

# Summary

## Seasonal Conditions

Weather was favourable for the mustard crop during the crop season 2019-20. Good rains were received during monsoon in the month of September almost at all the centres. The extremely low temperature  $-1.1^{\circ}\text{C}$  and  $0.7^{\circ}\text{C}$  was reported of Bajaura centre in the month of December & January 2019-20 respectively. Incidence of diseases and pest was very low that resulted high productivity (More than 14 qtl/ha).

## Genetics and Plant Breeding

### Varietal Improvement

Fourteen centres spread over 11 states carried out the varietal development activities as per the approved technical programme. The salient achievements during the year 2019-20 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 (*Eruca sativa*) are discussed below:

### Genetic Resource Management

A total of 7029 accessions comprising toria (508), Indian mustard (4,600), yellow sarson (548), gobhi sarson (146), brown sarson (108), karan rai (232), taramira (67), *B. caudatus* (04), *R. caudatus* (01), *B. rugosa* (30), *B. nigra* (22) S. Alba (01), Crambe sp (02), and Lapidium sp (02) were maintained through appropriate mating system at Bhubneshwar, Dholi, Hisar, Pantnagar, Ludhiana, Kanpur, Sriganagar, IARI, New Delhi, Jobner, Morena, Pannagar, Chatha-Jammu and SK Nagar (Table 2.1.1). In addition, 30 new accessions comprising Indian mustard (22), toria (03), and taramira (05) were collected. Further, 790 accessions consisting of 438 Indian mustard, 84 toria, 174 yellow sarson, 17 gobhi sarson, 41 brown sarson, 06 Karan rai, and 30 taramira accessions were evaluated. On the basis of germplasm evaluation, promising accessions were identified for seed yield, earliness, yield components, thermo-tolerant (early and terminal stages), resistance/tolerance to diseases/pests and quality traits in toria at Dholi and Chatha-Jammu.

### Creation of genetic variability through hybridization/ mutagenesis and selection

Creation of variability is the essence and backbone of the breeding programme. To cater the need of diverse agro-climatic conditions of the country, 99 crosses were attempted in toria, 26 in yellow sarson at Pantnagar and Kanpur and 933 in Indian mustard at Chatha, Hisar, IARI New Delhi, Ludhiana, Kanpur, Pantnagar, SK Nagar, Morena, Sriganagar, Jhansi and Varanasi to improve seed yield, earliness, seed size, component traits, disease/pest resistance, heat tolerance suitable for late sown condition, drought tolerance, "0" and "00" quality characters and high oil content (Table 2.1.2). Selection of superior plants/bulks at different centres was practised in toria, yellow sarson and Indian mustard. In toria, development of composites population after the selection was the main objective. In yellow sarson, hybridization and selection from segregating generations were attempted at Kanpur and Pantnagar. However, few of the centres reported that due to spread of COVID 19 across the region, the single plant selection could not be performed. In Indian mustard, 3581 single plants were selected at New Delhi, Jhansi, Pantnagar, Ludhiana, SK Nagar and Morena. In Indian mustard, about 887 bulks were selected from segregating and advanced generations.

### Evaluation of advanced breeding lines

The advanced breeding lines evaluated under different station/state /preliminary yield trials at various centres have been presented in Table 2.1.3. 56 strains of toria were tested at Kanpur,

Chatha, Ludhiana and Dholi. The yield superiority in toria was up to 17.18 % over the check (Tapeshwari) at Kanpur. In yellow sarson, 45 strains were tested at Kanpur and Dholi. The yield superiority up to 16.66 % over the check Pitambari was recorded at Kanpur. In Indian mustard, 467 strains were evaluated at 07 centres; Chatha, Hisar, Ludhiana, Kanpur, Dholi, Varanasi, and Sriganaganagar in 24 trials. Seed yield superiority up to 14.67 % over the check Kranti was recorded at Kanpur. Ten strains at Hisar, 32 strains at Ludhiana and 09 strains at Chatha of gobhi sarson were evaluated for seed yield and its component characters. In addition, 26 strains of Karan rai were also evaluated at Ludhiana for Seed yield and oil content under irrigated condition.

### **Hybrid development**

Efforts for hybrid development continued under “Consortia Research Platform on Hybrids”, at four centres including ICAR-DRMR Bharatpur, ICAR-IARI New Delhi, PAU Ludhiana and CCS HAU Hisar. A total of thirty six experimental hybrids including 8 from DRMR, 12 from IARI, 9 from PAU Ludhiana and 07 from Hisar were evaluated in three multilocation trials; early maturity group and medium to late maturity group, conducted at each of four centres. Under early maturity trial (MLT 1), 9 early maturing hybrids were tested against three checks. All experimental hybrids were late in maturity than earliest maturing check Keshri but matured as par with NRCHB 101, hence, these were compared with NRCHB 101 for seed yield. Fifteen experimental hybrids were evaluated under timely sown normal maturity (CRPMLT 2) group against three checks. In MLT 2, 03 hybrids, RHH1903, RHH 1904 and RHH 1905 out yielded the best check Pioneer 45S46 (2445 kg/ha) by a margin of 9.1, 8.6 and 8.5 percent, respectively. In MLT 3, one hybrid PHR 3328 out yielded the best check Pioneer 45S46 by a margin of 5.3% only. Seventy-six F<sub>1</sub> crosses comprising 22, 20, 19 and 15 from DRMR, PAU, HAU and IARI, respectively were evaluated at all four centres in MLT 4. Five crosses DRMREH 19-10, RHH 1915, DRMREH 19-3, RHH 1927, DRMREH 19-7 expressed >15% seed yield heterosis over best check Giriraj. Eight hybrids were inducted in All India Coordinated Research Project for multilocation evaluation. Out of eight 2 were evaluated in early mustard trial and remaining 6 in initial hybrid trial

