Summary

Seasonal Conditions
Weather during 2010-11 crop season was quite favourable. Late September rains delayed sowing of early mustard and toria trials. The timely sown mustard crop was good because of sufficient moisture at the sowing time. Rainfall during November-December 2010 resulted in good crop growth. Extremely low minimum temperature in January (3.5 °C) and February (4.2 °C) slightly affected the crop especially at Morena. Good intermittent rains occurred during the cropping season at Kangra, favoured crop growth. In zone II, except Bawal, maximum temperature was > 30°C at all the locations during September-October 2010. The maximum temperature during September-October 10 ranged between 30.4 °C - 35.9 °C in zone III. In zone IV, very good rains were received in the month of September and November. In zone V, rainfall ranged from 5.16 mm at Jagdalpur and 195.0 mm at Imphal during October. Berhampore, Dholi, Jagdalpur and Imphal recorded good rains in September also.

Plant Breeding and Genetics

Variatel Improvement
Twenty three centres spread over 18 states carried out the varietal development programme in toria (Brassica rapa var toria), yellow sarson (B. rapa var yellow sarson), gobhi sarson (B. napus), Indian mustard (B. juncea), karan rai (B. carinata) and taramira (Erucia sativa) during the year 2010-11 in accordance with agro-ecosystem requirements of different crops.

Genetic Resource Management
A total of 4,721 accessions comprising toria , Indian mustard, yellow sarson, gobhi sarson, brown sarson, karan rai, taramira, Brassica tournefortii, Sinapis alba, B. caudatus, B.nigra, B. oleracea, Raphanus sativa, R. caudatus, Crambe spp, Lepidium spp and Camellina spp. were maintained following appropriate mating systems. 521 new accessions of Indian mustard, toria and taramira were collected. 2,249 accessions including Indian mustard, toria, yellow sarson, gobhi sarson, brown sarson, karan rai and taramira were evaluated. On the basis of germplasm evaluation promising donors were identified for earliness, tolerance to aphid and drought.

Creation of genetic variability through hybridization/ mutagenesis and selection
With a view to improve seed yield, earliness, seed size, disease/pest resistance, high temperature tolerance, quality and high oil content, 953 crosses were attempted in toria (32), yellow sarson (5) and Indian mustard (770) at Morena, Kanpur, Pantnagar, Dholi, Hisar, Navgoan, Nagpur, Sriganganagar and Varanasi. Selection of superior plants/bulk at different centres was practiced in toria, yellow sarson and Indian mustard. In toria, development of composites and reconstituting population after selection were the main objectives. 810 bulks were made. In yellow sarson, hybridization selection from segregating generations was attempted at Pantnagar and Dholi. In Indian mustard, 8,624 single plants and 687 bulks were selected from segregating and advanced generations.

Evaluation of advanced breeding lines
Performance of selected advance breeding lines was evaluated under different station/ state /preliminary yield trials at various centres. 44 strains of toria were tested at Kanpur, Dholi and Pantnagar and yield superiority was up to 37.1 % over the check (PT-303) at Dholi. In yellow sarson, total of 49 strains were tested at Kanpur and Dholi and yield superiority up to 51.9 % over the check Swarna was recorded at Dholi. In Indian mustard, 559 strains were evaluated at 8 centres in 28 trials. Yield superiority up to 35.2 % over the check Kanti was recorded at Kanpur. 12 strains of taramira were evaluated in a trial at Jobner and yield superiority up to 15.5 % over the check, RTM 314 was recorded.
Hybrid/ Mapping populations’ development

In Indian mustard mapping populations for white rust disease were developed at IARI, New Delhi. CMS and restorer conversion programme for hybrid development has been undertaken at IARI New Delhi, Hisar, Morena, S.K. Nagar and Pantnagar

Breeder seed production

Against the indent of 75.32 q breeder seed of 37 centrally and 31 state released varieties of rapeseed – mustard, 152.41 q breeder seed was produced at 19 different centres.

