayyappan	Secretary (DARE) & Director General (ICAR),New Delhi	Feb. 20, 2014
Dr Arvind Kumar	DDG (Edu.)ICAR, New Delhi	Feb. 22, 2014
Dr D P Singh	Ex. Vice Chancellor, JNKVV, Jabalpur & Chairman RAC	March 5, 2014
Dr D P Singh	Ex- Director of Research, GBPUA&T, Pantnagar	March 27, 2014
Dr R K Chaudhary	Ex- Project Director, DSR, Mau	March 28, 2014

16 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	J Nanjundan, Scientist (SS) (Genetics & Plant Breeding)
7	H.S.Meena, Scientist (Genetics & Plant Breeding)
8	Priya Medha, Scientist (Genetics & Plant Breeding) on study leave
Natural Resource Management	
9	B K Kandpal, Principal Scientist (Agronomy)
10	O P Premi, Principal Scientist (Agronomy)
11	N S Bhogal, Sr. Scientist (Soil Science)
12	S S Rathore, Sr. Scientist (Agronomy)
13	S P Singh, Sr. Scientist (Plant Physiology)
14	Kapila Shekhawat, Scientist (SS)(Agronomy)
Plant Protection	
15	Y P Singh, Princiapl Scientist (Agril. Entomology)
16	S P Singh, Sr. Scientist (Agril. Entomology)#
17	P D Meena, Sr. Scientist (Plant Pathology)
18	Pankaj Sharma, Sr. Scientist (Plant Pathology)
Plant Biotechnology	
19	P K Rai, Principal Scientist (Plant Pathology)
20	Ajay Kumar, Thakur Scientist SS (Plant Biotechnology)
21	Binay Kumar Singh, Scientist SS (Plant Biotechnology)
Technology Assessment & Dissemination	
22	A K Sharma, Sr. Scientist (Agricultural Extension)
23	Lijo Thomas, Scientist (Agricultural Economics)

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	Sanjay Sharma, Senior Technical Officer (STO)**
8	Kailash Narayan, Technical Officer (TO)
9	Govind Prasad, Senior Technical Assitant (STA, Driver)
10	Ram Singh, Senior Technical Assitant (STA)
11	R. C. Meena, Senior Technical Assitant (STA)
12	Rakesh Goyal, Senior Technical Assitant (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	KS Tanwar, Finance & Account Officer
2	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

#Transferred at NBPGR New Delhi
** Promoted during the year

17 Panorama

Agriculture Commissioner visits village under DAC-DRMR collaborative Project

Dr. J S Sandhu, Agriculture Commissioner, Government of India, visited villages Unchagaon and Ekta on 25th January, 2014 where the DAC-DRMR collaborative project on *Enhancing Rapeseed-Mustard Productivity through inclusive technology package and Institutional linkage* is currently in operation. Dr. Sandhu monitored the progress of the project in the villages and visited different fields of the beneficiaries of the project. He interacted with the farmers regarding the operation of the project and their perception regarding its utility and effectiveness. The farmers expressed their satisfaction with the variety, NRCDR-2, disseminated under the project. The farmers also informed the agriculture commissioner that this variety occupies more than 85 per cent of the area under rapeseed-mustard in the village.Dr. Sandhu in his address said that the country looks towards its oilseed farmers to enhance the productivity of oilseeds and to increase the domestic availability of oilseeds in the country. He requested the farmers to

develop close links with research institutions like DRMR to remain aware of the latest technological advancements.

Visit of Deputy Director General (Crop Science)

The Deputy Director General (Crop Science), Prof. Swapan Kumar Datta visited the Directorate of Rapeseed-Mustard Research on 25th January, 2014. During his visit of the experimental fields of the directorate, Prof. Datta held detailed discussions with the scientists and suggested priority areas for taking up scientific enquiry. Apart from the field and laboratory visit, Prof. Datta held an interaction meeting with staff of the directorate on the same day. Dr. Dhiraj Singh, Director DRMR expressed his sincere gratitude for Prof. Datta for the continuous guidance and support received by the directorate in various matters of administration and research. In his address, Prof S K Datta, elucidated the urgent need for the agricultural research institutions in the country to address the yield gap between potential yield and farmers yield. He noted that such a yield gap is in existence in rapeseed mustard crop also. He urged the scientist of the directorate to take up the challenge of bridging the yield gap on a priority basis. He also emphasized the need for enhancing research investment in priority areas to achieve further yield breakthroughs in rapeseed-mustard crop.