### **Breeder seed production**

Indents of 76.02 q breeder seed of 54 rapeseed-mustard varieties were received from Department of Agriculture and Cooperation (DAC), Ministry of Agriculture and Farmer Welfare, Govt. of India for production during 2019-20. The allocation was made to 18 centres for the production of 76.00 q breeder seed of 54 varieties during the 26<sup>th</sup> annual group meeting held at BAU, Ranchi (Jharkhand). Against the indent of 76.02 q, 258.64 q breeder seed was produced, indicating a surplus availability of 164.20 q. Breeder seed of 02 varieties including rajendra Suphlam of Indian mustard and Benoy (B 9) of yellow sarson could not be produced. Further, less quantity of Sushree of toria; DRMR 601 of Indian mustard and Tapeshwari of Toria was produced. In addition production of, 116.19 q breeder seed of 24 varieties was also reported from different centres.

### **Coordinated Trials**

Performance of 163 strains including 16 of toria, 129 of Indian mustard, 15 of gobhi sarson and 03 of taramira was tested in thirty two performance evaluation trials consisting of toria (03), gobhi sarson (02), taramira (01) and Indian mustard (26) at 45 locations across the 6 agro-climatic zones of the country. On the basis of superiority for seed/ yield/ earliness/quality over the best check, 25 strains comprising taramira (01), gobhi sarson (05) and Indian mustard (19) were promoted for advanced stage evaluation.

**Rapeseed-Mustard strains promoted for advance stage testing on the basis of higher seed/oil yield/quality (2018-19)**

Zone I	Zone II	Zone III	Zone IV	Zone V
<b>Early Mustard, IVT, Irrigated</b>				
	RH 1999-42 2436(17.8)	KMR (E) 19-2 (2005,28.1 NPJ 229 (1886, 20.5) RH 1999-42 (1975, 26.2) PRE 17.5 (1917, 22.5) PRE 17.2 (1846, 17.9) DRMRCI 116 (1953, 24.8) NPJ 230 (1955, 24.9) KMR (E) 19.1 (2001, 27.9) PHR 8022 (Hybrid 19.6, 21.8)		
<b>Mustard, Timely Sown, Irrigated, IVT</b>				
AKM 5-19-2 (1202, 15.8)			NPJ 231 (2543, 10.8)	
<b>Mustard, Quality, IVT</b>				
	LES 60 (2912, 3.8) 9IJ5001 (2606, -7.09, 12.0)	LES 60 (2159, 1.4)		
<b>Mustard, Quality, AVT I + II</b>				
	PDZ 12 (2765, ≈) PDZ 11 (2703, ≈) RCH 1 (2765, ≈)			
<b>Saline/ Alkaline IVT</b>				
		CS 2005-143 (2054, 9.4)		
<b>Gobhi Sarson IVT</b>				
		GSH 2196 (1874, 15.0) AKGS 19-8 (1788, 9.8) HNS 0702 (1807, 10.9) GSH 2180 (1876, 15.2)		
<b>Gobhi Sarson AVT I</b>				
		GSH 1699 (1728, 9.2)		
<b>Taramira AVT I</b>				
		RTM 1624 (999, 19.8)		

Figures in parenthesis indicate seed yield (Kg/ha), percent superiority over best check  
\*\* promoted on the basis of oil yield; # double low strain.

## Crop Production

Six experiments on various crop production aspects of rapeseed-mustard were conducted at 23 cooperating centres across the 5 zones.

### 3.1 Long-term fertility experiment on cropping systems involving rapeseed-mustard

The result highlighted the long term effect of fertility levels on seed yield of mustard. Significantly higher seed yield was recorded with the application of 150% NPK at all the locations

except at PNT, and increased by 107, 197, 278, 172, 59, 556, 83, 157, 54, 78, 175% at KDW, KNG, LDH, HSR, SGN, DOL, KOT, MOR, SKN, BHU and SHL over control, respectively. At PNT, integrated use of 100% NPK+FYM 2.5 t/ha recorded highest seed yield.

### **3.2 Data generation for herbicide label claim registration in rapeseed-mustard.**

The results revealed that pre-emergence application of pendimethalin @ 1.0/0.5 kg a.i./ha recorded highest seed yield at BTE and PNT. Whereas, pre-emergence spray of oxadiargyl @ 0.09 kg a.i./ha recorded higher seed yield at HSR and LDH.

