SANCTION CODE 8 (16)/87–*OS*
Third Report
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INTER-INSTITUTIONAL COLLABORATIVE RESEARCH PROGRAMME ON RAPESEED-MUSTARD IMPROVEMENT WITH IDRC ASSISTANCE

TECHNICAL AND FINANCIAL REPORT

(APRIL 1991-MARCH 1992)

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
AND
DIRECTORATE OF EXPERIMENT STATION
G. B. Pant University of Agriculture & Technology
PANTNAGAR—263145, DISTT. NAINITAL
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CONTENTS

I. INTRODUCTION

Rapeseed-mustard is the second important edible oilseed crop of India but the production and productivity is the lowest among the rapeseed-mustard growing countries in the world. Possibility of increasing the productivity and sustaining the stability of production by way of development of Alternaria blight and white rust resistant cultivars is indicated based on the presently available information and technology. From the oil quality of point of view, the commercially grown cultivars in India contain very high amount of undesirable erucic acid and linolenic acid and the feed meal also contains very high amount of toxic glucosinolates which limits the utilization of rapeseed-mustard meal as a high quality feed. In order to fulfill the objectives of development of disease resistant cultivars and to develop double low(canola type) i.e. low erucic acid and low glucosinolate containing cultivars, Indian Council of Agricultural Research (ICAR) in consultation with International Development Research Centre(IDRC),Canada developed an "Inter-institutional Collaborative Research Programme on rape-seed-mustard Improvement with IDRC Assistance" for its implementation at five Indian and three Canadian institutions. The project was approved by the Government of India and IDRC vide 8-2/88-ICI dated 22.5.1989 for a period of four years from 1.4.1989 to 31.3.1993. Pantnagar is one such centres among the four centres in India and the Board of Management of the Pantnagar University approved the project as above in January 1990. The third year report (April 1991-March 1992) is given herewith.

II. PROJECT STAFF

PLANT BREEDING

Dr. Basudeo Singh	Senior Scientist(Oilseeds)
Dr. J.N. Sachan	Junior Research Officer
Dr. D.P. Pant	Junior Research Officer
Dr. S.P.Singh	Assistant Professor
Dr. R.L. Singh	Assistant Professor(Biochemistry)
Sri R.A. Khan	Research Associate
Sri Rajvir Singh	Field Assistant

PATHOLOGY

Dr. S.J. Kolte	Senior Research Officer
Dr. R.P.Awasthi	Junior Research Officer
Sri Vishwanath	Asstt. Agric. Inspector
Sri Dalganjan Singh	Research Fellow
Sri B.P.S. Adhikari	Graduate Student

Dr. Basudeo Singh	Project Leader and Programme Coordinator

III. ACTIVITIES PROGRAMMED AND EXECUTED

A. RESEARCH

The research work on breeding aspects in different projects was strengthened by extensive hybridization, rigorous testing and evaluation of segregating and advance lines under field, laboratory and glass house conditions and following additional approaches like recurrent selection and backcrossing. The research activities were planned and executed as per the 4 projects given below.

Project 1. Management of Alternaria blight

Project 2. Management of White rust

Project 3. Heterosis breeding in B. campestris

Project 4. Quality breeding

The projectwise plan of work and the results are given in following sections.

Project 1 Management of Alternaria blight

Breeding

Alternaria blight is most common and serious disease of mustard which causes heavy reduction (up to 60%) in seed yield, affect the quality of seeds and reduces oil content in

seeds. It occurs almost every year. Therefore, research efforts are underway to develop Alternaria blight resistant/tolerant varieties of mustard using available resistant source viz. RC 781, PHR-1 and PHR-2. The degree of resistance in these lines is low. But, due to lack of sources with high degree resistance, these are being used as donor parents in the breeding programmes.

Two breeding lines viz. PR 8925 and PR 9006 which showed disease index (at pod stage) 22 and 26 per cent, respectively(rated as resistant) under artificial inoculated conditions in field during previous year were tested for disease reaction at different centres of All India Coordinated Project on Oilseeds under National Screening for Alternaria blight. The results are awaited. Meanwhile, these entries were evaluated for their yield performance in a station trial at Pantnagar. The line, PR 8925 (925 kg/ha) yielded higher than checks, Varuna (773 kg/ha) and Kranti (666 kg/ha). However, these differences were non-significant. PR 8925 and both checks matured in 143 days. Test weight of PR 8925 (4.04 g/1000-seeds) was significantly higher than the check Kranti 3.61 g/1000-seeds) but similar to that of Varuna (4.04 g/1000seeds).

Six three way and one double crosses (listed below) made during previous year were grown and advanced to F_2.

1. IB 718 x (RC 781 x Pusa bold)
2. (JGM 87-3 x RC 781) x Kranti
3. (Varuna x RC 781) x Kranti
4. (RF 25 x RC 781) x Kranti
5. (JGM 87-2 x RC 781) x Kranti
6. (JGM 87-4) x RC 781) x Kranti
7. (RC 781 x *B. carinata*) x PHR-1 x Pusa bold)

Eleven F_2 populations derived from the crosses involving high yielding varieties/strains and one or more donors, (listed below) were grown under field conditions and spore suspension was sprayed twice (one at leaf stage and other at pod stage). All the populations showed susceptible reaction at leaf stage. However at pod stage variation in the intensity of disease reaction was observed. A total of 220 plants which showed less infection on pods were tagged and harvested at maturity. The seeds of individual plants have been collected separately for further evaluation and selection during coming crop season.

1. Kranti x RC 781
2. Varuna x RC 781
3. RF 25 x RC 781
4. JGM 87-2 x RC 781
5. JGM 87-3 x RC 781
6. JGM 87-4 x RC 781
7. RC 781 x PHR-1

8. RC 781 x Poorbiraya
9. (RC 781 x Krishna) x(PHR-1 x Pusabold)
10. (RC 781 x Krishna) x(PHR-1 x Kranti)
11. (RC 781 x Krishna) x (PHR-1 x Poorbiraya)

Ninety four progenies of crosses involving RC 781 and PHR-1 as donor parents and Poorbiraya, Pusa bold, Kranti and Krishna as receipient parents were grown under field conditions. The spore suspension was sprayed at leaf and pod stages. At leaf stage disease was observed in all the lines. However, at pod stage variation in the degree of infection was noticed. Thus, the plants showed less infection on pods were tagged and at maturity, seeds of individual plants were collected. As a result, seeds from 145 individual plants have been collected for further evaluation and selection.

In order to concentrate the genes for Alternaria resistance, available Alternaria resistant lines were inter-crossed. These crosses (listed below) will be grown during coming crop season for evaluation and additional round of selection.

1. PHR-1 x PR 9006
2. PHR-1 x PR 8925
3. PHR-1 x RC 781
4. RC 781 x PHR-1
5. RC 781 x PHR-2
6. RC-781 x PR 9006
7. RC 781 x PR 8925
8. PHR-2 x RC 781
9. PHR-2 x PHR-1

10. PR 9006 x PR 8925

Besides, following fresh crosses between extra early and dwarf mustard line PPMS-1 and Pusa barani and Alternaria resistant sources were made to isolate desirable segregants which have early and dwarf plant type with resistance to Alternaria blight.

1. PPMS-1 x PHR-1
2. PPMS-1 x RC 781
3. PPMS-1 x PHR-1
4. PHR-2 x PPMS-1
5. Pusa barani x PHR-1

PR 8903, a strain of mustard, derived from intervarietal hybridization involving RC 781 as one of the parents was tested at different centres of the country in AVT-1 trial of All India Coordinated project on Oilseeds Research. The results are awaited.

Project 1. Management of Alternaria blight

Pathological studies

1. Occurrence and distribution of Alternaria blioht in 1991-92

Survey work undertaken in the adjoining areas in Uttar Pradesh revealed low to moderate occurrence of the disease on leaves and pod infection was only to the extent 10-20 per cent in most areas. As per the information received through correspondence and personal messages from different scientists working at different centres in the country, the occurrence of the disease in other states of the country was also of low to moderate degree. Thus heavy pressure of the disease on the crop was not very much evident. At the Crop Research Centre, Pantnagar, the Alternaria blight (AB) appeared in varying intensities on commercial crop of toria and mustard. Toria cv 'PT 303' mustard cv 'PPMS-1' and 'PR-18' were planted in different planting dates and the time of first appearance of the AB under Pantnagar conditions is given in Table 1. Usually one such isolate was obtained from each host variety from a particular location for convenience of handling of the culture.

2. Laboratory and Glasshouse studies

2.1 Variability and identification of races of Alternaria brassicae

The work was continued, as in the previous two years, to determine variability in A. brassicae with a view to

Table 1 : Occurrence of Alternaria blight of rapeseed and mustard under Pantnagar conditions during 1991-92 crop season

Sowing date	First appearance of symptoms, days after sowing					
	On leaves of			On pods of		
	B. campestris var. toria cv PT 303	B. juncea cv PPMS-1	B. juncea cv PR-18	B. campestris var toria cv PT 303	B. juncea cv MKU	B. juncea cv PR 18
15 October	46	51	51	80	80	88
25 October	50	60	60	80	80	86
5 November	50	50	50	68	71	75
15 November	46	46	51	68	68	74
25 November	59	59	55	65	58	72
5 December	49	52	57	60	62	65

finding out the existence of physiological races. The details are given below.

2.1.1 Collection of AB- collected leaves and leaves and isolation of strains of *A. Brassicae*

Several cooperators working at different centres under AICORPO helped by way of sending the AB affected leaves/ pods of rapeseed-mustard. Similarly AB affected leaves were also collected from the crop grown at Pantnagar. The lesion characteristics and details of other leaf spot symptoms were noted with respect to any contrasting features of the observed symptoms and isolations were made accordingly. Usually a pure culture of the fungus was obtained from the single lesion by tissue planting method and the spores thus produced were subject to single spore isolation. The culture was further purified as generation of the single condium. Thus total 154 isolations were made and only 22 isolates were obtained from different geographical areas in pure culture using potato dextrose agar medium or radish root extract agar medium. The isolates were maintained at 20-23°c on agar as slants and these were coded according to the locality and host species from where they were collected and isolated as shown in Table 2 . One such isolate was selected from each host variety at the same location. Out of 22 isolates, 20 isolates were identified to belong to *A. brassicae*. Thus 7 such *A. brassicae* isolates were obtained from Pantnagar (Uttar Pradesh), 1 from Kanpur

(Uttar Pradesh), 3 from Faizabad (Uttar Pradesh), 2 from Dholi (Bihar), 1 from Muzarffarpur (Bihar), 2 from Kangra (Hima chal Pradesh), 2 each from Hisar (Haryana), and Morena Navgaon (Rajasthan). Two isolates were found to be A. alternata from collections made from Hisar (Haryana). As in the last year, A. raphani and A. brassicicola could not be isolated from any collections obtained from the above places.

2.1.2 Variability in growth, sporulation and spore morphology

The isolates were grown on PDA in petri dishes. the dishes were inoculated with 5 mm disc of the respective A. brassicae isolate as obtained from different geographical area of the country. The plates were incubated for about 3-4 weeks at 20-22°c providing 8-9 h diffused day light. All the 20 isolates of A. brassicae were included in this study for comparison among themselves in relation to standard reference A. brassicae isolates A, C, and D as studied by Awasthi and Kolte (1989) Indian Phytopath 42(2): 275; and Kolte et al (1991) Proceedings of GCIRC 8th International Rapeseed Congress (1991) pp 219-225.

The data on growth characteristics and sporulation intensity and ratio of spore beak length; spore body length were taken (Table 3).

Table 2 Alternaria isolates collected from different locations from different Brassica species in (1991-92)

Location from where collection was made	State	Host from where isolation was made	Characteristic symptoms spot type used for isolation	Alternaria species isolated	Isolate code
1	2	3	4	5	6
1. Faizabad	Uttar Pradesh	B. campestris var toria	Black brown spots with concentric rings	A. brassicae	$FBCAT_1$
2. Faizabad	Uttar Pradesh	B. campestris var yellow sarson	Black round spot	A. brassicae	$FBCAYS_1$
3. Faizabad	Uttar pradesh	B. juncea	Black brown colour spots	A. brassicae	FBJ_1
4. Kanpur	Uttar Pradesh	B. juncea	Brown larger spots with concentric rings	A. brassicae	$KNBJ_2$
5. Pantnagar	Uttar Pradesh	B. juncea(stern)	Grey round spots	A. brassicae	$PNBJ_3$
6. Pantnagar	Uttar Pradesh	B. juncea	Grey larger spots	A. brassicea	$PNBJ_4$
7. Pantnagar	Uttar Pradesh	B. campestris var toria	Black round larger spots	A. brassicae	$PNBCAT_3$
8. Pantnagar	Uttar Pradesh	B. carinata	Grey colour spots	A. brassicae	$PNBCR_3$
9. Pantnagar	Uttar Pradesh	B. carinata	Black solid dot like spot	A. brassicae	$PNBCR_4$
10. Pantnagar	Uttar Pradesh	B. carinata	Black spot with yell -ow halo	A. brassicae	$PNBCR_5$
11. Pantnagar	Uttar Pradesh	B. alba	Grey colour spots with necrosis in the centre	A. brassicae	$PNBA_1$
12. Hisar	Haryana	B. carinata	Larger grey spots	A. alternata	A. alternata
13. Hisar	Haryana	B. napus	Black brown larger	A. alternata	A. alternata

Contd....

Table 2 cont.....

1	2	3	4	5	6
14. Hisar	Haryana	B. campestris var toria	Black small round spots.	A. brassicae	HBCAT$_1$
15. Hisar	Haryana	B. campestris var yellow sarson	Black small round spots	A. brassicae	HBCYS$_1$
16. Dholi	Bihar	B. juncea	Grey larger round spots.	A. brassicae	DLBJ$_2$
17. Dholi	Bihar	B. campestris var yellow sarson	Grey smaller round spots.	A. brassicae	DLBJCAY$_1$
18.Mujaffarpur	Bihar	B. campestris var toria	Black broun spot	A. brassicae	MUBCAT$_1$
19. Morena	Madhya Pradesh	B. campestris var toria	Black broun small spots.	A. brassicae	MOBCAT$_1$
20. Morena	Madhya Pradesh	B. juncea	Small round black to brown spots.	A. brassicae	MOBJ$_1$
21. Novgaon	Rajasthan	B. campestris var toria	Black dot like spot.	A. brassicae	NVBCAT$_1$
22. Navgaon	Rajasthan	B. juncea	Grey small to larger	A. brassicae	NVBJ$_2$

Out of the 20 A. brassicae isolates, 9 were identified as possessing fast mycelial growth with poor to moderate sporulation with sporebeak to spore body length ratio of 1:1.90. This indicated that the above nine isolates i.e. $FBCAYS_1$, $PNBJ_4$. $PNBCAT_3$, $HBCAT_1$, $HBCAYS_1$, $DLBJ_2$, $DLBCAYS_1$, $MOBJ_1$ and $NVBJ_2$ belonged to the category of A. brassicae isolate A. Five isolates i.e. $FBCAT_1$, $KNBJ_2$ $PNBCR_3$, $PNBCR_4$ and $NVBCAT_1$ showed profuse pporulation with spore beak to spore body length ratio of 1: 2.86 and thus belonged to the category of A. brassicae isolate C. Similarly the remaining six isolates FBJ_1, $PNBJ_3$, $PNBCR_5$, $PNBA_1$, $MUBCAT_1$ and $MOBCAT_1$ were identified as A. brassicae D isolate (Table 3).