There is a pertinent need to integrate strategic research with applied research to harvest the full crop potential in different regions. Increasing efficiency in nutrient and water management, assuring the availability of superior seed material and rational policy choices in marketing and pricing of inputs and outputs can significantly enhance the production of rapeseed-mustard in India. Prof. Datta identified the integration of the different components of yield enhancement as the critical component in achieving higher productivity in rapeseed-mustard. He also advocated the need to adopt a holistic approach focusing on diverse sources of farm income for enhancing the livelihood security of the farmers. While expressing his appreciation for the various activities of the directorate, he also emphasized the need for further strengthening the basic and strategic research for North Eastern States of the country where a substantial yield reservoir is available for exploitation.

Secretary, DARE and Director General, ICAR visits DRMR

Dr S Ayyappan, Secretary, DARE and DG, ICAR visited the Directorate of Rapeseed Mustard Research, Bharatpur during 19-20th February, 2014. Dr. Ayyappan examined the research fields and laboratory facilities of the directorate. During the interaction meeting held with the scientists, Dr Ayyappan appreciated the efforts and initiatives taken by the directorate for enhancing rapeseed-mustard productivity in the country. Dr Ayyappan outlined the emerging challenges in the agricultural sector and the need to maintain scientific excellence and innovativeness to address these challenges. The director general praised the strategic initiatives taken by the directorate to enhance the seed production capacity and to enhance productivity in different regions of the country. He hoped that the directorate would take active interest to exploit biotechnological tools for enhancing our awareness and understanding about the crop functional genomics and subsequently use the knowledge in enhancing the genetic potential of the crop. The dream of self-sufficiency in oilseeds is critical for the nutritional security of the country and this can be achieved only through bringing about a yield breakthrough in the major oilseed crops. He reviewed the activities of the various forums like IMC and IJSC during the interaction meeting and expressed his happiness on the prevailing atmosphere of goodwill and cooperation amongst the personnel of the directorate.

DRMR celebrated its 20th Foundation Day

DRMR celebrated its 20th Foundation day on October 20, 2013. The celebration started with the cultural evening on October 19, 2013. Dr. J S Sandhu, Agricultural commissioner, Government of India delivered the foundation day lecture on this occasion. In his address to the scientists, officials of the agriculture department, farmers and other stakeholders, he recalled the path of attainment of self sufficiency in food grains and the effort that was demanded in this achievement. He called upon the scientist working on oilseed crops to strive to bring about similar self sufficiency in oilseeds so that nutritional security of the country can be ensured. The chairman Dr B.B. Singh, Assistant Director General (Oilseeds and Pulses), ICAR, New Delhi, expressed the pace of research and development at the directorate and reiterated the importance of rapeseed-mustard in the oilseed economy of the country. He pointed out that the directorate has succeeded in both technology generation and its dissemination among the farming community. Guest of honour Dr. N Gopalakrishnan, Assistant Director General (Commercial Crops), ICAR, New Delhi, exhorted the personnel of the directorate to uphold the values of integrity and hard work to become successful in fulfilling the mandate of the institution.

On the occasion, Dr Dhiraj Singh, Director, DRMR presented the salient achievements of the directorate during its 20 years of existence. He expressed his hope that the emerging challenges faced by farmers and researchers in enhancing rapeseed-mustard production and productivity can be tackled successfully through innovative and prudent application of

science, enabling policy and sound administration.

Four publications from the Directorate, "20 years of accomplishments and challenges"; "Siddarth *Sason Sandesh*", "*Sarson News*" and "Taramira ki unnat kheti" were released by the guests during this occasion. The Directorate also recognized the contributions from its staff during 2011-12 and presented awards in various categories of employees. The best scientist award was given to Dr P D Meena. Sh. U S Rana and Sh. Rakesh Goyal were awarded in the technical staff category, while Sh. Mukesh Kumar and Sh. Tara Singh were awarded in the administrative and supporting staff category, respectively.