### **3.3 Agronomic evaluation of promising rapeseed-mustard entries.**

The toria entry TS 38 produced 8.2% and 21.7% higher seed yield than the best check at KLY and IMP. Under late sown condition, DRMRIC 16-38 recorded 7.4% more seed yield over the nearest check at CHT only. *Brassica napus* entry AKMS 8141 gave significantly higher seed yield than best check by 41.0% at BJR and 85.0% at LDH.

### **3.4 Developing resource efficient and resilient rapeseed- mustard based cropping systems under current and future climates.**

The location-wise most productive cropping systems reported are; green gram-mustard at CHT and PNT, black gram-mustard at KPR and maize-mustard at MOR. Raised bed planting method recorded maximum mustard seed yield at all the locations except at MOR.

### **3.5 Studies on system of mustard intensification (SMI) in rapeseed-mustard through transplanting.**

Among different species *B. carinata* at IARI, SKN and LDH; *B. juncea* at NAG and MOR; and *B. napus* at PNT recorded more seed yield. Among planting methods, transplanting found more suitable and recorded higher seed yield at IARI and PNT. However, it was not found suitable at NAG, MOR, SKN and LDH.

### **3.6 Enhancing of water use efficiency in rapeseed-mustard under rainfed conditions.**

Application of hydrogel 5 kg/ha at sowing time followed by foliar spray of salicylic acid 200 ppm at flowering and silique formation stages recorded highest seed yield at KDW, HSR, BAW, SGN, JOB, NAG, KNG, CHT, BND, KPR, KOT, VAR, SHL, BHU. Whereas, hydrogel 2.5 kg/ha and foliar spray of salicylic acid 100 ppm at flowering and silique formation stage recorded higher seed yield at LDH, JHS and IMP.

## **Plant Pathology**

### **Disease Scenario**

During 2019-20, moderate to severe occurrence of Alternaria blight was recorded at all locations. However, low to the medium severity of Alternaria blight was recorded from JAG and MOR. White rust appeared in moderate to severe form at all locations except JAG. Medium to severe prevalence of DM was observed at the cotyledonary stage at JHS and PNT. Powdery mildew severity was moderate to high at JHS, SKN, MOR and low at JAG and BPR. Low to moderate incidence of Sclerotinia rot was observed at MOR, HSR, SGN, and PNT.

### **Screening of *Brassica* germplasm and breeding materials**

Under natural condition, PDZ 11, PDZ 12 (Bj) and AKMS 8141, AKGS 8146, AKGS 8217, GSH 1717, GSH 1699 (Bn) were found resistant to WR at all eight locations. Under artificial condition, PDZ 12, PDZ 11 (Bj), and AKGS 8217, HNS 1102, GSH 1699, AKMS 1841, AKGS 8146, GSH 1717, (Bn) were found resistant to WR at all locations except JHS. Genotype, RH (OE) 1706 of *B. juncea* and GSH 1717 of *B. napus* showed resistance to DM at PNT and JHS.

### **Uniform Disease Nursery for major diseases**

DRMRSJ 1, DRMRSJ 7, DRMR 2018-37, and PAB 14-5 of *B. juncea* showed resistance reaction to WR under natural conditions with mean disease severity below 10%, whereas highest WR severity was on check Rohini was 31.5%. DRMRSJ 25 at MOR and PNT while, RMM-10-1-1, DRMRSJ 26 and DRMR 2018-41 were found tolerant at MOR and SGN to SR under natural condition.

### **National Disease Nursery (NDN) for Alternaria blight**

None of the entries were tolerant to AB. Whereas, PMW 8, DRMR-2018-37, DRMR 2018-41, DRMRSJ 7, PAB 14-5, DRMRSJ 1, DRMRSJ 4, DRMRDJ 3, DRMRDJ 1, and DRMRSJ 19 of *B. juncea* showed resistant reaction to WR.

### **National Disease Nursery (NDN) for white rust**

PRD 17-1, PRD 17-2, DRMRIJ 12-40, DRMRIJ-16-7-1, RH 1400, RH 1400-1, entries of *B. juncea* showed immune reaction to WR at MOR, PNT, HSR locations. Some of the promising strains sowed resistance to WR viz., DRMRIJ 12-27, DRMRIJ 12-37, DRMR-5206, PDZ 5, DRMRSJ 1, DRMRSJ 4, DRMR 2018-41, DRMRDJ 1, DRMR 2018-37 and DRMRIJ 12-37 (3 locations).

PB (A4A5)-842, PJK (A4A5)-21, Varuna (A4A5)-936-279 were showed immune reaction to WR at 5 locations and also at cotyledonary stage under artificial conditions. PB (A4A5) 491 showed resistant reaction to WR at 3 locations.

DRMRIJ 12-26, and DRMRMJA 35 were found consistently resistant to WR during 2014-15, 2015-16, 2016-17, 2017-18, 2018-19 and 2019-20.

### **National Disease Nursery (NDN) for Sclerotinia rot**

DRMRSJ 21, DRMRSJ 22 and DRMR 5206 showed promising reaction to SR with small lesion size and <50% incidence under artificial condition consistently for second year.