2.1.3 Variability in pathogenicity of A. brassicae isolates collected from different places

Detached leaf technique was used to study variability in pathogenicity of the 20 A. brassicae isolates. Five B. juncea cvs PHR-1, PHR-2, Kanpur local, PPMS-1 and PR-18, and B. carinata cv PPSC-1 and B. napus cv PPNS were used. The results revealed differences in pathogenicity as it was evident from through the infection score (Table 4). The isolates $PNBCAT_3$ and $DLBCAYS_1$ produced '1' infection score on all the hosts, whereas all other isolates showed differences in producing infection scores.

2.1.3 Variability in pathogenicity among A. brassicae A, C, and D isolates

The three A. brassicae isolates showed differences

Table: 3 Variability in growth sporulation and spore morphology among 20 *A. brassicae* isolates collected from different geographical area in India(1991-92)

A. brassicae isolate	Mycelial growth	Sporulation	Growth Zonations	Ratio of spore beak to spore body length	The isolate identified as isolate or race
$FBCAT_1$	++	+++	Distinct	1: 2.86	C
$FBCAYS_1$	++++	++	distinct	1: 1.90	A
FBJ_1	+++	+++	distinct	1: 1.28	D
$KNBJ_2$	++	++++	distinct	1: 2.86	C
$PNBJ_3$	+++	+++	distinct	1: 1.28	D
$PNBJ_4$	++++	+	poor	1: 1.90	A
$PNBCAT_3$	++++	+	absent	1: 1.90	A
$PNBCR_3$	++	++++	distinct	1: 2.86	C
$PNBCR_4$	++	++++	distinct	1: 2.86	C
$PNBCR_5$	+++	++	distinct	1: 1.28	D
$PNBA_1$	++++	++	distinct	1: 1.28	D
$HBCAT_1$	++++	+	absent	1: 1.90	A
$HBCAYS_1$	++++	+	absent	1: 1.90	A
$DLBJ_2$	++++	+	poor	1: 1.90	A
$DLBCAYS_1$	++++	+	absent	1: 1.90	A
$MUBCAT_1$	++	+++	distinct	1:12.8	D
$MOBCAT_1$	++	++++	distinct	1:1.28	D
$MOBJ_1$	++++	+	poor	1: 1.90	A
$NVBCAT_1$	++	++++	distinct	1: 2.86	C
$NVBJ_2$	++++	++++	poor	1: 1.90	A

+	Slow	+	Poor
++	Medium	++	Moderate
+++	Moderate	+++	Good
++++	Fast	++++	Excellent

Table:4 Reaction of five B. juncea line/varieties and B. carinata and B. napus to twenty A. brassicae isolates

A.brassicae isolate	B. juncea lines/ varieties					B. carinata	B. napus
	PHR-1	PHR-2	PPMS-1	Kanpur local	PR18	'PPSC-1'	'PPNS'
$FBCAT_1$	1	1	1	1	2	1	1
$FBCAYS_1$	1	1	1	2	2	1	1
FBJ_1	2	2	1	1	3	1	1
$KNBJ_2$	1	1	1	1	2	-	1
$PNBJ_3$	3	3	2	2	4	2	2
$PNBJ_4$							
$PNBCAT_3$	1	1	1	1	1	1	1
$PNBCR_3$	1	1	1	1	3	2	1
$PNBCR_4$	2	2	2	1	4	1	2
$PNBCR_5$	1	1	-	-	1	1	-
$PNBA_1$	1	1	1	1	1	1	-
$HBCAT_1$	1	1	1	2	2	1	1
$HBCAYS_1$	1	1	1	1	1	1	1
$DLBJ_2$	4	4	3	3	4	2	2
$DLBCAYS_1$	1	1	1	1	1	1	1
$MUBACT_1$	3	3	2	2	4	2	2
$MOBCAT_1$	-	1	1	1	1	2	-
$MOBJ_1$	2	2	1	2	3	1	1
$NVBCAT_1$	2	2	2	2		1	1
$NVBJ_2$	4	4	2	2	5	1	1

Note: 1 indicates resistant reaction; 2-3 as moderate degree of resistance and 4 and 5 as susceptible reaction.

in pathogenicity by producing number of spots on pods of inoculated Brassica species as shown in Table 5 . A brassicae isolate A and C produced significantly more number of spots on unwiped pods of B. napus cv regent as compared to unwiped pods of other B. napus cultivars.

3. Studies on mechanism of resistance; relationship among different components of resistance

Based on our previous two years results, nine test plant species as shown in Table 6 . were grown at the same time in small field plots and arranged in randomized block design in three replications. The plants were inoculated at 28 days of age with conidial suspension of A. brassicae isolate A to cover the whole leaf surface with the help of atomizer @ 20 ml/row of 1.5 m length using 15 plants per entry in each replication. Just after inoculation, the plants were covered with large size (6.0 x 2.0 m) transparent polythene sheet and was lifted upto the plant height using bamboo sticks. The plants were irrigated after inoculation and left covered with polythene sheets for 72 h of after inoculation to facilitate infection. Observations on epidemiological components of resistance were taken which included recording (1) alternaria spots on leaf, stem and siliqua; (2) measurement of spot size on leaf, stem and pod; (3) estimation of leaf area affected; (4) percent leaf infection; (5) per cent defoliation, (6) average disease index on leaf

Table 5 : Average number of Alternaria spots/pod* of some oilseed Brassica species produced on artificially inoculated pods with 3 isolates of Alternaria brassicae

Brassica species	Average number of spots/pod+					
	Alternaria brassicae isolates					
	A		B		C	
	W	UW	W	UW	W	UW
1. B. alba	0.75	0.75	1.00	1.25	1.00	0.75
2. B. campestris var yellow sarson cvt-151	66.00	55.75	57.50	38.75	46.75	38.75
3. B. carinata cv GS	2.25	1.00	2.25	2.25	1.50	0.50
4. B. carinata cv. RS	2.25	0.75	0.75	0.50	1.25	1.00
5. B. juncea cv exotic	4.00	2.75	2.00	2.25	2.25	2.00
6. B. juncea cv PHR-1	3.25	2.25	6.75	9.50	7.00	3.00
7. B. juncea cv YRT-3	13.50	13.00	4.50	9.50	9.00	6.75
8. B. juncea cv T 59	4.25	2.50	3.50	3.00	3.25	3.25
9. B. napus cv 1	11.25	4.50	9.50	2.50	22.00	4.50
10. B. napus cv regent	10.50	8.75	13.00	8.00	14.00	8.00
11. B. napus cv EA	4.00	2.75	3.50	0.75	2.25	1.25
12. B. napus cv 2	2.00	1.50	3.00	1.25	8.75	12.50

C.D. at 5% cultivar x pod condition x isolate = 3.69

* Inoculated pods were incubated in pettidish moist chamber
\+ Based on 20 observations
W Wiped pods;
UW Unwiped pods

Table 6 : Cruciferous host species used for study of correlations among components of *Alternaria* blight resistance

S.N.	Botanical name	Common name/ variety	Reaction to *A. brassicae* isolate A
1.	*Brassica juncea*	Ornamental rai	MR
2.	*B. campestris* var yellow sarson	T-151	HS
3.	*B. juncea*	Krishna	S
4.	*B. campestris* ssp. *rapifera*	Turnip red	R
5.	*B. campestris* var *toria*	PT 303	S
6.	*B. carinata*	PPSC 1	MR
7.	*Camelina sativa*	Edmonton Accession	HR
8.	*B. alba*	Exotic	R
9.	*B. napus*	PPNS 1	MS

HR = Highly resistant; MR = Moderately resistant;

R = Resistant; HS = Highly susceptible;

MS = Moderately susceptible;

S = Susceptible

stem and pods; (7) incubation and latent periods; and (8) intensity of sporulation etc. Observations on conidial germination in leaf exudates and total phenolic contents of different plant species were also taken to understand the biochemical basis of resistance.

The results revealed interaction involving A. brassicae isolates x B. campestris spp rapifera; (2) A. brassicae and B.alba; (3) A. brassicae x Camelina sativa gave resistant type of reaction characterized by development of a few small-size lesions with grey centre and brown margin. The interation between B. campestris var toria x A. brassicae isolate A always showed susceptible type of lesions characterized by white to grey centre with high sporulating characteristics. Thus as in the previous season the reference host species which could be used as differential hosts include Camelina sativa as highly resistant host followed by B. campestris spp rapifera B. alba and B. carinata CVPPSC$_1$ and others as given in Table 6 .

3.1 Establishing correlations among components of resistance to AB.

i. Number of spots on leaf

The results obtained revealed that number of spots per unit area of leaf did not show significiant difference between

susceptible and resistant genotype and there was no correlation with the field disease score. For instance, the production of spots per unit, area of on susceptible yellow sarson cv YST-151 and resistant B. alba were found at per at 112 DAS. In some cases number of spots found even higher in resistant B. campestris spp rapifera than in susceptible yellow sarson. Therefore, this parameter alone could not be used as component of resistance (Table 7).

ii. Number of lesions on stem

Number of lesions on stem appeared to be an important criterion for evaluation of resistance to the disease. Number of lesions per unit length of stem was found positively correlated with other components correlated with siliqua infection (r= 0.939) and defoliation (r = 0.833) (Figs, 1,2, Table 7).

iii. Size of leaf spot

The degree of variation in the size alongwith colour of the spot was positively correlated with field disease score (r = 0.798) and sporulating ability of the pathogen on host (r= 0.894) (Fig. 3,4, Table 7).

iv. Leaf area affected

Leaf area damage was not correlated with the number of spots on leaf but showed positive relationship with the size of spot and chlorotic area around the spot. (Fig.5,6, Table 7).

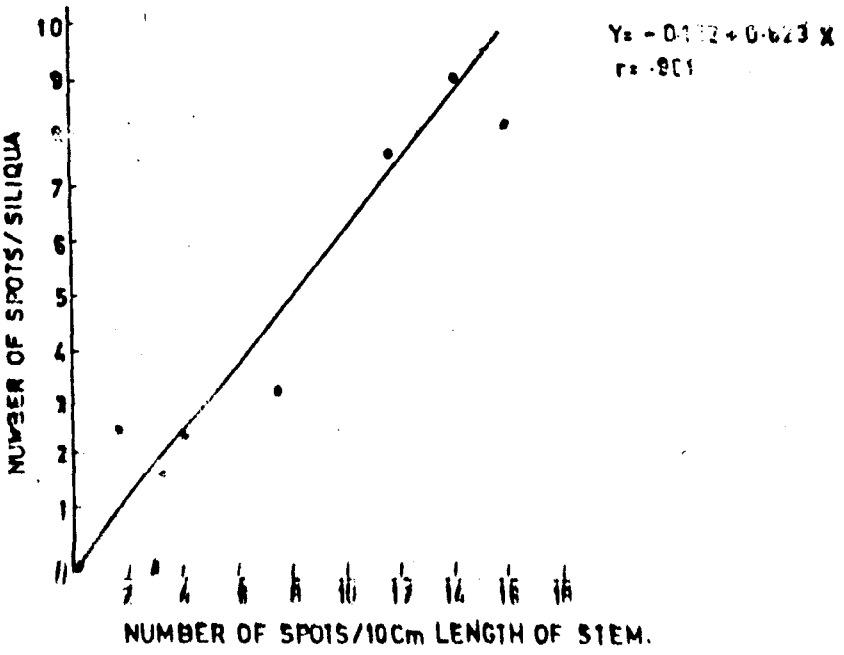

FIG. 1 LINEAR REGRESSION BETWEEN NUMBER OF SPOTS/ 10 Cm LENGTH OF STEM (X) AND NUMBER OF SPOTS ON SILIQUA (Y) OF EIGHT BRASSICA SPECIES.

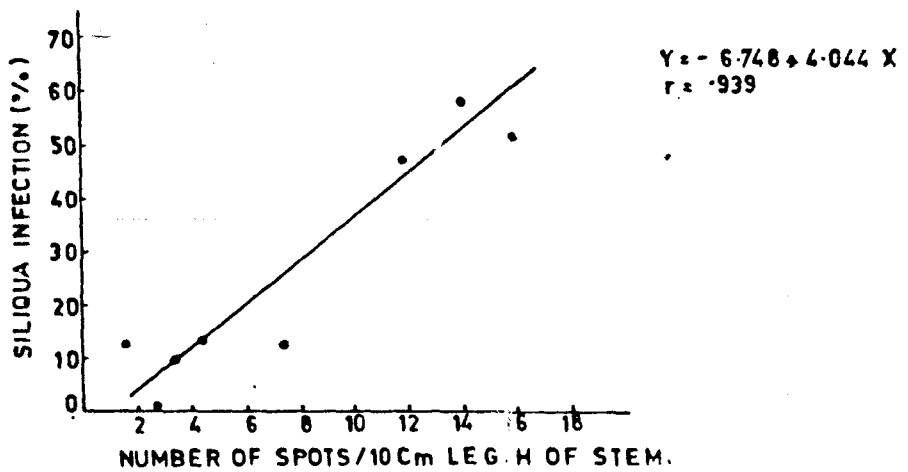

FIG. 2: LINEAR REGRESSION BETWEEN NUMBER OF SPOTS/ 10 Cm LENGTH OF STEM (X) AND SILIQUA INFECTION PERCENTAGE (Y) OF EIGHT BRASSICA SPECIES.