Coordinated Trials

One hundred seventy five promising strains of toria, yellow sarson, Indian mustard, gobhi sarson and taramira were evaluated in 24 yield trials at 179 locations across 5 agro-climatic zones of the country. A total 16 strains comprising 1 of toria, 14 of Indian mustard and 1 of gobhi sarson has been promoted for advance stage testing (see below):

Rapeseed-Mustard strains excelling the best check by 10% or more in seed or oil yield

<table>
<thead>
<tr>
<th>Zone I</th>
<th>Zone II</th>
<th>Zone III</th>
<th>Zone IV</th>
<th>Zone V</th>
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<tbody>
<tr>
<td>Toria/Early mustard IVT (Irrigated/Rainfed)</td>
<td>TKM 10-2 (2269)</td>
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<tr>
<td></td>
<td></td>
<td>Toria/Early mustard AVT-1 (Irrigated)</td>
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<td>44 S 01 (1109)</td>
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<td></td>
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<td>PRE 2007-06 (1018)</td>
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<tr>
<td>Mustard IVT Timely sown (Irrigated)</td>
<td>RGN-282 (2811)</td>
<td>PBR 375 (2807)</td>
<td>DRMRIJ-31 (2757)*</td>
<td>SKM B 817 (1726)</td>
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<td>PBR 375 (1722)</td>
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<td>SKM 815 (1705)</td>
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<td></td>
<td></td>
<td>RGN-282 (1679)</td>
</tr>
<tr>
<td>Mustard IVT Timely sown (Rainfed)</td>
<td>RH 0735 (2730)</td>
<td>PBR-375 (2666)</td>
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<td></td>
</tr>
<tr>
<td>Mustard AVT-I + II Timely sown (Irrigated)</td>
<td>RH 749 (2487)</td>
<td>Divya-33 (2464)</td>
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</tr>
<tr>
<td>Mustard AVT-I + II Timely sown (Rainfed)</td>
<td>PBR-378 (2692)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mustard IVT Quality</td>
<td>CJ 3761 (2617)</td>
<td>LES 43 (2238)</td>
<td>CJ 3761 (1859)</td>
<td></td>
</tr>
<tr>
<td>IVT Gobhi sarson</td>
<td>GSC 101 (1811)</td>
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</table>

Figures in parenthesis indicates seed yield kg/ha; * strains promoted on the basis of oil yield

Agronomy

Plant nutrition in mustard based cropping systems

At Khudwani, sulphur application @ 20 kg/ha increased seed yield of brown sarson by 7.8%. Cluster bean-mustard at SK Nagar and black gram-mustard cropping system at Dholi with 125% recommended fertility level recorded highest mustard seed yield.
Evaluation of land use systems
Organic system at Bharatpur (2792 kg/ha) and inorganic fertilization at Morena and Pantnagar produced significantly maximum mustard seed yield (1243-2317 kg/ha).

Paira cropping studies
Line sowing of brown sarson at Khudwani and toria at Dholi alongwith 80 kg N/ha gave maximum seed yield over other practices.

Diversification of crop
Maize (PSM-1) - mustard (NDRE-4) - green gram (PM-4) was most remunerative alternative system at Pantnagar. Mustard + maize (1:1) intercropping significantly increased mustard equivalent seed yield (MESY) over sole mustard crop by 18.0% at Bhubaneswar and 42.0% at Dholi. Wheat + mustard (9:1) increased MESY over sole wheat by 43.0% at Varanasi, while sole wheat crop was superior at Kangra, Kanpur, Pantnagar, and Kanke centres. Wheat or mustard intercropping with pea showed negative impact on system productivity at Kanpur and Kanke.

Fertilizer use efficiency
Seed treatment with Azotobactor + PSB along with 100% (N + P₂O₅) synergistically increased seed yield to the tune of 5.6-11.7% at Hisar, Kota, Morena, Pantnagar, Varanasi, Jobner and SK Nagar.

Weed management
Sheetal (gobhi sarson) at Kangra, Navgold at Bawal, Ashirwad at Varanasi, Kranti and GM-3 (Indian mustard) at Nagpur, Varuna at Bhubaneswar were found most competitive against annual weeds. However, Gulchin (brown sarson) at Khudwani, NRCDR-2 at Bawal, Chatha and Navgaon, Ashirwad at Varanasi, GM-3 at Nagpur produced maximum mustard seed yield.

Among the herbicides, Oxadiargyl (Ronstar) @0.75 kg a.i./ha (PE) at Varanasi, Morena, Kota, Sriganganagar, Bawal, Pantnagar and Chatha; Oxyfluorfen (Goal) @ 0.15 kg a.i./ha (PE) at Kangra, Khudwani and Sriganganagar; Quizalofop (Turga Super) @0.06 kg a.i./ha (25-30 DAS) at Kanpur, Khudwani, SK Nagar and Pantnagar; Clodinafop (TopiK) @ 0.06 kg a.i./ha (25-30 DAS); Isoproturon @ 1.0 kg a.i./ha (PE) at Jobner and Dholi were found most effective against weeds in mustard crop. The yield losses due to weeds ranged from 18.1% to 41.7% across different locations.