### **Screening of IVT entries of Brassica against different diseases**

MCB 1-2-3-2-4, PDZ 13, 91J5001 (Q), 7J157C (H) of *B. juncea* were found resistant to WR at five locations. Whereas, almost all the entries of *B. rapa* var. Toria and *B. rapa* var. Yellow Sarson, *B. napus* escaped WR infection.

### **Standardization of differential hosts for identification of races in *A. candida***

The reaction of 10 rapeseed-mustard genotypes was recorded against 5 isolates of *Albugo candida* (AcPNT, AcHSR, AcBPR, AcNDH, AcLDH) at LDH, HSR, PNT and NDH. None of the genotype gave WR resistant reaction against all 5 isolates. Genotype DRMRAB 753 gave susceptible reaction to all isolates at all five locations. Whereas, genotypes DRMR 2035 and Basanti gave resistant reaction against Ac-BPR, and Ac-HSR, and variable reaction to other isolates of *A. candida* at 3 locations.

## **Epidemiology of Alternaria blight, white rust, powdery and downy mildew**

Experiments on the epidemiology of foliar diseases of rapeseed-mustard were laid out using cv. Varuna and local cultivar. The experiment was sown on eight different dates at weekly interval starting from October 1 to November 19 without adopting any protection measures against pest and diseases.

At PNT, Two genotypes Varuna and Kranti were sown at eight different sowing dates. Downy mildew disease first appeared 10 DAS on Nov 05, Nov 12, and 11 DAS on Oct 29 and Nov 19 sown Varuna and Kranti cultivars. Whereas, on Oct 01 to Oct 22 sown crop, the DM appeared between 35 to 42 DAS and on Oct 29 to Nov 19 sown crop disease appeared between 56 to 70 DAS on both the cultivars. White rust disease first appeared 38 DAS on Nov 12 and Nov 19 sown crop while 50 DAS on Oct 1, and Oct 08, continued up to 97 DAS on late sown crop (Table 4.8.1). Alternaria blight disease was first noticed 39 DAS on Oct 08 and 46 DAS on Oct 01, and Nov 05 on both the cultivars. While, on Oct 22 sown crop, the disease appeared late i.e. 56 DAS. The Alternaria blight on pods first appeared 88 DAS on late (Nov 12) sown crop which is 7 days early in comparison to last year. On early (Oct 01) sown crop, the symptoms on pod appeared late after 120 days of sowing (Table 4.8.2).

At SHL, Epidemiological experiment was laid out with cv. Varuna and TM 2. The crop was sown with 6 dates of sowing started from Oct 15 to Nov. 19 at weekly intervals. AB was first observed at 41 DAS in Nov 05 sown crop. While AB appeared at 66 DAS in Oct 08 seeded crop during 2018-19, while, it appeared 39 DAS in Nov 19 sown crop during 2017-18. AB on silique first appeared at 85 DAS in Nov 19 sown crop which appeared at 110 DAS in early sown crop on Oct 15 in both the cultivars. Maximum disease severity was 100 DAS (39.2%) in Nov 19 on cv TM 2 (Table 4.8). Maximum yield was recorded in Oct 29 sown cv Varuna (17.2 q/ha) while in TM 2 it was 12.9 q/ha (Oct 29). Yield data revealed that the best sowing time of crop in the region is last week of October (Table 4.8.3).

At SKN, Experiment was laid out with cv. Varuna and GM 2 sown on 8 dates of sowing started from Oct 01 to Nov 19 at weekly intervals. Powdery mildew disease first appeared at 78 DAS instead of 83 DAS, 76 DAS during 2018-19 & 2017-18, respectively, on Nov 19 sown crop of Varuna and 79 DAS instead of 88 DAS last year in Nov 19 sown GM 2. The maximum disease severity was observed 99% in Nov 19 sown crop cv Varuna followed 97% in Nov 12 sown GM 2. The maximum seed yield reduction was observed in late sown crop. Although, highest yield was observed in Oct 01 sown crop (Table 4.8.4).

At MOR, trial on epidemiology of foliar diseases of Indian mustard was laid out with cv. Varuna and Rohini. The crop was sown with 8 dates of sowing started from Oct 01 to Nov 19 at weekly intervals using recommended agronomic practices. Alternaria blight on leaf first appeared 70 DAS in Nov 12, and Nov 19 sown crop of both cultivars Varuna and Rohini. Whereas, AB on siliques appeared at 80 DAS on same plots (4.8.5). PM was observed first 80 DAS and was maximum 63.1 % in cv Varuna (130 DAS) in Nov 19 sown crop.

WR appeared first on 48 DAS in Nov 19 sown crop and continued till 110 DAS in Oct 01 sown crop. WR disease severity was maximum upto 44.0% in Nov 05 sown crop both cv Varuna and Rohini. Maximum staghead was observed 44.4% in Nov 19 sown cv Rohini followed by Nov 05 sown both cultivars. Maximum yield (26.5 q/ha) was recorded in both cultivars on Oct 08 sown.