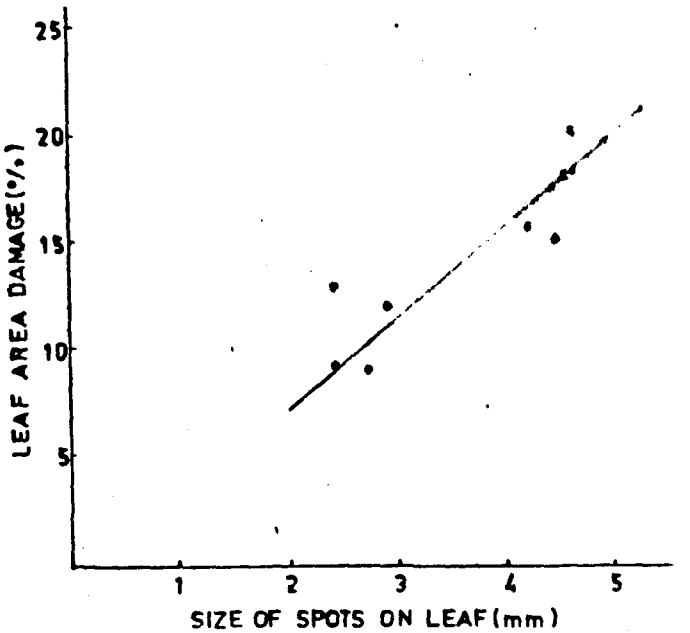

FIG. 3 : LINEAR REGRESSION BETWEEN SIZE OF SPOTS ON LEAF (X) AND LEAF AREA DAMAGE (Y) OF EIGHT BRASSICA SPECIES.

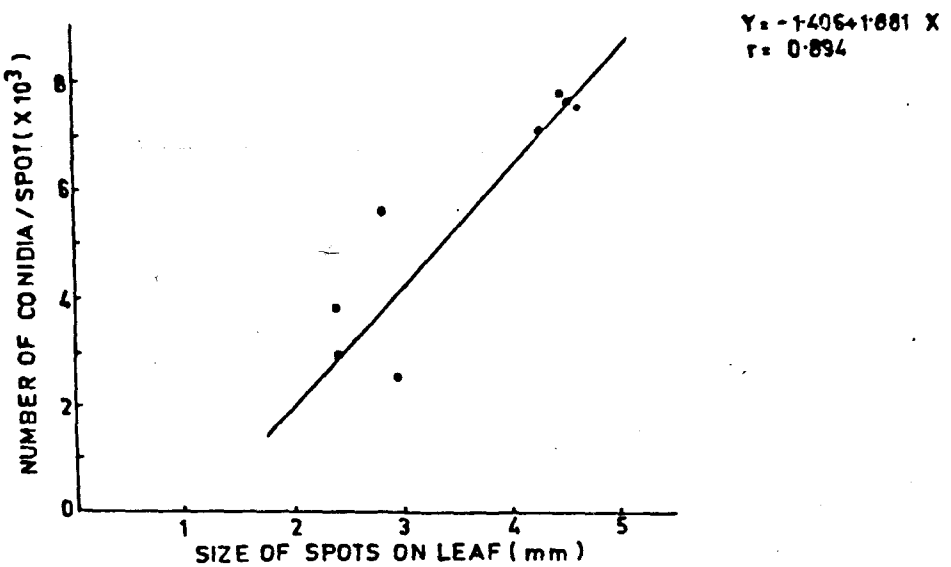

FIG. 4 : LINEAR REGRESSION BETWEEN SIZE OF SPOTS ON LEAF (X) AND NUMBER OF CONIDIA / SPOT (Y) OF EIGHT BRASSICA SPECIES.

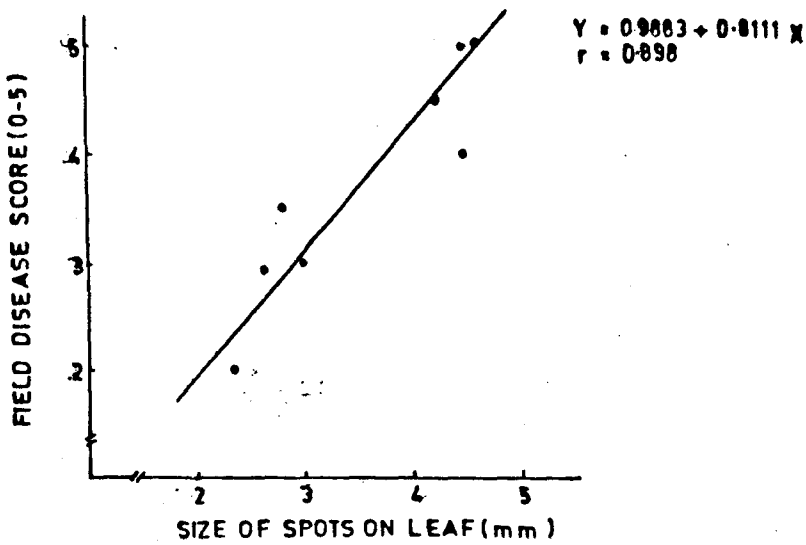

FIG. 5: LINEAR REGRESSION BETWEEN SIZE OF ALTERNARIA SPOT ON LEAF (X) AND FIELD DISEASE SCORE (Y) OF EIGHT BRASSICA SPECIES.

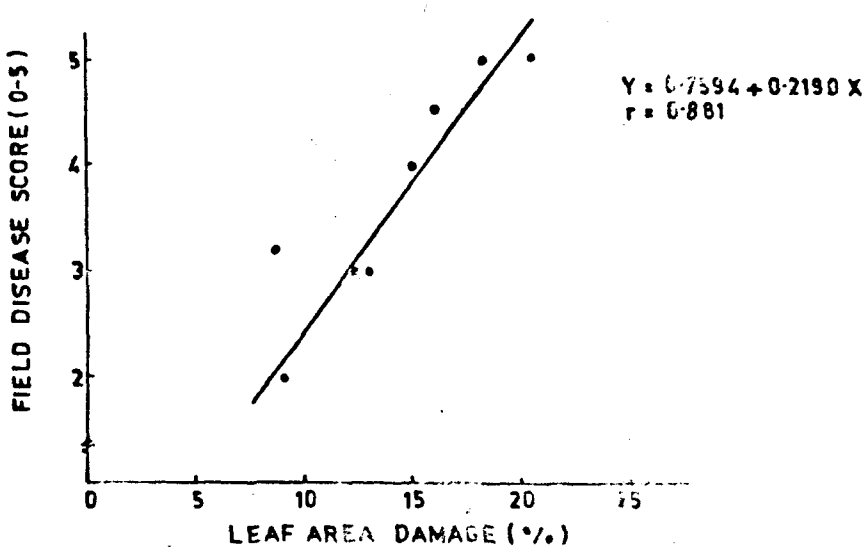

FIG. 6: LINEAR REGRESSION BETWEEN LEAF AREA DAMAGE (X) AND FIELD DISEASE SCORE (Y) OF EIGHT BRASSICA SPECIES.

V. Defoliation

There was a significant difference in defoliation of susceiptible and resistant Brassica species. The defoliation was positively correlated with field disease score (r =0.873), (Table 7).

vi. Incubation period

Incubation period of A. brassicae on different Brassica species showed variations and found to be negatively correlated with field disease score (r= 0.938) and with other parameters such as size of spot on leaf, number of spots on stem, leaf area affected and sporulation, but in contrary positive non- significant correlation was found with phenolic contents of the cruciferous host species. This indicates that on the basis of phenolic content alone the genotypes cannot be evaluated for resistance neither being correlated with field disease score at maturity because of variations of phenolic contents with increasing age of the plant (Table 7)

Based on the components of resistance, Camelina sativa was found to be highly resistant and B. campestris ssp. rapifera ssp oleifera is genetically very close to B. campestris ssp. oleifera so that conventional breeding technique might be used to transfer this resistance to rapeseed. However, camelina sativa is not related to rapeseed and its crossing with oilseed brassicas is not possible. However, biotechnological

Pooled mean values of the tables of components of resistance

Test entries: Cruciferous host species	No. of spots on leaf (n)	No. of spots on stem (n)	No. of spots on silliqua (n)	Spot size on leaf (mm)	Leaf infection (%)	Siliqua infection (%)	Leaf area damage (%)	Defoliation (%)	Sporulation X 10^3	Incubation period (d)	Latent period (d)	Phenolic compounds (mg/g)	Disease index (%)	Field disease score (0-5)
1. Brassica juncea-Ornamental rai	8.77	3.32	1.6	2.44	49.66	10.04	13.11	18.63	3.00	3.5	8.0	65.29	35.19	3.0
2. B. campestris var. yellow sarson cv. YST-151	6.33	16.10	8.2	4.53	59.82	51.42	18.35	27.33	7.72	3.0	6.0	46.01	46.14	5.0
3. B. juncea cv. Krishna	6.93	11.88	7.4	4.25	54.34	47.02	15.81	16.43	7.18	3.0	6.0	36.48	39.94	4.5
4. B. campestris ssp. rapifera	9.89	1.51	2.50	2.98	55.64	10.37	12.38	6.71	2.52	4.0	9.0	45.58	33.02	3.0
5. B. campestris var. toria cv. PT-303	8.01	14.09	9.0	4.64	58.46	59.75	20.78	22.95	7.62	3.0	6.0	46.83	45.19	5.0
6. B. carinata cv. PPSC-1	5.84	7.58	3.2	2.78	61.12	12.71	9.25	19.48	5.67	3.5	7.0	45.70	32.02	3.5
7. Camelina sativa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.85	0.0	0.0
8. B. alba	4.1	2.77	0.0	2.35	43.78	0.0	9.07	4.77	3.87	4.0	10.0	48.42	27.89	2.0
9. B. napus cv. PPNS-1	5.31	4.16	2.4	4.5	36.89	12.77	15.00	12.54	7.87	3.5	7.0	46.79	34.67	4.0

Components of resistance	Components of resistance													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
01. No. of spots on leaf	1.00	-.060	.172	-.033	.413	.111	.287	.113	-.394	-.034	.128	.278	.269	.269
02. No. of spots on stem		1.00	.901**	.732*	.592	.939**	.755*	.833*	.768	-.914**	-.521	-.603	.894**	.814*
03. No. of spots on siliqua			1.00	.774*	.551	.960**	.788*	.659	.694	-.894**	-.415	-.636	.871**	.816*
04. Size of spots on leaf				1.00	.092	.832*	.870**	.527	.894**	-.769*	-.276	-.607	.807*	.898**
05. Leaf infection (%)					1.00	.535	.248	.589	.066	-.421	-.560	-.331	.490	.399
06. Siliquat infection (%)						1.00	.864**	.683	.746*	-.869**	-.367	-.641	.919**	.813*
07. Leaf area damage (%)							1.00	.650	.669	-.800*	-.109	-.316	.942**	.881**
08. Defoliation								1.00	.592	-.864**	-.648	-.180	.821*	.873**
09. Sporulation									1.00	-.795*	-.518	-.606	.668	.713*
10. Incubation period										1.00	.545	.400	-.892**	-.938**
11. Latent period											1.00	.304	-.300	-.472
12. Phenolic compounds												1.00	-.411	-.275
13. Disease index													1.00	.933**
14. Field disease score														1.00

* Significant at 5%

** Significant at 1%

methods may be useful for transferring its resistance to cultivated rapeseed- mustard.

4. Evaluation of different genotypes of cruciferous hosts for resistance to A. brassicae

As in the previous year, seedling inoculation technique was used for determining the differences in AB reaction among different genotypes. However, during the year under report, only most promising genotypes, as identified in 1990-91 were used and the moderate degree resistance of CSL-1, Hc-4, PR 86-2, $PPSC_1$ BEC 141 and K-41731 A. brassicae isolate was confirmed.

An interspecific cross between B. carinata line " DBO 54" x B. napus cv Oliva was made in 1989-90 and the crossed seeds were obtained to grow further F_1 generation in 1990-91. Out of 100 seeds sown only one could germinate and produce the healthy plant. This plant was resistant to AB and White rust under artificial infection conditions. However, seed setting was poor but a few seeds could be obtained. The seeds obtained from this plant were further sown in 1991-92 in pods. But [redacted] again only one plant could be germinated to produce the healthy partially fertile plant. Again this plant showed resistance to AB and White rust. A number of seeds have been collected from this plant to grow furhter progeny for possibility of obtaining desirable AB and white resistant plant.

5. Yield performance of a newly developed early dwarf Mustard cv "PPMS-1".

5.1. Under different environments using different sowing dates

A newly developed early dwarf mustard named "Divya" mustard (PPMS-1) developed at Pantnagar was used in a field trial to study its yield stability performance in comparison with best national check Toria cv'PT 303'and mustard cv 'PR-18'. As in 1990-91, six planting dates i.e. October 15, 25, November 5,15 25 and December 5, 1991 (representing six different environments) were followed. The trial was laid out in a randomized block design in split-plot arrangement, keeping planting dates as main plot treatment and varieties as sub-plot treatment. Three replications were kept and the sub-plot size was 4 m x 3 m. Sowing was done in rows spaced at 30 cm and plant to plant distance was 15 cm. The recommended package of practices was followed. Observations on AB disease and WR intensity and staghead incidence and severity were taken. Similarly observations on days to first flowering, 50 and 70 per cents flowering and maturity were taken, The number of pods/plant, yield/5 plants, 1000-seed weight and total yield were recorded (Table 8).

Early dwarf mustard 'PPMS-1&(Divya) showed significantly less AB disease index both on leaf in comparison with toria a PT 303 and mustard cv 'PR-18' (Table 8). But the pod infection of AB in the case of 'PPMS-1' beyond 5th November

planting was more than mustard cv 'PR-18' but it was significantly very much less as compared to AB infection on pods of toria even in the late sown plots. Similarly WR leaf infection in the case of PPMS-1 upto 5th November planting was significantly less as compared to toria PT 303 and mustard 'PR-18'. The incidence and severity of staghead phase was high particularly in plantings done beyond 5th November and thus PPMS-1 was not found to be suitable for late splanting in November or December as compared to mustard cv 'PR-18', though PPMS-1 always yielded more than toria cv PT 303 under such environments (Table 8). The 15-25th of October sowing gave highest yield of PPMS-1 in the range of 10-12 q/ha as compared to 8-11 q/ha of toria'PT 303' in about the same maturity period of 99-100 days as compared to maximum of 12 q/ha yield in the case mustard cv 'PR-18' in 125 days. The results thus indicated potential superiority of mustard'PPMS-1' over toria cv 'PT 303' and mustard cv'PR-18' in terms of yield per unit area and time. Mustard 'PPMS-1' characterized by a typical desirable compact plant type is resistant to lodging besides its high yielding potential. This was actually experienced in 1991-92 crop season when toria 'PT 303' and mustard 'PR-18' subjected to lodging in December 1991 as against no such lodging effect in the case of PPMS-1 under the influence of rainfall and windy storm. The results are thus in confirmity with out previous year results. But the

Table:8 Reaction of Toria cv 'PT 303' and mustard cvs 'PPMS-1' and'PR18' to AB and WR disease and effect on yield under different environments of plantings done in 1991-92 at Pantnagar.