Agronomy of hybrid mustard
DMH-1 at Bawal and Jobner, PAC 432 at IARI and Morena produced maximum seed yield. The wider spacing (45 cm x 15 cm) at Bawal, IARI, Ludhiana and Jobner and increased fertility to 125%RDF at Morena and Pantnagar significantly increased mustard seed yield.

Genotypic variation to changing climate scenario
Sept 30 to Oct 10 for Kranti; Oct 11-20 for NRCDR-2 and Oct 21-30 for PBR-357 and RL-1359 was observed optimum sowing time in zone II. While, October 11-20 across the centres in Zone III and at Jobner and October 21-30 at Nagpur and SK Nagar in Zone IV were found optimum.

Fertilizer management
Zone II: PR 2006-1 consistently produced higher yield at all the locations except Sriganganagar under early sowing conditions, where NPJ-124 and NPJ-112 significantly out yielded other varieties. Decreasing fertility levels to 75%RDF significantly reduced the average productivity by 8.6 to 19.5%.
Under rainfed conditions all mustard genotypes significantly out yielded Geeta at all the locations except at Navgaon where only SKM-01 was superior to Geeta. RH 406 and SKM-301 at Hisar; SKM 526 and RH 406 at IARI, PKRS-28 at Ludhiana, SKM-301 at Navgaon and PBR-97 at Sriganganagar produced significantly higher yield than rest of the genotypes. Under late sown situations, RGN-236 at Bawal, Ludhiana, Hisar and Sriganganagar and ELM-123 at Navgoan were found superior.

Zone V: PT 303 at Bhubaneswar; JD-6 at Dholi and Kanke; and NDRE-7 at Shillongani were highest yielder. The fertilizer levels up to 125%RDF at Kanke; up to 150% at Dholi and Shillongani increased the seed yield significantly.

**Plant Pathology**

**Disease scenario**
Moderate to severe incidence of AB was recorded at FZB, KPR and LDH. WR severity was low to moderate at most of the locations. Low to moderate SR severity was recorded at most of the places except NAV. In general, low to moderate incidence of PM was recorded at most of the centers except HSR and KPR where it was severe on late sown crop. Moderate to high severity of DM was observed at FZB and KPR. Moderate incidence of bacterial rot (BR) was recorded from HSR and FZB.

**Promising entries against various diseases**

<table>
<thead>
<tr>
<th>Strains</th>
<th>Disease</th>
<th>Reaction</th>
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<tbody>
<tr>
<td>NPC-20, NPC-21 of B. carinata and EC 339000 and EC 338997 of B. napus</td>
<td>AB</td>
<td>Tolerant</td>
</tr>
<tr>
<td>NPJ 127, NRCM 810, NRCDR 805, RAURDL 02-01 and EC 399313 of B. juncea; DRMR 270, DLSC 1, DRMR 243, MCB-1, BCS 3, BCS 4, NPC 16, NPC 20 and NPC 21 of B. carinata; NUDB 16-11, EC 339000 and EC 338997 of B. napus; TL 17, EC 414291 and EC 414293 B. rapa ssp toria; YSB 9 of B. rapa ssp yellow sarson</td>
<td>WR</td>
<td>Resistant</td>
</tr>
<tr>
<td>BCS-3, BCS-4, NPC-16, NPC-20, NPC-21, DRMR 243, DRMR 261 and DLSC 1 of B. carinata; EC 414293 of B. rapa ssp toria; EC 338997, and NUDB 16-11 of B. napus</td>
<td>DM</td>
<td>Resistant</td>
</tr>
<tr>
<td>DRMR 243, DRMR 261 and DLSC 1 of B. carinata</td>
<td>PM</td>
<td>Resistant</td>
</tr>
<tr>
<td>NPC-20, NPC-21 of B. carinata</td>
<td>SR</td>
<td>Tolerant</td>
</tr>
</tbody>
</table>

**Standardization of differential hosts for A. candida races**
Relative reaction of 13 rapeseed-mustard genotypes was tested against four isolates of *Albugo candida* collected from PNT, HSR, LDH and BHP. Variable reactions of genotypes were observed with different isolates both, at cotyledonary true leaf stage.

**Variability in Alternaria brassicae and Sclerotinia sclerotiorum**
Profound variation in wet mycelia biomass *A. brassicae* isolates was observed on different test synthetic media. Aggressiveness of theses isolates was evaluated with regard to lesion development on 8 different *Brassica* species. Most of the isolates produced lesions of variable sizes on detached leaf after 4-5 days of inoculation at 25°C temperature. Variable reaction of isolates on different *Brassica* species suggests variability among the geographical isolates. Significant morphological, cultural and pathogenic variability was recorded among 37 geographical isolates of *S. sclerotiorum*. On the basis of morphological data, isolates were grouped into two major clusters I and II which showed only 7% similarity to each other.