At JAG, Experiment on epidemiological studies of PM and WR was laid out with cv Varua and DRMRIJ 31 with 8 dates of sowing starting from 01 Oct to Nov 19 at weekly interval using

recommended agronomic practices. PM appeared first at 66 DAS on cv Varuna whereas 70 DAS on cv DRMRIJ 31 in Nov 19 sown. WR first appeared 48 DAS on cv DRMRIJ 31 sown on Nov 19. Optimum date of sowing for maximum seed yield seems between Oct 08 to Oct 15 sown crop.

At DOL, Experiment was laid out with cv. Varuna and Rajendra Suflam sown with 8 dates of sowing starting from Oct 01 to Nov 19 at weekly intervals. AB first observed 41 DAS in Nov 19 sown cv Varuna and 50 DAS on cv Rajendra Suflam, while, it appeared late in early sown (Oct 01) crop (90 DAS). The disease continued to progress on leaves up to 140 DAS on both the cultivars.

### Testing of IDM module for major rapeseed-mustard diseases

AB, WR, DM, PM, SR diseases were observed in integrated disease management practices and farmer's practice to standardise the best integrated disease management module. Module included seed treatment with *Trichoderma harzianum* @10g/ kg seed, soil application of *Trichoderma* (1 kg/ 50 kg FYM), basal application of zinc sulphate @ 15 kg/ h + S (dose as per location recommendation) + boron (10 kg borax/ ha), line sowing 45 x 20 cm spacing, no irrigation during 25<sup>th</sup> to 15<sup>th</sup> Jan. AB severity recorded from 18.2 % at MOR to 40.2% at PNT in module while in farmer's practices AB severity ranged from minimum 21.2% at JAG to highest at PNT (46.9%). Similarly, WR severity was recorded minimum 6.3 % at DOL and maximum 36.2 % at PNT in module while minimum at DOL (10.0%) and maximum 60.0% at BPR in farmer's practices. PM severity was observed in module between 19.3 % at JAG to 73.0% at SKN while in farmer's practices 15.9% at JAG to 75.5% at SKN. Mean SR disease was reduced from 23.3% in farmer's practices to 12.2% in module. Results showed that the significant increase in yield upto 2034 kg/ha by using IDM module over 1650kg/ha in farmer's practices

### Entomology

The 2019-20 crop season witnessed low to moderate population development of mustard aphid on different *Brassica* species. JT 13-8, Rasi 1605 (hybrid), BAUM 08-14, DRMRCI 116, , RH 1999-18, TM-52, AKMS 19-2, RMM 12-2-18, PM-30, PRB 15-2, JM 14-2, HUJM 18-7, RMM 12-1-18, RH 1424, SKM 1621, NPJ 231, BAUM 08-18, DRMRCI 117, CAN 184/ACN 184, RGN 462, DRMRCI 118, NPJ 234, RH 1799-24, RH 1653, TM 263-3, NPJ 235, SVJH 85, RHH 1902, 7IJ0004, DRMRHJ 817, PHR 3828, RH (OE) 1710, LES 60, HNS 0901, GSH 1699, AKGC 19-14, HNS 0702, AKGS 19-8, RTM 1726, RMT 314, RMM 10-1-1, PBR 385, RH 1676, 7IJ0003 (Hybrid), DRMRIC 16-38, Raj Vijay Mustard 2, RH 1599-41, SVJH 108, NRCHB 506 (HC), PM 29 (LC), AKGS 8217, GSH 1707, AKGS 8146, GSH 1717, GSH 1699, GSH 6 (QC), Tapeswari (LC), BSH-1, Kranti (NC), RGN 73(LR), GSL 1 (ZC) were found promising since these recorded AAI  $\leq 1.5$ .

The highest yield loss was observed in PM 31 (60.22%) followed by RH 725 (58.94%) and BSH-1 (55.44%) at **Kanpur**. In general, PM 31 suffered high yield loss at **Kanpur** (60.22%), **Dholi** (32.68%), **Hisar** (27.2%), **New Delhi** (21.6%%), **Pantnagar** (20.25%) and 9.37% at **Bharatpur**(9.37)

Moderate to high population of mustard aphid was reported at most of the centers from 3<sup>rd</sup> to 12<sup>th</sup> with peak during 7<sup>th</sup> to 11<sup>th</sup>. Low to moderate population of painted bug was observed from 11<sup>th</sup> to 13<sup>th</sup> std week. The activity of Coccinellid predators was moderate to high during 7<sup>th</sup> and 11<sup>th</sup> std week. However, low population of leaf miner was observed which remained active from 3<sup>rd</sup> to 11<sup>th</sup> std week. In addition to this, low to moderate population of saw fly was observed on early sown crop from 46<sup>th</sup> to 49<sup>th</sup> std week. Very low activity of cabbage caterpillar was recorded both under late sown conditions. Cabbage caterpillar appeared as early as on 9<sup>th</sup> std week under timely sown conditions and remained active till 12<sup>th</sup> std week, under late sown conditions.