Planting date/ variety	1st flowering (DAS()	50% flowering (DAS)	75% flowering DAYS	AB index on leaf (%)	AB index on pod (%)	WR index on leaf (%)	Staghead Inci. (%)	Staghead Sever-rity (%)	Yield q/ha	Lodging rating &
October 15,1991										
PPMS-1	29	54	64	40.00	18.66	2.66	0.60	4.54	11.77	++
Toria'PT 303'	29	56	64	44.66	66.46	4.00	2.07	5.05	10.64	++
Mustard 'PR 18'	46	75	87	62.66	20.00	13.39	7.38	10.51	6.10	++++
October 25,1991										
PPMS-1	32	53	68	25.30	20.00	26.66	2.46	0.00	10.64	-
Toria'PT 303'	32	53	68	33.33	70.00	29.33	3.72	5.48	8.21	-
Mustard 'PR 18'	51	71	81	49.30	24.53	40.00	7.60	6.01	11.05	++
November 5,1991										
PPMS-1	33	59	67	57.30	21.33	25.33	2.89	7.31	6.94	-
Toria 'PT 303'	32	52	66	77.33	33.30	21.33	7.47	10.86	3.51	-
Mustard 'PR 18'	50	70	81	86.66	20.66	30.66	11.33	16.20	11.87	-
November 15,1991										
PPMS-1	36	61	69	57.33	24.00	17.33	4.40	12.89	6.82	-
Toria'PT 303'	30	52	65	65.33	36.00	14.66	4.60	11.38	3.56	-
Mustard 'PR 18'	50	70	81	85.33	13.33	28.00	22.18	13.95	7.19	-

Table8conti.....

Planting date/ variety	1st flowering (DAS)	50% flowering (DAS)	75% flowering (DAS)	AB index on leaf (%)	AB index on pod (%)	WR index on leaf (%)	Staghead(%) Inci.	Staghead(%) Severity	Yield (q/ha)	Lodining rating
November 25, 92										
PPMS-1	36	62	69	41.33	14.66	13.33	20.60	17.43	3.90	-
Toria'PT303'	30	50	62	54.60	29.33	12.00	6.07	13.63	1.17	-
Mustard'PR-18'	49	68	80	62.60	14.60	12.60	23.31	12.03	7.12	-
December 5,1992										
PPMS-1	41	64	71	29.30	22.60	12.00	34.44	15.84	4.74	-
Toria'PT 303'	31	50	62	34.00	38.6	10.66	3.16	13.70	1.18	-
Mustard'PR-18'	47	69	82	41.33	16.00	14.00	18.06	16.73	6.66	-
CD at 5%				4.85	5.82	2.62	6.49	NS	1.00	
S.Em ±				1.66	1.99	0.89	2.22	NS	0.34	

++ indicates = moderate loding involving 50 per cent plants falling down on the ground;
++++ indicates severe lodging involving 80 per cent plants falling down on the ground due to heavy rains accompained by wind storm in December 91.

yield ranges were of the higher order in 1990-91 as compared to 1991-92 crop season.

5.2 Under different row spacings

Field trials were conducted at Crop Research Centre Pantnagar during 1990-91 and 1991-92 crop seasons. Three row spacings viz. 20, 30 and 40 cm in 1990-91 and four row spacings viz. 15, 20, 25 and 30 cm were selected using three varieties viz. an early dwarf mustard 'PPMS-1' toria cv 'PT 303' and mustard cv 'PR-18'. The trials were laid out in randomized block design in split plot arrangement with three replications. The sub-plot size was 4 x 3m. Sowing was done on the 13th of October 1990 and on the 23rd of October 1991. The plant to plant distance was 10-15 cm. The package of agronomic practices were followed. The crop was sprayed once with Metasystox for the control of aphids. Observations on AB disease index on leaf and pods, WR intensity on leaf and staghead incidence and severity, yield contributing characters and total yield etc. were taken (Table 9,10).

The results revealed that 'PPMS-1' gave significantly higher yield in all the row spacings, as compared to toria cv 'PT 303' in 1990-91, the maximum being in 20 cm row spacing (Table 9). Similar results were obtained in 1991-92, though magnitude of yield quantity was lower in 1991-92 as compared to 1990-91 crop season. Differences in yield between PPMS-1 and

Table: 9 Yield performance and disease reaction of PPMS-1 in comparison to mustard (PR18' and toria 'PT 303' under different row spacings in 1991-92 at Crop Research Centre, Pantnagar (sowing date 23.10.1991)

Variety/ row spacing	AB index on leaf (%)	AB index on pod (%)	WR index on leaf (%)	Staghead (%)		Yield q/ha	Maturity days
				Incidence	Severity		
PPMS-1							
15 cm	49.33	34.66	3.33	2.73	7.01	11.31	100
20 cm	44.00	28.00	1.33	2.66	5.33	11.61	100
25 cm	46.66	29.33	2.66	0.20	2.08	11.62	99
30 cm	56.66	33.33	7.33	0.20	3.03	10.06	98
Mean	48.66	31.33	3.66	1.45	4.41	11.15	97
Toria'PT 303'							
15 cm	44.00	54.66	4.66	4.81	14.41	10.47	100
20 cm	46.66	48.00	4.66	4.26	10.74	9.91	99
25 cm	52.00	58.66	4.66	5.23	13.70	9.44	99
30 cm	57.33	57.33	5.33	2.72	10.87	9.46	98
Mean	50.00	54.66	4.82	4.25	12.43	9.82	97
Mustard 'PR 18'							
15 cm	57.33	10.66	33.33	3.08	9.99	13.15	130
20 cm	54.66	9.33	36.00	3.78	12.70	13.58	131
25 cm	53.33	10.66	42.66	1.94	12.84	11.77	131
30 cm	54.66	10.66	35.66	4.43	10.66	12.93	131
Mean	56.21	10.33	36.88	3.31	10.54	12.86	131
CD_1 at 5%	NS	2.86	11.15	NS	5.42	2.27	
CD_2 at 5%	NS	3.69	4.59	NS	NS	NS	

Table: 10 Yield performance and disease reaction of PPMS-1 in comparison to mustard cv 'PR-18' and Toria cv 'PT 303' under different row spacing in 1990-91 (Sowing date 13.10.1990)

Variety/ spacing	AV plant height (cm)	Length of main recene(cm)	No. of pods per main recane	Total pods/ plant	Yield/ plant (g)	Yield q/ha	Harvest index %	Root length (cm)	AB index on pod (%)	Maturity (days
PPMS-1										
20 cm	100.67	48.73	36.20	319.13	55.00	22.16	35.42	10.53	15.33	100
30 cm	109.07	46.33	42.13	473.40	57.67	20.83	39.60	9.20	21.33	99
40 cm	98.33	52.13	37.13	368.33	60.33	13.74	38.48	8.87	20.00	99
Mean	102.69	49.07	38.49	386.96	57.67		37.83	9.53		
Toria'PT 303'										
20 cm	116.73	48.47	41.47	138.27	30.00	18.28	31.81	6.53	26.00	100
30 cm	110.67	49.87	46.53	172.33	32.00	19.62	33.83	7.47	27.33	99
40 cm	117.40	55.87	47.20	226.87	39.00	15.70	33.90	8.07	26.00	99
Mean	114.93	51.40	45.07	179.16	33.67		33.18	7.36		
Mustard'PR18'										
20cm	196.67	63.00	29.13	141.67	20.00	19.42	37.46	4.70	14.00	132
30 cm	186.27	62.47	31.97	116.33	23.00	19.13	22.23	11.00	15.33	135
40 cm	178.27	53.53	29.47	129.60	37.67	17.01	27.59	12.47	21.30	135
Mean	187.07	59.67	30.19	129.20	26.89		25.76	9.47		
CD_1 at 5% (spacing)	NS	NS	NS	NS	3.58	5.16	NS	1.21	7.62	
CD_2 at 5%	11.58	5.13	5.77	79.20	11.09	3.31	4.72	1.35	8.05	

mustard cv 'PR-18' were non-significant, though PR-18 yielded more than PPMS-1 in 30-40 cm row spacings (Table 9,10). There was no significant difference in AB index disease and WR leaf intensity and staghead severity due to different row spacings in all the three varieties (Table 9).

5.3 PPMS-1 is a suitable genotype for spring cultivation

A small field plot 5 x 3 m was sown with PPMS-1 on March 10, 1992 at Pantnagar and the preliminary observations and data collected revealed the suitability of PPMS-1 for spring cultivation also. The crop took only 87 days for complete maturity yielding about 7-8 q/ha. The crop showed moderate development of powdery mildew which could be controlled by just one spray of Bayleton @ 0.05%.

Project2: Management of white rust

Breeding

(i) Development of white rust resistant varieties of rapeseed and mustard

White rust (WR) disease caused by Albugo candida is another disease of rapeseed-mustard, causes reduction in seed yield. Thus a programme for the development of white rust resistant varieties of mustard using YRT- 3 as donor parent was initiated.

Later, 2 more resistant sources viz. Domo and Cutlass (Canadian varieties fof mustard) were added. Subsequently, backcross breeding programmes were initiated to transfer white rust resistance, from Domo and Cutlass to Kranti and Varuna varieties of Indian mustard (B. juncea (L.) Czern & Coss) and from SW 83-4302, a Canadian strain of toria (B. campestries var toria), to PT 303 and PT 30 Indian varieties of toria.

(a) Varieties of toria(B. campestris var toria)

A population named as SW 83-4202 observed free from white rust resistance under artificial epiphytotic conditions is being used as donor parent. During the season under report following F_1's g were grown under field conditions and advanced to F_2.

1. PT 303 x SW 83-4302
2. PT 30 x SW 83-4302
3. SW 83-4302 x PT 303
4. SW 83-4302 x PT 30

Following backcrosses (BC_1) were made to transfer WR resistance from SW 83-4302 to PT 303 and PT 30.

1. (PT 303 x SW 83-4302) x PT 303
2. (PT 30 x SW 83-4302) x PT 30.

(b) Indian mustard (B. juncea (L.) Czern & Coss)

Domo, cutlass and YRT-3 are being used as donor parents in the development of WR resistant varieties of Indian mustard. Based on 2 years data obtained from artifically inoculated conditions in field, PR 8998 and PR 9021 (disease index 10.35 and 10.33 respectively) were rated as resistant during previous year. These lines were included in National Screening Nursary for white rust resistance to evaluate for disease reaction at different locations in the country, during rabi 1991-92. The results are awaited. Mean while these lines were evaluated for their yield performance in a station at Pantnagar. Results revealed that PR 8998 (694 kg/ha) and PR 9021 (648 kg/ha) were at par in seed yield with checks, Varuna (716 kg/ha) and Kranti (666 kg/ha), PR 8998 (142 days) matured one day earlier than Varuna and Kranti (143 days), whereas PR 9021 (145 days) was found 2 days late in maturity. The test weight of PR 8998 (3.98g/1000seeds) and PR 9021 (3.48 g/1000 seeds) was significantly lower than checks Varuna (4.04 g/1000 seeds weight) Kranti (3.61 g/1000seeds).

Twelve lines developed recently were evaluated for white rust reaction under artificial epiphytic conditions in glass house. WR 9201 and WR 9205 were observed moderately resistant with score 2 in the rating scale of 0-5.

Following F_1 crosses involving WR resistant sources and promising lines, made during previous year were grown and advanced to F_2.

1. EC 175438 x Cutlass
2. EC 175439 x Cutlass
3. EC 175441 x Cutlass
4. IB 718 x Cutlass
5. EC 175438 x Domo
6. EC 175439 x Domo
7. EC 175445 x Domo

Six F_2 populations (listed below) were grown under field conditions and spore suspension was sprayed at leaf stage. After 28 days of inoculation, resistant plants were observed and tagged. At maturity these plants were harvested and seeds of individual plants have been collected separately. As at result 140 individual plant from F_2 were finally selected for further evaluation and selection.

1. Kranti x Domo
2. Kranti x Cutlass
3. Varuna x Domo
4. Varuna x Cutlass
5. YRT-3 x Kranti
6. YRT-3 x RC 781

Similarly, 128 F_3 progenies were grown under field conditions and inoculated artificially. The plants free

from WR spots were tagged. The consideration was given to Alternaria blight at the time of final selection. At maturity the seeds of selected plants were collected separately. As a result 186 individual plants have been selected.

In order to transfer white rust resistance of Domo and Cutlass in to Kranti and Varuna, backcrossing programme was initiated during previous year. During current crop season following back crosses were subjected to seedling screening in glass house and resistant seedlings were crossed with corresponding recurrent parent(i.e. BC_2 = second generation of backcrossing).

1. (Varuna x Cutlass) x Varuna
2. (Kranti x Cutlass) x Kranti
3. (Varuna x Domo) x Varuna
4. (Kranti x Domo) x Kranti

Besides, following fresh crosses were attempted during the season.

1. PPMS-1 x Domo
2. Pusa barani x YRT-3
3. YRT-3 x Pusabold
4. YRT-3 x NDR 8501
5. NDR-8501 x Domo
6. Pusa barani x Domo
7. Cutlass x Kranti
8. Domo x NDR-8501
9. Domo x Pusa bold
10. Krishna x Domo

(ii) Screening of Indian mustard for downy mildew genotypes resistance

Twenty five genotypes of Indian mustard (B. juncea (L.) Czern & Coss). were grown in a randomized block design with 3 replications at a fertility level of 80:40:40 kg NPK/ha, respectively. The crop was sown on Dec. 10, 1991, keeping 30 cm distance between rows and 10 cm distance between plants was maintained by thinning. Observations on percent infect plants, average length of stag head (based on 10 infected plants) and average number of branches infected per plant (based on infected plants) was recorded and have been presented in Table 11.

The results presented in Table 11 revealed that none of the genotypes was free from downey mildew infection as indicated by staghead formation. Number of infected plants ranged from 1.86 (MLS-1) to 22.1 percent (MLS 14). Disease severity was evidenced by infection of more than one branche per plant (ranging from 1.00 to 2.6) and length of staghead (ranged from 4.08 to 12.04 cm). If consider all the three factors at a time MLS-9 was observed to be the most promising among the genotypes screened.

Table 11: Downy mildew incidence on different genotypes of Indian mustard under late sown conditions during 1991-92.