**Epidemiology of AB, WR, PM and DM**
At BHP, first appearance of ABL occurred on January 14 in October 22 sown crop (84 DAS) on cv Varuna whereas, it appeared seven days later on cv NRCDR-2. The maximum severity of ABL on cv Varuna as well NRCDR-2 was observed in the 3rd week of February when temperature was 24.4°C (max.), 10.2°C (min.), morning RH 96.8% and BSSH 7.2. One week before harvest, the maximum severity of ABP was observed on October 29 sown crop. Initiation of WR on leaf occurred at 111 DAS on both the cultivars.
The maximum staghead formation was observed in November 19 sown cv Varuna while in NRCDR-2 no staghead formation observed.

**Integrated Disease Management**

Soil application of ZnSO$_4$ @ 15 kg /ha + borax @ 10 kg /ha + sulphur as per recommendation combined with foliar application of carbendazim + mancozeb was found most effective in controlling AB, WR, DM and PM diseases of mustard.

**Management of major diseases of Indian mustard using micro-nutrients**

Alternaria blight was reduced effectively with mancozeb spray and use of sulphur in combination with borax. Soil application of ZnSO$_4$ + sulphur minimized the severity of WR and PM. Soil application of ZnSO$_4$ soil @ 15 kg /ha + borax @ 10 kg /ha + sulphur as per recommendation also increased the seed yield,1000-seed weight and oil content.

**Entomology**

This year the weather conditions were not congenial for the development of insect-pests of rapeseed-mustard crops.

**Screening of Advanced Breeding Germplasm**


**Avoidable yield losses**

At Ludhiana and Hisar, highest yield loss of 18.4% and 22.2% was recorded respectively in BSH-1. At Kanpur, avoidable yield loss was recorded maximum in purple mutant (26.7%) followed by DLSC-2 (25.8%) while at Dholi in RK-9501 (16.0%).

**Biochemical basis**

At Ludhiana, higher amount of total phenols, ortho-dihydroxyphenols, flavonols and glucosinolates were found responsible for low aphid infestation in purple mutant, DLSC-2 and T-27.

**Population dynamics of various insect pests on Brassica crops**

Low population of mustard aphid was reported active from most of the centres during 1st to 12th with peak during 6th-8th standard week. Low to moderate population of painted bug was active from 46th to 1st and again 7th to 13th std. week at Hisar while at Bharatpur it was found active during 47th-50th and again 6th-14th std. week. Similarly, low to moderate population of sawfly was reported from Faizabad centre. Low to moderate population of cabbage caterpillar was recorded from 5th to 13th std. week at Hisar and 12th to 13th std. week at Ludhiana (25.4 larvae/plant on PC-5). Low population of leaf miner was reported from Bharatpur. Alate aphid appeared as early as in 43rd standard week at Ludhiana. This year population of alate aphid from most of the centre was reported low while moderate from Berhampore, S.K. Nagar and Pantnagar.

**Bio-efficacy of newer insecticides against mustard aphid**

Oxy-demeton methyl 25 EC @ 250 g a.i./ha and imidacloprid 17.8 SL @ 20 g a.i./ha gave the highest seed yield at Berhampore (1347 kg/ha) and Morena (1606 kg/ha), respectively.
Bio-intensive integrated pest management of mustard aphid

Significantly higher aphid control and yield was obtained in the treatments where the use of NSKE @ 5%, neem oil @ 2% and dimethoate 30 EC @ 1 ml/litre was followed by Verticillium lecanii @10⁸ CS/ml, Coccinella septempunctata @ 5000 beetle/ha and Chrysoperla carnea @ 50,000 larvae/ha.

Plant Physiology

Of the 43 rapeseed-mustard genotypes screened for salinity tolerance (12dS/m) during seedling stage at Hisar, Kanpur and S.K.Nagar centres, RH-0555A expressed salinity tolerance at all the locations based on < 20% reduction in shoot length and seedling dry weight. The genotypes, DRMR-902, JS-29 and RH-0555A showed higher imbibition rate in saline medium. On the basis of < 20% seedling mortality, BPR-349-9 and BPR-540-6 were identified as promising strains for high temperature tolerance at seedling stage at 4 locations. Strains BPR-349-9 and RGN-236 were identified to possess tolerance and PBR-378, NRCDR-701, PRKS-28 and PBR-357 had high photosynthetic efficiency under high temperature stress during terminal stage.