The alate aphid population was recorded by eight centres. First appearance was recorded during 1<sup>st</sup> std week from **Morena**. It started increasing at most of the centers from 51<sup>st</sup> – 1<sup>st</sup>std. week and reached its peak from 8<sup>th</sup> – 11<sup>th</sup> std. week. The highest peak (1523.6 aphids/ trap) was recorded at **SKN** during 7<sup>th</sup> std week. After 11<sup>th</sup> std. Week, in general trend of decline in alate aphid population was observed which disappeared from most of centers after 13<sup>rd</sup> standard week.

At **New Delhi**, treatment T<sub>3</sub> i.e. application of *Beauveria bassiana* @ 2 g/l was found to be the most effective and resulted in seed yield of 1918 kg ha<sup>-1</sup> and 50.7 IBCR. At **Dholi, Hisar, Kanpur Ludhiana, Morena, Shillongini, SK Nagar and Bharatpur** treatment T<sub>6</sub> i.e. application of dimethoate 30 EC @ 1ml/l was found effective with respective seed yield of 880.0, 1687.4, 1904.0, 1788.0 kg, 2799.2 kg ha<sup>-1</sup>, 1005.0, 1268.0 and 2910.0 kg ha<sup>-1</sup> and IBCR of 7.86, 12.80, 44.35, 40.87, 2.0, 3.00, 4.28 and 41.67, respectively. At **Pantnagar**, treatment T<sub>5</sub> i.e. *Verticillium lecanii* @ 2g/l was found effective with seed yield of 1798.0 kg ha<sup>-1</sup> and IBCR of 5.74 followed by treatment T<sub>4</sub> (azadirachtin 3000 ppm @ 5 ml/l followed by *Verticillium lecanii* @2 g/t) was found effective with seed yield of 1682 kg ha<sup>-1</sup> and IBCR of 2.67.

At **Kanpur, Shillongini, SK Nagar and Bharatpur** treatment T<sub>1</sub> (Imidacloprid 17.8 SL @ 0.25 ml/l) was found effective with yield 1772.0, 1024.23, 1247 and 2209 kg ha<sup>-1</sup> and IBCR of 71.44, 3.15, 4.39 and 17.92, respectively. At **Delhi, Hisar, Ludhiana** treatment T<sub>2</sub> (thiamethoxam 25 WG @ 0.2 g/l) was found effective with seed yield of 1930 kg/ha, 1827.6 kg ha<sup>-1</sup>, 1827.8 kg ha<sup>-1</sup> and 68.5, 19.7, 49.60 IBCR followed by treatment T<sub>5</sub> (clothianidine 50 WDG @ 0.12 g/l) with 1791.7 kg ha<sup>-1</sup> yield and 26.1 IBCR. At **Dholi and Pantnagar** treatment T<sub>5</sub> (clothianidine 50 WDG @ 0.12 g/l) was found to be the most effective with 891.0 and 2434 kg ha<sup>-1</sup> yield with 7.86, 3.2 IBCR respectively. At **Morena** treatment T<sub>4</sub> (Dimethoate 30 EC @ 1 ml/L) was found to be the most effective with yield 2382 kg ha<sup>-1</sup> and IBCR 3.3.

Survey and surveillance of insect-pests was conducted at **SKN, PTN, KPR, LDH** and **SHL** Mustard aphid, painted bug, sawfly, flea beetle and coccinellid predators were reported from fields with moderate to low activity.

## Plant Physiology

Five experiments were conducted to evaluate mustard genotypes from different agro-climatic zones to abiotic stresses while sixth experiment was conducted at two locations to test the efficacy of PGR's under rainfed conditions. Thirty genotypes of Indian mustard (*B.juncea*) were tested for high temperature tolerance at seedling stage both under laboratory and field conditions. Seedling mortality  $\leq 20\%$  and DW/10 seedlings  $\geq 40\text{mg}$  rated genotypes tolerant under controlled conditions. PM 25 (NC) and DRMR 2018-27 at Hisar while PM 25 (NC), RGN 229 and DRMR 4009 at Kanpur showed thermo tolerance. Three genotypes namely JD 6(ZC), PM 25 (NC), DRMRHT 13-22-10 at Kanpur and Ludhiana, DRMR 2018-27 at Hisar and Ludhiana, DRMRHT 13-22-10 at Kanpur and Ludhiana while RMM 10-17, PM 25 (NC), PM 27 (NC), RGN 229, DRMR 2017-27 at 3 locations showed seedling mortality  $\leq 30\%$  indicating moderate thermo tolerance under controlled condition. In the field sown trial, DRMR 2059, PM 25(NC), DRMR 2017-8 and DRMR 2275 at Dholi and Ludhiana had seedling mortality  $\leq 30\%$  and dry matter per 10 seedlings  $\geq 4.0\text{g}$ . Conclusively, only PM 25 (NC) was highly tolerant at Hisar and Kanpur while RMM 10-17, PM 27 (NC), RGN 229, DRMR 2017-27 moderately tolerant at Hisar, Kanpur and Ludhiana. JD- 6 (ZC) was moderately tolerant at Kanpur and Ludhiana under controlled condition. PM 25 (NC) and JD- 6 (ZC) showed tolerance to high temperature at seedling stage both under laboratory and field conditions with seedling thermo tolerance index (STI)  $\geq 50\%$ . Light stress due to shading for 30 days impaired physiological and yield traits to variable extent within the genotypes and also at two locations. Lesser reduction in the physiological traits and seed yield ( $\leq 20\%$ ) identified RMM 10-1-1, RH 1676 and SVJH-108 at Hisar and Ludhiana as promising genotypes under low light stress. Moisture stress imposed by withholding irrigations at 35 and 65 DAS significantly affected the performance of thirty one genotypes tested at 3 locations. NPJ 214, LES 54, NPJ 210, NPJ 225, DRMR 2017-15 and DRMR 1222 at Dholi, Hisar and Ludhiana were tolerant to moisture stress. Only one genotype LES 54 was rated highly tolerant at Hisar and Ludhiana whereas DRMRCI 114 moderately tolerant at 3 locations (Dholi, Hisar and Ludhiana) to moisture stress. Tolerance to moisture deficit in these genotypes was attributed to higher