Entries	Percent infected plant(%)	Average length of staghead(cm)	Average No. of infected branches per plant(no)
MLS-14	22.10	6.27	2.60
MLS-19	17.46	4.45	1.40
MLS-20	16.01	8.34	1.40
MLS- 4	13.74	8.53	1.33
MLS-10	12.65	7.53	1.53
MLS-13	12.51	6.46	2.06
MLS- 7	12.49	7.84	1.20
MLS-22	12.38	7.29	1.20
MLS-16	10.68	11.58	1.46
MLS-17	10.19	8.60	1.33
MLS- 1	9. 55	4.23	1.60
MLS- 5	9.25	12.54	1.06
MLS-25	9.35	6.37	1.46
MLS-18	8.93	9.95	1.33
MLS-23	8.78	10.00	1.26
MLS- 6	8.62	8.54	1.33
MLS-11	8.14	9.36	1.40
MLS- 15	7.33	9.71	1.13
MLS- 8	6.88	10.20	1.46
MLS-21	5.78	10.12	1.40
MLS-12	5.58	10.11	1.06
MLS-24	4.79	6.70	1.20
MLS- 2	4.64	4.08	1.26
MLS- 3	3.44	8.01	1.00
MLS- 9	1.86	10.82	1.16

(iii) Study of inheritance of white rust resistance in toria and Indian mustard

(a) Toria (B. campestris var toria)

In order to workout the inheritance of white rust resistance in toria following set of crosses were attempted during the season.

Parents

Resistant : SW 83-4302
Susceptible : PT 303 and PT 30

F_1's

1. PT 303 x SW 83-4302
2. SW 83-4302 x PT 303
3. PT 30 x SW 83-4302

F_2's

1. PT 303 x SW 83-4302
2. SW 83-4302 x PT 303
3. PT 30 x SW 83-4302
4. SW 83-4302 x PT 30

BC_1s

1. (PT 303 x SW 83-4302) x PT 303
2. (PT 30 x SW 83-4302) x PT 30
3. (SW 83-4302 x PT 303) x SW 83-4302
4. (SW 83-4302 x PT 30) x SW 83-4302

BC_2

1. (PT 303 x SW 83-4302) x SW 83-4302
2. (SW 83-4302 x PT 303) x PT 303
3. (PT 30 x SW 83-4302) x SW 83-4302
4. (SW 83-4302 x PT 30) x PT 30

Observations on white rust reaction will be recorded in glass house during coming season by applying seedling screening technique.

(b) Mustard (B.juncea (L.) Czern & Coss)

With a view to study the inheritance of white rust resistance in Indian mustard, Domo and cutlass were used as resistant parents and Kranti and Varuna as susceptible parents.

All possible crosses (F_1) between resistant and susceptible parents and their reciprocals, were subjected to seedling screening technique during rabi 1991-92. The results revealed that the resistance is dominant over susceptibility. Results of 4 F_2's and backcrosses are presented in Table12.

It is evident from the table referred above, that the inheritance of resistance to white rust race 2 in mustard was controlled by a single dominant gene.

Table12: Observed segregation in B. juncea and chi^2 test for back crosses and F_2 reaction to A. candida

Pedegree	Reaction		Ratio	X^2	P
	resis-tant	suscep-tible			
Parents					
Domo	15	0			
Cutlass	14	0			
Kranti	0	20			
Varuna	0	20			
F_1's					
Kranti x cutlass	41	0			
Cutlass x Kranti	Not germinated				
Varuna x cutlass	40	0			
Cutlass x Varuna	43	0			
Kranti x Domo	45	0			
Domo x Kranti	26	0			
Varuna x Domo	28	0			
Domo x Varuna	45	0			
Cutlass x Domo	42	0			
Kranti x Varuna	0	45			
F_2's					
Kranti x Cutlass	142	38	3:1	1.451	0.20-0.30
Kranti x Domo	146	52	3:1	0.168	0.60-0.70
Varuna x Domo	142	40	3:1	0.887	0.40-0.50
Varuna x Cutlass	103	41	3:1	0.925	0.40-0.50
Back crosses					
(Varuna x Cutlass) x Varuna	95	82	1:1	0.954	0.40-0.50
(Kranti x Cutlass) x Kranti	52	68	1:1	2.133	0.10-0.20
(Varuna x Domo) x Varuna	85	97	1:1	0.791	0.40-0.50
(Kranti x Domo) x Kranti	76	60	1:1	1.882	0.10-0.20

Project 2 : Management of White rust

Pathological studies

1. Occurrence and distribution of white rust (WR) in 1991-92

White rust (WR) disease appeared in varying intensities in different planting dates under Pantnagar conditions as shown in Table 13 . The occurrence of the WR, however, was negligible in normal planting but the late planted crop showed severe development of both leaf and staghead phase infection. The overall incidence and severity of occurrence of WR in different parts of the country also remained to be low to moderate under normal sowing as against severe development of the disease under late sown conditions as revealed through survey visits and from correspondence made with the cooperators at different centres.

2. Laboratory and greenhouse experiments

i. Variability and identification of races of Albugo candida

This part of the project activity was also continued during 1991-92 crop season to confirm our previous two years results on identification of races of Albugo candida. The methodology is described in the following paragraphs.

Table 13: Occurrence of white rust of rapeseed-mustard under Pantnagar conditions during 1991-92 crop season.

Sowing date	First appearance of white rust on leaves: days after sowing		
	B. juncea cv 'PPMS-1'	B. juncea cv 'PR 18'	B. campestris var toria
15,October	51	51	46
25,October	60	60	50
5,November	50	50	50
15,November	40	45	40
25,November	30	30	36
5, December	39	39	39

a. Collection of WR-affected leaves and maintenance of the inoculum

WR- affected leaves of mustard (B. juncea) toria (B. campestris var toria) and gobi sarson (B. napus) were obtained from different states as shown in Table 14. The isolates were designated as shown in Table 15 in continuation of serial order of the isolates designated during 1989-90 and 1990-91. Thus the isolates from mustard are designated as WRM_{28-39} and the isolates from toria as WRT_{10} to $_{12}$ and that from gobi sarson as $WRGS_3$. The isolates were maintained as in the previous year, on the respective host species and preserved in gelatin capsules.

b. Method of inoculation and study of development of infection

The same method, as used in 1990-91, was used for inoculation. Inoculum from WR-affected leaves of the respective isolate was prepared in double distilled water by scratching the WR-pustules with a blade or tooth brush. The inoculum (sporangic suspended in water) was then passed through muslin cloth and incubated at $10^{o}c$ for sporangial germination. After $4-5^{h}$, when the sporangia germinated to give rise to zoospores, the inoculum was sprayed on the pot-grown test plants i.e. on differential hosts at 3-leaf stage. The inoculated plants were then kept in the moist chamber for development of symptoms.

The observations on pustule type and pathogenicity differences were noted.

Variability in pustule type

The details of differences in size, shape and texture of the WR pustule types on samples of the leaves collected from different locations are given in Table 14.2. As in 1990-91, four different pustule types, were noted as described below.

Pustule	Characteristic of the pustule type	Host	Location
1. Pin-head size pustule	White dot-like pin-head pustules measuring 0-5-2 mm in size. Such pustules contained globulor sporangia measuring in the range of 14-21-20 m. and showed 70-92% germination by giving rise to zoospores at 15°c in 4h.	B. juncea and B. campestris var toria cv 'T-9'	Kangra(Himanchal Pradesh) Morena(Madhya Pradesh) Faizabad(Uttar Pradesh); Dholi(Bihar); Pantnagar (Uttar Pradesh)
2. Small circular smooth to rised pustule	Creamy yellow circular to irregular raised pustules of 6.5-12mm size. The sporangia in the range of 13.55-2 m and showed germination upto 68-90% by giving rise to Zoospore at 15°c in 4h.	B. juncea	Kangra(Himanchal Pradesh) Navgaon and Durgapura(Rajast-han) Morena(Madhya Pradesh) Pantnagar (Uttar Pradesh)
2. Broad circular discontinuous ring type pustule.	Circular pustules varying in size from 2-5 mm with white dot like centre surrounded by distinct discontinous ring pattern.	B. juncea	Navgaon and Durgapur (Rajasthan)
3. Necrotic lesion type pustules.	Minute lesion characterized by necrosis measuring in size of 0.5mm-like a hyper sensitive response.	RH 30 x Zem	a few lines breeding at Pantnagar (Uttar Pradesh)

Table 14 Morphological variation in Sporangia of Albugo candida from [illegible] collected from different locations in India in 1991-92.

Sl. No.	Location		Host	Characteristic of Pustule	Size of Pustule (mm)	Size of Sporangia (mm)	Shape of Sporangia	Germination of Sporangia (%)
	Place	State						
1	2	3	4	5	6	7	8	9
1.	Kangra	Himachal Pradesh	B. juncea	Pinhead size pustule	0.5 - 1	16.5 - 19.80 (18.33)	Globular	
				Irregular broad type pustules	4 - 7	14.85- 20.99 (18.00)	Globular	
2.	Navgaon	Rajasthan	B. juncea	Circular	3 - 5	16.00- 20.0 (17.70)	Spherical	67.45
				Broad circular raised mass	7 - 12	16.00- 21.20 (18.50)	Spherical	70.20
				Irregular broad pustules	5 - 7	13.55- 19.98 (16.96)	Blightly spherical	68.80
3.	Durgapura	Rajasthan,	B. juncea	Circular	3 - 5	15.20-20.5 (18.46)	Globular	72.00
				Broad circular	7 - 9	13.00-19.40 (17.52)	Elongate to circular	74.50
4.	Morena	Madhya Pradesh	B. juncea	Pinhead datted pustules	0.5 - 2	14.00-21.20 (17.75)	Micro-circular	78.45
				Broad circular	5 - 7	15.50-21.00 (18.32)	Globular	78.50
			B. campestris T-9	Circular surrounded by dark green border	1 - 3	13.60-19.50 (16.40)	Spherical	74.20
5.	Kanpur	Uttar Pradesh	B. juncea	Circular dark green colour	1 - 3	16.50-20.00 (18.50)	Globular	78.50
				Irregular broad	3 - 5	16.45-21.50 (18.80)	Globoular	76.78
6.	Faizabad	Uttar Pradesh	B. juncea	Pinhead datted circular	1 - 2	16.50-18.89 (17.40)	Spherical	72.60
7.	Dholi	Bihar	B. juncea	Pinhead circular	1 - 2	14.00-18.50 (15.60)	Globular	70.50
8.	Hisar	Haryana	B. juncea	Broad circular	3 - 5	16.40-21.00	Globular	76.78

contd...

Table 14 cont.....

1	2	3	4	5	6	7	8	9
				Circulardiscontinuous ring	3 - 5	16.20 - 19.50 (17.60)	Slightly	72.80
9. Pantnagar		Uttar Pradesh	B.juncea	Circular	0.5 - 2	16.66 - 18.88 (17.53)	Slightly spherical	92.14
				Broad circular surrounding green border.	2 - 5	16.00 - 20.80 (18.28)	Globular	92.50
				Irregular having hallow form.	5 - 7	16.50 - 20.24 (17.64)	Globular	90.20
			B.campestris var.Toria in PT 303	Irregular surrounding by greenring circular broad pustule raised mass.	3 - 5	13.50 - 18.50 (16.00)	Globular	94.40
					5 - 7	14.00 - 20.68 (16.50)	Globular	92.00

Variability in Pathogenicity

Among isolates of A. candida collected from B. juncea

Twelve A. candida isolates WRM 28-39 collected from different cultivars of mustard from Pantnagar, Navgaon, Durgapura, Morena Kanpur, Faizabad; Dholi and Hisar revealed that these all infected Indian of B. juncea cv Varuna and B. juncea MKU line(PPMS-1) and these failed to show any evidence of infection on canadian B. juncea cvs Domo and cutlass. This indicates that all Indian A. candida isolates obtained from B. juncea show specificity by infecting only Indian mustard cultivars and not the Canadian ones. Thus B. juncea cvs Domo and cutlass are resistant to A. candida isolates.

Out of the twelve isolates, two isolates viz. WRM 28 from Pantnagar and WRM 33 from Morena infected both B. campestris cv toria and B. juncea (Indian cultivars). This thus indicates that in Pantnagar and Morena areas, isolates of A. candida exist which can cause infection both on B. juncea and B. campestris cv toria. WRM 28 isolate, like WRM 13 in 1990-91, showed development of symptoms on B. alba. This indicates that WRM_{28} is the same type of WRM_{13} showing high degree of virulence on B. juncea (Indian cultivars), B. campestris var toria and B. laba (Table16) During 1991-92, we did not receive WR-affected leaves from Bhatinda (Punjab) and confirmity about infecting of white rust isolate from that place could not be done as it was reported during 1990-91.

Table 15 : White rust isolates collected from different geographical areas of India 1991-92 crop season

Brassica species	Cultivar/location		Isolates designated as
B. juncea	Varuna	Pantnagar	WRM_{28}
	Kranti		WRM_{29}
	Krishna		WRM_{30}
	Varuna	Navgaon	WRM_{31}
		Durgapura	WRM_{32}
		Morena	WRM_{33}
		Kanpur	WRM_{34}
		Faizabad	WRM_{35}
		Dholi	WRM_{36}
	RH-30	Hisar	WRM_{37}
B. juncea	MKU	Pantnagar	WRM_{38}
B. juncea	CBPPS	Pantnagar	WRM_{39}
B. campestris var toria	PT-303	Pantnagar	WRT_{10}
	PT-30		WRT_{11}
	T-9	Morena	WRT_{12}
B. napus		Pantnagar	$WRGS_3$

Note: Isolate from Kangra could not be obtained in vaible form perhaps because of poor sample collection.

Table 16 : Reaction of differential host Brassica species against different isolates of A. candida obtained from different geographical regions of India in 1991-92.