Independence Day celebrated

67th Independence Day was celebrated with full color and zeal on 15th August 2013. Flag hoisting was done by Director (Acting) Dr Y P Singh. In his Independence Day speech he wished all the staff members & their family a happy independence day and reminded about the sacrifices made for achieving this moment of glory. He congratulated all the staff for working hard in bringing pride for the institute. Further it was reiterated that we should contribute in nation building by sustainably enhancing the oilseed production of the country and making the country self reliant in meeting its edible oil demand.

Republic day celebrated

Directorate celebrated 65th Republic day on January 26, 2014. Dr Diraj Singh, Director DRMR did flag hoisting in presence of DRMR staff and their family members. He congratulated all the staff for working hard in bringing many feat for the institute. Dr P R Varma, former scientist from Agri-Food Canada, Saskatoon Research Centre, Saskatchewan, Saskatoon was the chief guest on this occasion. Director in his republic day speech emphasized to promote qualitative efforts in the field of Brassica research for achieving self sufficiency in oilseed production

in the country. On this occasion Director reiterated that each challenge becomes an opportunity to strengthen our resolve to achieve self reliant in edible oil production. On the eve of republic day different games and sport activities were organized for different categories of age group including children and staff of DRMR. Later, winners and the runner of different games/sports were felicitated on this occasion.

Hindi Pakhwara

Hindi Pakhwara was organised in Directorate during 14 - 29 September 2013. During this period various competitive events were organised and winners were awarded. Dr. Dhiraj Singh, Director DRMR motivated the

participants to work in Hindi particularly in transfer of technology from lab to land.

Samaj Sadan

In general body meeting, Samaj Sadan elected new executive on June 4, 2013 for next two years. The newly elected samaj Sadan management will work for 2013-14 to 20014-15. Dr Bhagirath Ram, Senior Scientist (Genetics and Plant Breeding), Sh. Shitanshu Kumar, AO, Sh. Umesh Sharma, AAO, Sh. Karnal Singh, STO and Dr (Smt) Kapila Shekhawat , Scientist (SS) Agronomy were elected as General Secretary, Joint Secretary, Treasurer, Sport and Cultural secretary, respectively. During current year samaj sadan organized many activities which include fare well and welcome parties for outgoing, newly joined staff respectively. Fare well parties was given to Dr Manju Bala, Senior Scientist (Biochemistry), Dr S P Singh, Senior Scientist (Agrill Entomology, Sh. J L Sharma, AO., who has been promoted or got transferred to other ICAR institutes.Also holi and diawli Milan samaroh were organized. On the eve of New Year 2014, a New Year party was organized on December 31, 2013.

Budget (Rs in lakhs)

Head	Plan		Non-Plan	
	Sanctioned	Utilized	Sanctioned	Utilized
DRMR	175.00	175.00	502.00	487.98
AICRPRM	860.00	860.00	-	-