Biochemistry

The highest oil content was recorded in strain PR-2006-1 (44.4%) of B. juncea at LDH; JMT-08-12 (43.9%) of B. rapa var. totria at MOR and NDYS-09-01 (45.7%) of B. rapa var. yellow sarson at KPR. Seven strains (Pusa Karishma, LET 36, RH 801, ELM 3031, Pusa Mustard-21, LES-42 and LES 43) had erucic acid < 2% among the 15 strains evaluated in IVT and AVT-I. High total phenols and glucosinolates were recorded in DLSC-2 (B. carinata), Purple Mutant (B. juncea) and T-27 (Eruca sativa) at LDH. Among the aphid infested and healthy plants, DLSC-2 and Purple Mutant, respectively had maximum lectin activity. Of the six strains evaluated, total phenols and o- dihydroxy phenols increased and flavonols decreased with increase in Alternaria blight infestation. Further, genotypes EC-399313, EC-399296, EC-399299 had higher oxidative enzymes and phenyl ammonia lyase specific activity in the leaves of infested plants.

The salicylic acid (50µmoles/l) increased survival by 17% in B. juncea susceptible genotype. Increase in high temperature tolerance during seedling stage could be due to increased activity of oxidative enzymes. Tocopherols in leaves was highest in PBR-91 (2107.3 mg/100g) followed by RLC-1 (1858.3 mg/100g) of B. juncea. Highest carotenoids were recorded at 35 DAS in RLM-619 of B. juncea. Highest phenols (10.6 mg/g and 13.1 mg/g) were observed in Purple Mutant at 45 and 75 DAS at BPR. The maximum flavonols and chlorophyll were observed in RH-7846 at 75 DAS. The sinapine content estimated in seed meal ranged from 0.8- 2.1% in B. rapa, 1.0- 2.6% in B. juncea and 0.9- 2.2% in B. napus. The fibre content in 45 rapeseed-mustard genotypes ranged from 2.65(Kiran of B. carinata) to 13.3% (Pusa bold of B. juncea).

Frontline demonstrations

Twenty three cooperating centres conducted 429 FLDs on rapeseed (110) and mustard (319) in 60 districts across 16 states of the country. Rajasthan had maximum FLDs (105) followed by Haryana (40). There were 121, 161 and 147 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 and karan rai, respectively was 1,900, 1,250, 900 and 647 kg/ha. The yield gap between realizable and realized was 50.9%, 63.4%, 84.4% and 47.4%, respectively with maximum additional net monetary return (ANMR)/ha of Rs 2,250, Rs 9,743, Rs 6,866 and 2,034, respectively.

The maximum average yield from the WP under irrigated conditions for Indian mustard, toria, yellow sarson and gobhi sarson was 2,316, 1,431, 1,402 and 1,877 kg/ha, yield gap 38.4%, 16.6%, 9.7% and 7.5% and ANMR/ha Rs 11,516, Rs 2,753, 1,301 and 1,907, respectively.

Twenty three improved varieties of Indian mustard, 7 of toria and 4 of yellow sarson were used for varietal trial FLDs under irrigated conditions. Among all the states, improved variety demonstrated in Madhya Pradesh recorded maximum yield of 2,375 kg/ha with an improvement of 16.6% over local (FP) and ANMR of Rs 9,298/ha under irrigated conditions. It was followed by Haryana where demonstrations on improved varieties recorded average yield of 2,269 kg/ha with yield improvement of 3.8%. The improved varieties of Toria and yellow sarson had the maximum average yield of 1,544 and 1,742 kg/ha, respectively under irrigated conditions. The RB-50 variety of Indian mustard, Jayanti of karan rai, and Neelam of gobhi sarson had an average yield of 2,210, 665 and 567 kg/ha, respectively under rainfed conditions.

A total of 103 FLDs with 12 component technologies for Indian mustard were carried out. Among all the components, 2 irrigations component demonstrated by Bawal centre had maximum average yield of 2,580 kg/ha. However, maximum yield improvement of 56.1% was recorded in component of sowing method and seed rate demonstrated by Bhubaneswar centre that accrued maximum ANMR of Rs12,445/ha with additional cost of Rs. 1, 385/ha.

Sowing method & seed rate and aphid management component in toria, interculture, plant protection, sowing method and seed rate, aphid management, club root management in yellow sarson and recommended fertilizer with improved variety of taramira and proper plant protection gave 28.7, 29.9, 11.4%, 6.0%, 35.6%, 48.7%, 50.2, 36.9 and 21.9% yield enhancement over FP, respectively.