Cruciferous host species	WRM_{28}	WRM_{29}	WRM_{30}	WRM_{31}	WRM_{32}	WRM_{33}	WRM_{34}	WRM_{35}	WRM_{36}	WRM_{37}	WRM_{38}	WRM_{39}
B. alba	-+	-	-	-	-	-	-	-	-	-	-	-
B.campestris var toria PT 303	-+	-	-	-	-	-+	-	-	-	-	-	-
B.campestris var yellow sarson	-+	-	-	-	-	-	-	-	-	-	-	-
B. campestris cv.TORCH	-	-	-	-	-	-	-	-	-	-	-	-
B. campestris cv.Tobin	-	-	-	-	-	-	-	-	-	-	-	-
B. carinata	-	-	-	-	-	-	-	-	-	-	-	-
B.juncea var Varuna	+	+	+	+	+	+	+	+	+	+	+	+
B. juncea cv. Domo	-	-	-	-	-	-	-	-	-	-	-	-
B.juncea cv. cutllas	-	-	-	-	-	-	-	-	-	-	-	-
B. juncea cv. MKU	-+	+	+	-+	-+	+	+	+	-+	+	-+	+
B. juncea cv. CBPPS	-+	-	-	-	-	-	-	-	-	-	+	-
B. napus PPNS	-	-	-	-	-	-	-	-	-	-	-	-
B. nigra	-	-	-	-	-	-	-	-	-	-	-	-
Camelina sativa	-	-	-	-	-	-	-	-	-	-	-	-
Raplanus sativuscv.COMMET	-	-	-	-	-	-	-	-	-	-	-	-
R. sativus cv. CHERRY BELLE	-	-	-	-	-	-	-	-	-	-	-	-

+ Indicates good symptom development
-+ Indicates traces infuction.
- Indicates absence or infection.

Among isolates of A. candida collected from B.campestris var toria

Only three isolates WRT_{10} WRT_{12} collected from B. campestris var toria from Pantnagar and Morena were obtained in pure form for pathogenicity studies. Collections received from other places did not reveal presence of viable and sufficient quantity of inoculum. Pathogenicity studies revealed that WRT_{10-12} isolates produced symptoms only on B. campestris var toria or on B. campestris var yellow sarson. None of the WRT_{10-12} isolates produced symptoms of Indian B. junceacv Varuna or MKU line or on Canadian B. juncea cv Domo and Cutlass. It was thus confirmed that WRT_{10-12} isolates did not infect Canadian B. campestris cv Tobin but the Pantnagar isolates WRT_{10-12} infected the other type of Canadian B. campestris cv Torch. This once again confirm our previous years results that A. candida isolates from B. campestris from India show specificity in its infectivity (Table 17).

Among isolates of A . candida from B. napus cv PPNS

As in 1989-90 and 1990-91, B. napus cv PPNS was found to get infected with white rust. The A. candida isolate thus obtained from infected leaves of B. napus cv PPNS in 1991-92 was designated as $WRGS_3$. The $WRGS_3$ showed cross infectivity between B. juncea cv Varuna and B. napus cv PPNS indicating thereby the isolate of B. napus PPNS is the pathotype of A. candida infecting B. juncea cv Varuna (Table 17).

Evaluation of greenhouse-cum-laboratory screening technique for staghead phase resistance based on last year results

Based on last year results, whole seedling inoculation technique are repeatable and could be used for screening for resistance to staghead phase of the disease. The technique consisted of using seeds of mustard (or toria) and germinating them on towel paper after surface sterilization at 25°C in an incubator and at 4 to 5 days after germination, the seedlings were picked-up gently with the help of a pair of forceps and the whole seedlings were dipped into the previously obtained Zoospore suspension for 18 h in a test tube kept at 15-20°C. The seedlings were then transferred to sterilized soil in pots for establishment at 20-25°C in greenhouse under diffused light conditions and observed for WR symptom development.

Table: 17 Reaction of differential host Brassica species against isolates of A. candida obtained from different geographical regions of India in 1991-92.

Cruciferous host species	White rust isolates from B. campestris var toria			White rust isolate from B. napus
	WRT_{10}	WRT_{11}	WRT_{12}	$WRGS_3$
B. alba	-	-	-	-
B. campestris var toria cv PT 303	+	+	+	-
B. campestris var Yellow sarson	+	+	+	-
B. campestris cv Torch	-+	-+	-	-
B. campestris cv Tobin	-	-	-	-
B. juncea cv Varuna	-	-	-	-
B. juncea cv Domo	-	-	-	-
B. juncea cv cutlass	-	-	-	-
B. juncea cv MKU	-	-	-+	-+
B. juncea cv CBPPS	-	-	-	-
B. napus	-	-	-	+
B. nigra	-	-	-	-
Camelina sativa	-	-	-	-
Raphanus sativus cv Commet	-	-	-	-
R. sativus cv cherry belle	-	-	-	-

Field inoculation technique for creation of artificial epiphytotic and assessment of resistance to staghead phase of white rust

Field inoculation technique (as described 1990-91) consisting of inoculating the test plants with Zoospore suspension at 30, 50, 70, 90 and 110 days after sowing was followed (total five inoculations) for screening for white rust resistance in the case of most promising lines. The technique was quite useful and it could be possible to screen the most promising genotypes to staghead phase of the disease under field conditions. Total five such repeated inoculations resulted in about 90 per cent success in the screening methodology. Thus our last year observation on field inoculation was confirmed. (Table 18)

Confirmation of resistance of some promising germplasm culturs

All the B. carinata entries i.e. HC 2,4,5, PPSC-1, B. napus entries viz. GSL-1, PR 86-31 (9) were found to possess very high degree of resistance to A. candida. Canadian B. juncea cv Domo and cutlass also showed resistance to WR. Some of the newly developed breeding lines were screened for resistance to WR as per the suggestion given by Dr. J.N. Sachan. Such entries and their reaction tow WR is given below in table. Three entries WR 9209 (Domo) WR 9201 and WR 9205 showed resistant type of reaction to WR. (Table 19)

Table18:Effect of whole seedling inoculation technique in the development of staghead phase of white rust of mustard and toria.

Mustard/Toria cultivars	Total number of seedlings inoculated	Number of plants showing systemic development of staghead phase	Infection (%)
Mustard cvs			
Kranti	25	23	92
Krishna	20	17	85
Varuna	25	21	84
Vardan	25	24	96
Rohini	25	22	88
Toria cvs			
PT 303	25	21	84
PT 30	20	18	90
T-9	20	16	80
M-27	30	26	86
RL-15	25	18	72

Table 19 Reaction of some promising breeding lines against WR.

Entry	Trial I		Trial II	
	R_1	R_2	R_1	R_2
	WR infection score on leaf			
Domo(resistant check)	0	0	0	0
WR 9201	2	2	1	2
WR 9203	3	5	3	5
WR 9204	2	3	3	3
PR 9205	2	2	2	2
WR 9206	5	5	5	5
WR 9207	2	4	2	3
WR 9208	3	4	4	4
WR 9209	0	0	0	0
WR 9210	5	5	5	5
WR 9211	4	4	4	3
Varuna (susceptible check)	5	5	5	5

0-1= highly resistant, 2= resistant 3 = moderate resistant 4 and 5 = susceptible/highly susceptible.

Project III Heterosis Breeding in Rapeseed (B. campestris)

A. Toria (B. campestris)

Project 1: Continue conversion of selected Indian and Canadian breeding materials into one or more CMS cytoplasm-genetic restorer system.

Tobin CMS A and B lines (100 and 80 seeds, respectively) received from Canada in March 1991 were sown at Pantnagar and few seeds were supplied to Project Coordinator(R&M), Haryana Agricultural University, Hisar. However, the germination was very poor, consequently one plant of Tobin and 3 plants B line were survived upto flowering.

The sterile plant of Tobin A was crossed with Tobin B to maintain the male sterility and with PT 303 for the transfer of male sterility in the genetic background of Indian material. At the same time male parents were maintained through sibbing.

Project 2: Preliminary field evaluation of new CMS systems previously developed or identified

Progenies of male sterile x male fertile sibs were grown. All the progenies segregated for male sterility with varying number of sterile plants ranging from 1-6 (Table 20) Male sterile plants have been crossed with their fertile sibs, and 30 germplasm lines. Besides, parents used as male were sibbed. The male sterile plants were also crossed with

Table 20: Male fertile and Male sterile plants in male x male fertile crosses during rabi 1991-92

S.N.	Male sterile x male fertile	Total plants	Male Ost Sterile	Male O Fert fertile
1.	1 Progenies	10	-	10
2.	2 "	20	-	20
3.	3 "	20	1	19
4.	4 "	24	5	19
5.	5 "	4	-	4
6.	6 "	30	2	28
7.	7 "	56	-	-
8.	8 "	15	1	14
9.	9 "	10	-	10
10.	10 "	71	6	65
11.	11 "	51	2	49
12.	12 "	30	3	27
13.	13 "	60	-	60
14.	14 "	27	2	25
15.	15 "	10	- 9	10

PT 303 to develop progeny for F_2 analysis of male sterility. Sufficient crossed seed have been obtained to raise F_1 and produce F_2 seeds.

Development of new CMS systems

The backcross progeny of an interspecific cross, Altex (B. napus) x PT 303 (B. campestris) was grown and backcrossed with PT 303. Sufficient BC_2 seeds have been obtained. Back crossing with PT 303 was also done with another interspecific cross i.e. HNS-6 x PT 303. However, crossing of PT 303 with the B. carinata x PT 303 did not produce any back cross seed. In addition F_2 seeds from an interspecific cross Olivia x PT-303 has also been obtained. MLS-31, a strain of toria crossed with Polima CMS during previous year was grown. The progeny was all sterile and plants were very vigourous but very high degree of female sterility was observed due to which back crossing with MLS-31 was not successful. However, a few open pollinated seeds has been obtained. Therefore, attempts were made to utilize Ogura CMS and five varieties of toria viz. PT 303, NDT 871, PT 885, PT 30 and Bhawani were crossed with Ogura CMS line.

Project 3: Complete preliminary assessment of combining ability of diverse germplasm, continue assessment of selected and newly available materials.

A set of B x B diallele crosses (28 F_1's), involving 8 diverse parents viz. Span and Tobin (Canadian cvs) and PT 303, PTB-1, Agrani, M-27, D-1 and T-9 (Indian cvs) and

Parents were sown in a complete randomized block design with 3 replications. However, due to poor germination and non-availability of competitive plants data could not be recorded. Further a set of 'line x tester' crosses involving 15 lines viz. GTCN-76, 79, 134, 182, 32, 38, 181, Agrani, TS-29, NDT-871, PT 30, PT 507, PT 9005 PT 8857 and B-3 and 3 testors (PT 303, T-9 and Bhawani) were attempted for assessing the combining ability of promising available material.

Project 4: Continue recurrent selection in one or more open pollinated B. campestris populations.

Two broad genetic based populations viz. early dwarf (RCP-90-1) and medium dwarf (RCP 90-2) synthesized during previous year were grown, in barrier isolation.

About 200 plants were selected and self pollinated through bud pollination (about 25 buds in each plant) in each populations. At maturity self as well as open pollinated seeds from each plant have been harvested separately. The bulk seed of original population has also been harvested.

Project 5: Continue research on value of synthetics vs open pollination cultivars in B. campestris

In order to develop the synthetic varieties of B. campestris var toria, development and evaluation of inbred lines is in progress. During the current year $52S_2$ progenies were grown 2 plants were bud pollinated in each progeny.

selfed seed from 23 plants has been obtained. Besides, selfing was attempted in open pollinated varieties and selfed seed from 19 plants have been collected.

B. Indian mustard (B. juncea)

Project 1: Maintenance of male sterility system

In order to exploit male sterility systems, in hybrid breeding progremme, their maintenance and multiplication is essential. Therefore, different CMS systems available in different genetic backgrounds were grown and multiplied by crossing male sterile (A) with corresponding maintainer (B) line.

System	Genotypes
Carinata CMS	RLM 198 A and B
Anand CMS	Pusa bold A and B
	Pusa Barani A and B
	Prakash A and B
	PCMS 10 A and B.
	PCMS 71 A and B
Ogura CMS	Ogura CMS and Norin 16 (maintainer
Polima CMS	Polima CMS and Bronowski (Maintainer)

Project 2: Identification of restorer lines

Two hundred and six crosses between male sterile line (RLM 198A) and different Indian mustard germplasm lines were grown to identify restorer line(s). However, none of the crosses yielded fertile progeny.

During the current crop season about 150 new crosses were made between carinata CMS (RLM 198A) and different Indian mustard germplasm lines(other than used previous year). Similarly, 100 new crosses between Anand CMS (Pusa barani A) and different Indian mustard germplasm lines were attempted.

Project 3 Transfer of male sterility in Kranti and Varuna

Efforts are under way to incorporate carinata CMS system in Agronomically superior, widely adopted and high yielding genetic backgrounds lines Kranti and Varuna is in progress. During the current season, 1st backcrossing with Kranti and Varuna was attempted.

(i) Evaluation of mustard hybrids

Significant differences were observed for seed yield and 1000 seed weight. In general low seed yield was evident from all the hybrids studies (Table 21). Highest yield was observed in MHC-2 (1254 kg/ha) followed by MHC-4 (1039 kg/ha).

Table 21. : Performance of mustard hybrid evaluated during rabi 1991-92

S. N.	Strains	Yield (kg/ha)	Maturity (days)	1000-seed weight(g)
1.	MHC-1	871	129	3.627
2.	MHC-2	125A	128	3.942
3.	MHC-3	958	126	4.207
4.	MHC-4	1039	128	3.807
5.	MHC-5	866	129	4.717
	General mean	998	126	4.060
	S.Em ±	88.594	0.786	0.221
	C.D. (at 5%)	253.35	NS	0.328
	C.V. (%)	17.159	1.231	10.932

Project 4: Quality Breeding

Rapeseed and mustard varieties grown in India generally contain a higher amount of erucic acid (30-60%) in oil and glucosinolates in seed meal. Therefore, research efforts are underway to evolve toria (B. campestris var toria) and Indian mustard (B. juncea (L) Czern & Coss) varieties with low erucic acid an in oil and/or low glucosinolates in seed meal.

A. Toria

Canadian cultivars Tobin and Parkland are being used as donor parents in the hybridization to evolve toria varieties with low erucic acid in oil and low glucosinolates in seed meal.

Three yellow seeds toria population viz. TPYS-12, TPYS-13 and TPYS-14 synthesized during previous year were grown in barrier isolation for the improvement in yield and its component characters.

A F_2 populations of cross PT 303 x Tobin was grown in barrier isolation for improvement in yield and yield components including oil content before analysing quality traits. In addition following F_1's were advanced to F_2.

1. Tobin x PYS 188
2. Candle x PYS 842
3. (Agrani x Span) x Parkland
4. (NDT 8502x PTB-29) x Tobin
5. (Agrani x Torch) x Tobin
6. (PT 507 x Torch) x Tobin
7. (NDT 8502 x PT 303) x Parkland
8. (T-9 x Span) x Parkland

Besides, following fresh crosses were made during current crop season.

1. T-9 x Tobin
2. T-9 x Parkland
3. PT 303 x Parkland
4. PT 30 x Parkland
5. PT 303 x Candle

A number of toria lines were screened for glucosinolate applying tes tape method and following lines were identified as promising containing low glucosinolate.