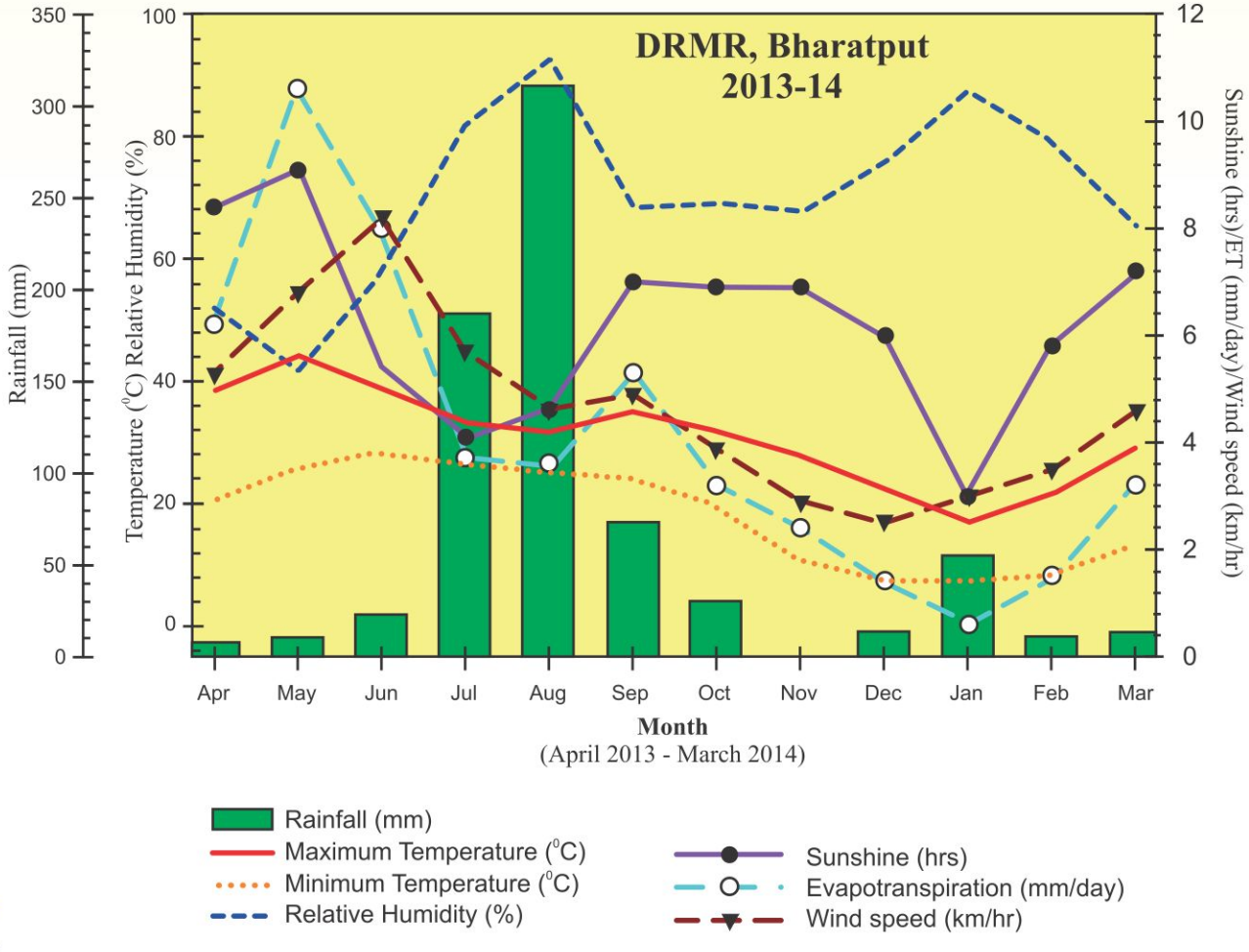
Resource generation

Head of Account	Amount (Rs)
Sale of farm produce	18,49,123
Sale of tender forms	65,800
Sale of publication and advertisement	4,492
License fee	2,94,467
Analytical testing fee	1,92,419
Income generated from internal resource generation schemes	
(a) Training	1,90,000
(b) Guest House	3,72,200
(c) Transport charges	91,430
(d) DRMR	30,40,732
(e) RTI	160
Total 61,00,823	

18 Meteorological Data

Year 2013-14 was a good monsoon year in succession. A total739.8 mm of precipitation was received in 67 rainy days. The monsoon became active in last week of June and remained active throughout July, August and September (up to 3rd week). The rainfall at good interval during *rabi* season promoted growth of rapeseed-mustard crop. But rains due to western disturbances during maturity and harvesting stage caused increased disease infestation and harvesting losses.

Throughout the cropping season the mean monthly temperature remained favorable except few incidence of frost injury in some pockets during first week of January 2014. The evaporation losses ranged from 0.6-10.6 mm/day during the year and 0.6-3.2 mm/day during *rabi* season. The average sunshine during crop season was 3.0-6.9 hours. However, minimum daily temperature reached <4.5°C during last week of Dec. 2012 to 2nd week of Feb. 2013. The lowest daily minimum temperature of -1.5°C was recorded on Jan. 8, 2013 causing severe frost damage to mustard crop in Bharatpur district.



Giriraj (DRMRIJ 31), a high yielding Indian mustard variety developed by DRMR