chlorophyll content, RWC, SPAD values and lesser decline in seeds per siliqua siliqua, seed weight with DSI  $\leq 1.0$  and YSI  $\geq 0.82$ . Genotype RH 0725 (check) suffered decline in seed yield  $\leq 30\%$  and was rated moderately drought tolerant at Dholi and Hisar but highly tolerant at Ludhiana with yield reduction  $\leq 20\%$ . RGN 229 (check) was highly tolerant with yield reduction  $\leq 20\%$  at Dholi and Hisar and moderately drought tolerant at Ludhiana with  $\leq 30\%$  decline in seed yield. Out of thirty four mustard genotypes only Raj Vijay Mustard 2 (LR) was rated highly tolerant to terminal heat stress with seed yield reduction  $\leq 20\%$  and high stability indices (HSI  $\geq 0.75$  and YSI  $\geq 0.82$ ). Three genotypes (DRMR 2059, Raj Vijay Mustard, DRMRHT 13-28-8) showed yield reduction  $\leq 30\%$  with HSI  $\geq 0.48$  and YSI  $\geq 0.70$  at Hisar and Ludhiana and were considered moderately tolerant to terminal high temperature with relatively lesser depression in membrane stability, seed weight, seeds per siliqua and cooler canopies. PDZ 4 seems promising at 3 locations for salinity tolerance (Hisar, Kanpur and Ludhiana) with relatively lesser decline in germination percentage, seedling length, dry matter accumulation at 3 locations and decrease of 19.4% in vigor index II at Hisar only. Foliar spray of brassinolide @ 20ppm and salicylic acid @ 200ppm at 2 locations (Hisar and Ludhiana) improved seed yield under rainfed conditions.

## Biochemistry

Entries of IVT/AVT quality trials were evaluated at Bharatpur, Kangra, Pantnagar, Hisar and Ludhiana. Oil stability index which is the ratio of MUFA: PUFA ranged from 0.40 in PR-2016-4 to 1.57 in GSH-16-99. The SFA: MUFA: PUFA ratio ranged between 1:07:09 (GSH-21-80) to 1:24:10 (PT-2015-6). RCH-1, GSH 16-99, LEC 61, PDZ- 13, RH(OE)-1705, JC-21, GSH-1707, RH(OE)-1710, RH(OE)-1711, PDZ-1, PM 29, PM-30, LES-60, LES-59 and LES-54 had  $< 2\%$  erucic acid content. Palmitic acid mean values ranged from 2.71% (PT-2015-6) to 4.27 % (GSH-17-17); Stearic acid mean value ranged from 0.76 % (PT-2015-6) to 2.08% (PDZ-1). Oleic acid from 9.71 % (PRE-2017-5) to 43.62 % (GSH-1707); Linoleic acid from 15.04 % (PR-2016-8) to 40.05 % (LEC-61). Linolenic acid: 11.39 % (PT-2015-7) to 25.84 % (RH (OE)-1711); Eicosanoic acid: 4.76 % (RH (OE)-1711) to 11.50 % (GSH-21-80).  $\omega 6:\omega 3$  ratio ranged from 1.05 (PRE-2017-5) to 3.06 (LES-59). Total Protein ranged from 28.42 (JC-21) to 35.53% (RH (OE)-1706); Methionine ranged from 1.28 (JC-33) to 2.08 (LEC-61, RH(OE)-1711) g/100g protein. Tryptophan: 0.81 (LES-54) to 1.25 (PR-2017-7) g/100g protein. Total antioxidant capacity ranged from 15.04 (PDZ-1) to 26.01 (JC-21) mg/g AAE;  $\beta$ -carotene ranges from 2.80 (PDZ-13) to 5.22 (PRC-2017-5). Variations in glucosinolate content were observed from 10.89 to 99.42  $\mu\text{mole/g}$  defatted meal. Less than 30  $\mu\text{mol/g}$  glucosinolate was observed in GSH 21-80, GSH 17-17, RCH 1, GSH 16-99, PDZ-13, JC-21, GSH-1707 and JC-33 genotypes. Phytic acid content was reported less than 2% in LEC-61, JC-21, RH(OE)-1706, RH(OE)-1711, PRE-2017-5 and PRL- 2017-5.