1. TCN-1
2. TCN-7
3. TCN-11
4. PTC-8
5. PTC-18

Promising toria lines and crosses which gave low and medium glucosinolate reaction in tes tape method, were further analysed for glucosinolates using glucose eassay method for confirming the results. The results are presented in Table 22. The results revealed that 17 strains and 6 crosses contain glucosinolate below 32 u mol/g fat free seed meal which is equals to the check Tobin.

Table 22 : Clucosinolate contents in promising strains and crosses of toria.

S. N.	Entries	Reaction for glucosinolates		
		Tes tape method	Clucose Assay method(concen -tration of u mol)	Total glucosinolate u mol/g
	Tobin (standard check)	L	2.00	32.0
1.	PT 889	M	0.37	6.0
2.	PT 888	M	0.50	8.0
3.	MSP 92-10	M	0.50	8.0
4.	PTQ 1	M	0.75	12.0
5.	PTC 24	M	1.00	16.0
6.	PTC 15	M	1.00	16.0
7.	PTC 7	M	1.00	16.0
8.	PT 884	L	1.00	16.0
9.	PTC 18	L	1.00	16.0
10.	MSP 92-13	M	1.00	16.0
11.	TCN 13	M	1.50	24.0
12.	MSP 92-18	M	1.50	24.0
13.	MSP 92-20	M	2.00	32.0
14.	TCN 5	M	2.00	32.0
15.	TCN 19	M	2.00	32.0
16.	PTC 6	M	2.00	32.0
17.	TCN 11	L	3.00	48.0
18.	TCN 2	M	3.00	48.0
19.	TCN 4	M	4.00	64.0
20.	TCN 1	M	4.00	64.0
21.	PTC 8	L	4.0	64.0
22.	PT 885	L	4.00	64.0
23.	PT 887	L	4.00	64.0
24.	MSP 92-14	M	4.00	64.0
25.	MSP 92-24	M	4.00	64.0

contd....

Table 22 continue

26.	MSP 92-14	M	4.00	84.0
27.	TCN 7	L	5.00	100.0
28.	TCN 14	M	5.00	100.0
29.	PT 883	L	5.00	100.0
30.	PT 8801	M	5.00	100.0
31.	MSP 92-23	M	5.00	100.0
32.	MSP 92-38	M	5.00	100.0
33.	PT 881	L	6.00	120.0
34.	MSP 92-19	M	6.00	120.0
35.	MSP 92-26	M	6.00	120.0
36.	MSP 92-7	M	8.00	128.0
38.	(Type 9 x Span) x Parkland	L	0.50	8.00
39.	(NDT 8502 x PT 303) x Parkland	L	1.00	16.0
40.	(Agrani x Torch) x Tobin	L	1.00	16.0
41.	(PT 507x Torch) x Tobin	L	2.00	32.0
42.	(NDT 8502 x PTB-29) x Tobin	L	2.00	32.0
43.	(Agrani x Span) x Parkland	L	2.00	32.0
44.	(PT 303 x Tobin)	L	3.00	48.0
45.	(D_1 x NDT 871) x Tobin	L	6.00	120.0

M = Medium L = Low

Following F_1's involving Tobin, Parkland, Candle, PT 303, PT 30 and T-9 were made to develop the set of P_1,P_2, F_1, F_2 and backrosees (BC_1 and BC_2) of these crosses during coming season to workout the inheritance of erucic acid and glucosinolate in toria.

1. T-9 x Parkland
2. T-9 x Tobin
3. PT 303 x Parkland
4. PT-30 x Parkland
5. PT-303 x Tobin
6. PT 303 x Candle

B. Mustard

Zero erucic mustard varieties viz. Zem-1 and Zem-2 are being used as donor parents for the development of mustard varieties with Zero/low erucic acid in oil. During the current season following F_1's were grown and advanced to F_2.

1. EX 175441 x Zem-1
2. EC 175433 x Zem-1
3. EC 175439 x Zem-1
4. EC 126745 x Zem-1
5. IB 718 x Zem-1

Six F_2 populations (listed below) were grown and 124 desirable plants were selected. Seeds of individual plants have been collected separately. Final selection of plant will be done after analysis for erucic acid using paper chramotography/gas liquid chramatography.

1. Kranti x Zem-1
2. Pusabold x Zem-1
3. Krishna x Zem-1
4. Pusabold x Zem-2
5. Zem-1 x PHR-1

Fifty eight progenies of F_3 and 28 of F_4 were grown. At maturity 285 desirable plants from F_3 and 139 from F_4 were selected and harvested separately. Final selection would be based an analysis of erucic acid using paper charamatography/ gas liquid chramatography. Besides, 14 fresh crosses (listed below) were made during the current season.

1. Pusa bold x Zem-1
2. Pusabold x Zem-2
3. NDR-8501 x Zem-1
4. Varuna x Zem-1
5. Varuna x Zem-2
6. Kranti x Zem-1
6. Kranti x Zem-2
8. PPMS-1 x Zem-1
9. PPMS-1 x Zem-2
10. PR-1108 x Zem-2
11. PR-1108 x Zem-1
12. Krishna x Zem-1
13. YRT-3 x Zem-2
13. NDR-8501 x Zem-2

A number of mustard varieties/lines were screened for glucosinolate content using test tape method and following lines were identified, desirable as these contain low glucosinolates.

MLS-2, MLS-11, MLS-14, MLS-19, MCN-10, PR-9001, PR-9024, MECN-17, MECN-6, MECN-11, MECN-1, MECN-2, MECN-7, MECN-4, MECN-8, MECN-12, and PR 8928.

Colorimetric estimation of glucosinolates and quantitative detection of erucic acid by paper chramatography could not be done due to want of DEAE sephadex A 25, Ion exchange columns and rubeanic acid which are not available in India. These chemicals have been received from Agriculture Canada Research Station in May 1992 and the standardization will be done after receiving the samples for glucosinolates.

Strain PR 8958 containing erucic acid 10.37% was encluded for yield performance in quality trait (B. juncea) under All India Coordinated Project on Oilseeds during 1991-92. The results are awaited. Besides early maturing and desirable plants from exotic lines viz. EC 287711, EC 287717, EC 287718, EC 287719 and EC 287720 were selected for further evaluation and selection.

A set of 7 x 7 diallele crosses involving Varuna, Kranti, Pusabold , PR 1108, NDR 8501, Zem-1 and Zem-2 Varieties/strains of mustard were made to workout the inheritance of erucic acid in mustard.

Paired rows of 23 strains containing higher oil content (more than 43%) were grown in 3 replications for evaluating the yield performance. The data are being presented in Table 23. Entry HOCN-6 (1149 kg/ha) yielded highest followed by HOCN-7 (1112 kg/ha) and HOCN-12 (1047 kg/ha). However, these differences were non-significant. The strains like HOCN-6, HOCN-24, HOCN-4, HOCN-3 and HOCN-25 were observed desirable with regards to 1000-seed weight. Since the entries are coded thus could not be compared with check.

Nine strains containing low erucic acid were evaluated for their performance in a randomized block design with 3 replications. The results are presented in Table 24. Significant differences among the strains were observed for seed yield (kg/ha), primary branches and 1000 seed weight. Since the entries are coded, thus comparison with checks could not be made.

Performance of exotic B. napus lines

Fifteen strains of B. napus and 2 check (B. juncea) were tested in a randomized block design with 3 replications. Significant differences were observed for days to maturity, yield, primary branches, secondary branches, seeds/siliqua and 1000 seed weight(Table25).

Highest yield was observed in strain MECN-10 (1368 kg/ha) followed by MECN-11 (1089 kg/ha), MECN-17(1087 kg/ha) and

Table 23: Performance of high oil content lines of mustard (B. juncea (L) Czern & Coss) during 1991-92.

Sl. No.	Strains	Days to maturity	Yield (kg/ha)	Primary branch (No.)	Secondary branch (No.)	Seeds per siliqua (No.)	1000-seed weight(g)
1.	HOCN-6	143	1149	5	7	12	4.59
2.	HOCN-7	146	1112	5	6	12	3.89
3.	HOCN-12	145	1047	5	8	12	3.80
4.	HOCN-22	142	918	5	8	12	3.38
5.	HOCN-13	144	914	4	6	12	3.53
6.	HOCN-8	146	880	5	4	11	3.87
7.	HOCN-15	149	850	5	7	11	2.93
8.	HOCN-17	145	840	5	7	10	3.36
9.	HOCN-10	143	790	4	6	12	3.68
10.	HOCN-11	147	774	4	2	12	3.61
11.	HOCN-2	144	742	4	6	12	3.77
12.	HOCN-23	144	699	4	6	13	3.36
13.	HOCN-20	143	682	4	6	11	3.82
14.	HOCN-19	145	682	4	6	11	4.21
15.	HOCN-9	149	655	5	7	11	3.37
16.	HOCN-21	145	634	4	6	11	3.34
17.	HOCN-5	143	552	4	4	11	5.37
18.	HOCN-18	149	520	13	2	9	3.36

Table 23 continued

S.N.	Strains	Days to maturity	Yield (kg/ha)	Primary branch (No.)	Secondary branch (No.)	Seeds per siliqua (No.)	1000-seeds weight(g)
19.	HOCN-	140	492	4	4	10	4.49
20.	HOCN-4	147	489	4	7	13	4.40
21.	HOCN-24	143	455	5	5	11	4.75
22.	HOCN-25	148	447	5	6	10	4.40
23.	HOCN-1	143	419	5	7	12	3.21
	C.D.(at 5%)	NS	70.905	1.128	3.199	1.714	0.402
	C.V.(%)	2.311	13.489	13.857	13.507	9.149	6.356

Table24: Performance of low erucic mustard (B. juncea (L) Czern & Coss) lines during 1991-92

Sl. No.	Strains	Days to maturity	Yield (kg/ha)	Primary branch (No.)	Secondary branch (No.)	Seeds per siliqua (No.)	1000-seeds weight(g)
1.	MECN-8	139	1094	5	5	13	3.40
2.	MECN-9	143	933	5	7	14	3.70
3.	MECN-2	136	760	5	6	13	3.27
4.	MECN-7	139	714	4	6	11	4.91
5.	MECN-1	133	711	5	10	13	3.06
6.	MECN-4	142	664	4	7	11	3.24
7.	MECN-3	132	655	5	8	14	3.20
8.	MECN-6	138	439	5	4	14	3.54
9.	MECN-5	140	383	5	8	14	3.57
	C.D.(at 5%)	NS	60.503	0.788	NS	NS	0.518
	C.V.(%)	3.313	13.553	9.517	6.645	8.610	8.445

Table25: Performance of exotic B. napus lines during 1991-92

S. No.	Strains	Days to maturity	Yield (kg/ha)	Primary branch (No.)	Secondary branch (No.)	Siliquae/ plant (No.)	Seeds/ siliqua (No.)	1000-seed weight(g)
MECN-								
1.	MECN-10	136	1368	4	7	234	12	3.74
2.	MECN-11	140	1089	4	6	171	11	4.50
3.	MECN-17	148	1087	6	1	162	16	3.09
4.	MECN-13	161	1061	6	1	137	20	2.78
5.	MECN-14	162	999	6	1	153	20	2.52
6.	MECN-9	153	900	6	1	138	18	2.94
7.	MECN-8	159	834	6	1	179	19	2.94
8.	MECN-12	163	831	4	1	147	22	2.60
9.	MECN-16	157	820	6	4	158	18	3.00
10.	MECN-15	155	808	6	3	185	22	3.16
11.	MECN- 7	149	783	3	1	173	19	3.74
12.	MECN-2	142	730	2	2	71	14	2.94
13.	MECN-1	148	729	3	1	83	18	3.79
14.	MECN-4	162	646	6	1	162	21	2.97
15.	MECN-3	142	637	3	1	65	17	3.34
16.	MECN-6	159	572	7	2	147	21	3.05
17.	MECN-5	164	477	6	1	147	21	2.89
C.D.(at 5%)		8.987	60.549	1.982	2.098	NS	4.080	0.439
C.V.(%)		3.534	11.960	13.794	7.969	12.457	13.560	8.302

MECN-13 (1061 kg/ha). The strain MECN-10 yielded significantly higher than MECN-11, MECN-17 and MECN-13.

The strain MECN-10 (136 days) took minimum time for maturity followed by MECN-11 (140 days). However, both the the strains did not differ significantly for maturity. Maximum test weight was found in strain MECN-11 (4.50g/1000-seeds) followed by MECN-1 (3.79 g/1000seeds). The comparison with check could not be done due to coding of strains.

B. TRAINING AND EXTENSION

1. Training of project staff

Dr. D.P.Pant, Junior Research Officer (Plant Breeding) and Dr. R.L.Singh, Asstt. Professor (Biochemistry) undertook inservice training for joint research studies on development of hybrid and quality breeding in development double low rapeseed at the Agriculture Canada Research Station, Saskatoon, Canada, in collaboration with Dr. R.K. Downey and Dr. D. I.MC Grogov at that station from June 29 to October 18, 1991. (Dr. R.L. Singh's stay was from June 29 to 18 September,1991).

2. Visits/ participation in conference(s)

Dr. S.J. Kolte, Senior Research Officer, Oilseeds Pathology, participated in eighth GCIRC International Rapeseed Congress held at the University of Saskatchewan, Saskatoon, Canada on July 9 to 11, 1991. Drs. D.P.Pant and R.L. Singh and Dr. Basudeo Singh (on leave) also participated in the conference.

3. IDRC Project Review Meeting/ Network Meeting

Dr. Basudeo Singh (on leave), Drs. S.J. Kolte, D.P.Pant and R.L. Singh attended IDRC Project Review Meeting on July 5 and IDRC Oilseed Crops Network Meeting on July 6, at the Agriculture Research Station, Saskatoon, Canada. In the project review meeting, progress of work was discussed and some additional requirement in terms of facilities etc. were finalized.

4. Publications

1. Sachan, J.N., Kolte, S.J. and Singh Basudeo (1992). Inheritance of resistance to white rust race 2 in Indian mustard (B. juncea (L.) Czern & Coss) (under preparation).

2. Sachan, J.N.,Singh Basudeo and Khan R.A.(1992). Selection criteria for selecting downy mildew resistant genotypes of mustard (B. juncea (L.) Czern & Coss) (under preparation).

3. Sachan, J.N. and Rana Debashish 1992. Comparative performance of Indian and Exotic genotypes of different Brassica species (under preparation).

4. Kolte, S.J.'Diseases' In Oilseed Brassicas in Indian Agriculture. V.L. Chopra and Shyam Prakash (Eds.) Vikas Publishing House Comp. New Delhi, 1991, Chapter 8.