## Frontline demonstrations 2019-20

Under the scheme “Frontline demonstrations and other related activities of Oilseeds”, 26 cooperating centres of AICRP-RM/ ICAR institutes/ Ag. Universities conducted 1405 frontline demonstrations (FLDs) on rapeseed-mustard during 2019-20 in 57 districts across 15 states. Rajasthan had maximum FLDs (467) followed by Manipur (240), Uttar Pradesh (183), Assam (135), and Jharkhand (78). Two hundred thirty six FLDs were conducted on rapeseed and 1169 on mustard. All the demonstrations were conducted under whole package demonstrations in two different situations viz., irrigated (870) and rainfed (535).

The maximum average yield of 2,497 kg/ha from the IP under irrigated conditions was in Haryana followed by 2,211 kg/ha in Rajasthan; 2,157 kg/ha in Gujarat; 2,022 kg/ha in Punjab, 1,923 kg/ha in Uttar Pradesh; 1,675 kg/ha in Madhya Pradesh; 1,383 kg/ha in Uttarakhand; 1,225 kg/ha in Jharkhand and 1,143 kg/ha in Telangana. The maximum yield gap of 61.0% was recorded in Odisha followed by 54.1% in Jammu & Kashmir; 49.2% in Telangana; 33.4% Himachal Pradesh; 26.7% in Uttar Pradesh; 21.3% in Maharashtra; 19.2% in Haryana, 17.6% in Madhya Pradesh and 15.3% in

Gujarat. The maximum ANMR/ha were Rs 19,027; Rs 14,602; Rs. 13,794; Rs. 12,933; Rs. 11,875, Rs. 10,681; Rs. 9,848; Rs. 7,075 and Rs. 6,670 in Jammu & Kashmir, Haryana, Uttar Pradesh, Telangana, Gujarat, Rajasthan, Odisha, Punjab and Himachal Pradesh, respectively. The cost of cultivation ranged from Rs. 14,520/ha in Maharashtra to Rs. 34,514 /ha in Haryana in IP under irrigated Whole package demonstrations.

The maximum average yield of 1,720 kg/ha from the IP of WP under rainfed conditions was in Rajasthan followed by 1,388 kg/ha in Uttar Pradesh; 1,306 kg/ha in Uttarakhand; 1,141 kg/ha in Assam; 1,076 in Jharkhand; 1,020 in Manipur and 916 in Himachal Pradesh. The maximum yield gap of 45.0% was recorded in Jharkhand followed by 36.6% in Assam; 33.9% in Himachal Pradesh; 28.8% in Manipur; 26.1% in Uttar Pradesh; 20.6% in Uttarakhand and 14.0% in Rajasthan. The maximum ANMR/ha were Rs 12,478; Rs 8,780; Rs 8,221; Rs 7,429; Rs. 6,699; Rs 6,220 and Rs. 5,250 in Uttar Pradesh, Manipur, Uttarakhand, Rajasthan, Assam, Himachal Pradesh and Jharkhand, respectively. The cost of cultivation ranged from Rs. 13,060/ha in Manipur to Rs. 29,702/ha in Uttar Pradesh in IP under rainfed Whole package demonstrations.

A total of 10 improved varieties of Indian mustard, 2 each of yellow sarson and toria and one of gobhi sarson were used in WP covering 12 states under irrigated condition. Under irrigated condition, improved variety RH 725 of Indian mustard demonstrated in 29 FLDs in Haryana recorded highest average yield of 2,525 kg/ha with a yield improvement of 18.1% over FP followed by Giriraj demonstrated in 6 FLDs in Haryana with average seed yield of 2,358 kg/ha with yield improvement 25.1%. The minimum yield improvement of 8.5% was reported from CS 60 variety from 9 FLDs in Rajasthan, while minimum average seed yield of 826 kg/ha was reported from TAM 108-1 variety from 30 FLDs in Maharashtra. However, the variety RH 749 in Jammu & Kashmir under irrigated condition recorded highest yield improvement of 62.6% with average seed yield of 1,190 kg/ha.

The maximum yield improvement of 12.8% from Pant Sweta variety of yellow sarson in Uttarakhand, 33.4 % from GSC 7 variety of gobhi sarson in Himachal Pradesh, 9.1% from PT 508 in Uttarakhand were recorded under irrigated condition.

Under rainfed condition, the demonstrations with RGN 298 recorded the highest average seed yield of 2,160 kg/ha with yield improvement of 11.1% in Rajasthan under rainfed situation. In Manipur, 85 demonstrations with NRCHB 101 recorded lowest average seed yield of 1,008 kg/ha with yield improvement of 28.2% over FP. However, The variety PM 27 in Assam under rainfed condition recorded highest yield improvement of 84.0% with average seed yield of 1,325 kg/ha.

The maximum yield improvement of 53.8% from YSH 401 variety of yellow sarson in Assam, 33.4 % from GSC 7 variety of gobhi sarson in Himachal Pradesh, 61.0% from TS 38 variety of toria in Assam and 23.1% from RTM 1351 of taramira in Rajasthan were recorded under rainfed condition.