5. Awasthi, R.P. and Kolte, S.J. 1991. Establishing coreletions between plant height and Alternaria infection on rapeseed-mustard. Indian phytopath. (Abstr.).(in press).

6. Singh, D. and S.J. Kolte, 1991. Variability in Albugo candida affecting rapeseed-mustard in India. Indian phytopath.(in press).

7. Kolte, S.J., D.K. Bordoloi and R.P. Awasthi. 1991. The research for resistance to major diseases of rapeseed-mustard. Proceedings GCIRC 8th Int. Rapeseed Congress Vol. 1; 219-225.

8. Khan, S.J. and S.J. Kolte. 1991. Seedling disease problem in rapeseed-mustard. Indian J. Mycol Plant Pathol. (communicated).

9. Bordoloi, D.K. and S.J. Kolte, 1991. Antigenic disparity amorg isolates tof Albugo candida. Indian phytopath (communicated).

C. CONSULTANCIES

(i) Consultancies received

No Consultancies received during the 1 year 1991-92.

(ii) Consultancies offered

Nil. (directly related to project)

D. ADMINISTRATIVE ACTIVITIES

(i) Organizational aspects

The project is primarily on improvement of rapeseed-mustard with a view to breed for Alternaria blight and white rust resistant varieties and to develop double low (low glucosinolate and low erucic acid type) cultivars. Hence, only two disciplines i.e. Breeding and Pathology disciplines are involved in implementation of the project as per the sanction letter from ICAR F. No. 8(16) 87/OS dated 21-8-1989. The scientific personnels under All India Coordinated Project on Oilseeds are involved in the actual work without any additional staff under the project except that appointment of one Research Fellow. The appointment of Research Fellow, Mr. Dalganjan Singh, was made w.e.f. 23 July,1990. However, Dr. Dalganjan has now resigned and the post is vacant since April 10,1992. Thus the SRF post will be required to be filled up in order to facilitate the working of the project.

a. Equipment purchases

Equipment purchased under ICAR- administrated funds in 1989-90 and 1990-91 are given below:

Equipment purchased in 1989-90

S.N	Item	Quantity	Sanctioned cost(Rs)	Actual cost(Rs)	Unspent balance(Rs)
1.	Refrigerator	1	9700.00	7037.00	+ 2665.00
2.	Mist chamber	1	8730.00	6247.50	+ 2482.50
3.	Back-pack sprayers	4	5820.00	3120.00	+ 2700.00
	Equipment purchased in 1990-91				
1.	Incubating room	1	77,600.00	99,543.00	-21,943.00
2.	Generator	1	48,500.00	51,120.00	- 2620.00
3.	Soil shaker (Quality Breeding)	1	7760.00	7644.00	+ 116.00

Note: The construction of incubation room is in progress. All the civil work including insulation, false ceilling is completed. Internal electrification work is in progress. It is expected that by August end the incubating room will be in order to use it for actual experimentation.

b. Equipment received out of centre (IDRC)- administrated funds upto Sept. 1990

White rust Alternaria project

	Item	Quantity
1.	Deep Freezer (Chest-Freezer)	1
2.	Low temperature Incubator(Lab. like)	1
3.	Centrifuge (mega fuge with complete set and accessories)	1
4.	Rotary shaker (shaker orbit junior with complete accessories) with 5 clamps in access	1
5.	Ependorff pipettes	4
6.	Research microscope (Olympus with complete accessories)	1
7.	Humidifier misting	4

Quality Breeding

1.	Spectronic spectrophotometer -501	1
2.	Seed grinder (Raney oilseed crusher, lacking with one hex ball driver)	1
3.	Paper chromotographic apparatus	1
4.	Vortex mixture	1
5.	Ependorff pipettes	1

C, Equipment yet to be received from centre (IDRC) administrated funds

White rust-Alternaria project

1.	Lights for incubating room (total cost $ 2000)	1
2.	Haemocytometer counting chamber cover glass (20 x 26 mm)	2 pks
3.	Autoclave (CAD $ 4000/-)	1

Quality Breeding

1.	GLC with Integrator	1
2.	Ependorff pipette	1

d. Additional equipment agreed upon during IDRC- Project review meeting held at Saskatoon on July 5,1991

Equipment	Quantity	Amount(Rs.)
1. Desert Cooler	1	5000.00
2. Exhaust Fan	1	3500000
3. Haemocytometer	1	6000.00
4. Fume Hood	1	30,000.00
5. Air Conditioner	1	30,000.00
6. Stabilizers (electircal	5 (1kv) 4 (0.5 kv) 1 (2.5 kv)	12,700.00
	Total	87,200.00

Additional funds

	Budgeted amount	Additional amount required
1. Incubating Room	77,600.00	18,600.00
2. Field sprinklers	29,100.00	20,900.00
	Total	39,500.00

Grand total : 87,000.00 + 39,500.00 = 1,26,700.00

IV OUTSTANDING RESULTS

BREEDING

Research efforts are underway to develop Alternaria resistant/tolerant varieties of Indian mustard using RC 781 PHR-1 and PHR-2 as donor parent. Two advance lines, PR 8925 and PR 9006, rated as resistant during previous year, are under multilocation testing. In a yield trial conducted at Pantnagar, PR 8925(925kg/ha) yielded higher than the best check, Varuna (773 kg/ha) and was significantly superior in test weight. Eleven F_2 populations and 94 F_3 progenies involving above sources were grown in field and disease pressure was developed by spraying disease inoculum at leaf and pod stages. All the entries showed susceptible reaction at leaf stage. However, variation in the disease reaction was observed at pod stage. Two hundred and twenty desirable plants with less disease were selected from F_2 populations. Similarly, 145 individual plants and 2 lines (PAB 9211 and PAB 9213) were selected from F_3 progenies. These lines have been included in National Screening Nursary (Alternaria blight) for multilocation testing. Besides, $7F_1$'s were advanced to F_2 and 5 fresh crosses were made.

In order to concentrate the genes for Alternaria blight resistance, the available sources, RC 781, PHR-1, PHR-2, PR 8925 and PR 9006, were intercrossed in a diallel fashion.

Backcross approach is being followed for the transfer of white rust resistant genes from SW 83-4302 to PT 303 and PT 30, (cultivars of toria) and from Domo and Cutlass to Kranti and Varuna (cultivars of Indian mustard). During the year under report, I and II backcrossing in toria and mustard, respectively, was done. Twelve advance lines of mustard were tested for white rust under artificial epiphytotic conditions.in glass house. WR 9201 and WR 9205 with score 2 in the scale of 0-5 were observed as moderately resistant. These have been included in National Screening Nursery (white rust) for multilocation testing PR 8998 and PR 9021 which showed mean disease index (in last 2 years) 10.35 and 10.33 percent, respectively are being evaluated for disease reaction in multilocation trials under All India Coordinated project on Oilseeds. Six populations and 128 F_3 progenies involving identified donors (YRT-3, Domo, Cutlass) were grown in field and artificial epiphytotic conditions were created by spraying spore suspension at leaf stage. Resistant plants were tagged at leaf stage and final selection was made at maturity. One hundred and forty individual plants from F_2 and 186 from F_3 were selected. Besides, 10 fresh crosses were made and 8 F_1's were advanced to F_2.

Inheritance of resistance to white rust, Albugo candida race 2 was studied in Indian mustard. The results revealed

New male sterile source, Tobin CMS A (Diplotaxis muralis) and its maintainer (Tobin B) received from Canada, were sown in field. However, only one plant of Tobin A and 3 plants of Tobin B were germinated. Male sterile plant was crossed with Tobin B to maintain the male sterility, and with PT 303 for transfering in Indian genetic background. In order to creat new male sterility sources, the progenies of $2F_1$'s of interspecific crosses, HNS-6 x PT 303 and B. carinata x PT 303 and one backcross, B. napus x PT 303, were grown and backcrossed with their recurrent parent, PT 303. Besides, other interspecific crosses were also attempted.

Fifty two S_2 progenies were grown and bud pollination was attempted. The selfed seed from 23 plants has been obtained. Selfing attempted in 10 open pollinated populations, yielded selfseed from 19 plants. Recurrent selection in 2 populations (RCP 90-1 and RCP 90-2) was also practiced.

In Indian mustard, different male sterility systems, B. tournefortii (RLM 198A & B; Pusa bold A &B), B. carinata (PCMS 10 A &B and PCMS 71 A & B), Polima and Ogura were maintained for their use in hybrid programme. Two hundred and six crosses between RLM 198A and Indian mustard germplasm made during rabi 1990-91 were grown to identify restorer line(s). However, none of the crosses yielded fertile progeny.

Further, more than 150 male sterile x male fertile crosses involving above male sterility sources and mustard germplasm were made to search restorer line(s). Back crossing with Kranti and Varuna was attempted in male sterile x Kranti and male sterile x Varuna crosses to transfer male sterility in these back ground.

In quality breeding Canadian Cultivars Tobin and Parkland are being used as donor for the development of double low varieties of toria and Zem-1 and Zem-2 in mustard for the development of low erucic mustard varieties.

In toria, a population (PT 303 x Tobin) is being improved for yield before being analysed for quality characters. Besides, 8 F_1's were advanced to F_2 and 5 new fresh crosses were made.

In addition 3 yellow seeded population are bing improved for yield and its component characters. A number of toria lines were screened for glucosinolate content through test tape method and TCN-1, TCN-7, TCN-11 PTC-8 and PTC-18 were identified promising as they contain low glucosinolate.

In mustard, a promising strain Viz. PR 8958 (containing 10.37% erucic acid in oil) was evaluated for yield performance in quality trial under AICAPPO. The results are awaited. Besides, early maturing and desirable plants have been selected for quality analysis from exotic juncea lines. During the

season $5F_1$'s were advanced to F_2. Six F_2 populations, $58F_3$ progenies and 28 F_4 progenies were grown. At maturity 124 desirable plants from F_2, 285 plants from F_3 and 139 plants from F_4 were selected and harvested separately. Final selection would be based on analysis of erucic acid using paper chramatography/GLC. Besides, 14 fresh crosses were made during current season.

A number of mustard varieties/lines were screened for glucosinolate content using test tap method and following lines were identified desirable as these contain low glucosinolate- MLS-2, MLS-11, MLS-14, MLS-19, MCN-10, PR 9001, PR 9024 MECN-17, MECN-6, MECN-11, MECN-1, MECN-2, MECN-7, MECN-4, MECN-8, MECN-12 and PR 8928.

IV. OUTSTANDING RESULTS

Pathological Studies

During 1991-92, laboratory and greenhouse experiments were continued to determine variability in A. brassicae. Total 154 isolates were obtained out of which only 22 isolates from Uttar Pradesh, Haryana, Madhya Pradesh, Rajasthan and Bihar could be obtained in pure form and 20 such isolates were identified to be A. brassicae and two were of A. alternata. Out of the 20 A. brassicae isolates, 9 were identified to be A. brassicae isolates (race) 'A' five belonged to A. brassicae isolate 'C' and the remaining six isolates were identified as A. brassicae 'D'. Pathogenicity studies using five B. juncea cvs PHR-1, PHR-2, Kanpur local PPMS-1 and PR-18, and B. carinata cv PPSC -1 and B. napus cv PPNS revealed differences in infectivity among the twenty isolates of A. brassicae. The A. brassicae isolate obtained from B. alba showed the least virulence as compared to the A. brassicae isolates obtained from B. juncea.

The three isolates of A. brassicae i.e. the A,C and D isolates also showed differences in their infecting when inoculated on detached pods of 12 different brassicae species.

The results revealed interactions involving(1) A. brassicae isolates x B. campestris ssp rapifera; (2) A. brassicae x B. alba; (3) A. brassicae x Camelina sativa; and (4) A. brassicae x B. carinata gave resistant type of reaction charactized by development of a few small-sized lesions with grey centre and brown margin. The interaction

between B. campestris var toria x A. brassicae isolate A always showed susceipible type of lesions characterized by white to grey centre with high sporulating characteristics. Thus corelations among different components of resistance were established using nine cruciferous host species differing in their reaction to A.brassicae. Number of Alternaria spots on stem was found to be positively correlated with field disease score (r= 0.814), per cent siliqua infection (r=0.939), percent defoliation (r = 0.833) and size of spots (r =0.732). Similarly number of spots on siliqua was also positively correlated with field disease score (r= 0.816), disease index (r= 0.871) and size of spots on leaves (r = 0.774).

An interspecific cross between B. carinata line DBO 54 x B. napus cv Oliva resulted in identification of one viable typical plant type possessing resistance to Alternaria blight and white rust diseases. Attempts to stablize this plant type are in progress.

A newly developed early dwarf compact plant type mustard (B. juncea) named as 'PPMS-1' (Divya) mustard maturing in 100 days showed significantly less AB disease index both on leaf and pods as compared to toria cv PT 303 in the 15-25th October planting giving significantly higher seed yeild in the range of 10-12q/ha as compared to 8-11 q/ha of toria cv PT 303 in about the same maturing period of 100-105 days as compared to 12 q/ha yield in the case of mustard cv 'PR-18'

in 32 days. The results thus indicated potential superiority of mustard 'PPMS-1' over toria 'PT 303(and mustard cv 'PR-18' in terms of yield per unit area and time. Mustard 'PPMS-1' yielded maximum in 20 cm row spacings as compared to 15, 30, 40 cm row spacings, though the differences in yield due to spacings were insignificant. The late planted crop sown between 25 Nov.- Dec. 5 severe infection of white rust and downey mildew in all the three isolates, crops.

Total 12 A. candida isolates WRM 28-WRM-39 obtained from B. juncea from five different states. As in the last year, all these mustard isolates were mainly pathogenic to Indian B. juncea cv Varuna and MKU but not to the canadian B. juncea cvs Domo and cutlass. This is thus confirmation of our previous year result that B. juncea cv Domo is resistant to all A. Candida isolates in India. Similar is the case with another Canadian B. juncea cv cutlass. The WRM 28 isolate (like WRM 13 isolate in 1990-91) of A. candida from Pantnagar was found to be more virulent as it caused infection not only one B. juncea cv Varuna but also on B. alba B. campestris var toria. The WRM 33 isolate from Morena also showed infection both on B. juncea and B. campestris var toria cv PT 303. This suggests, like previous years observations, that in Morena and Pantnagar areas isolates of A. candida exist which can cause infection both on toria and mustard. The WRGS 3 isolate from B. napus was found to be a pathogype of A. candida primarily infecting B. juncea.

Different pustule types, as in the previous year, were observed on different host plants. The pin-head size pustules, small circular smooth to raised pustule, broad circular discontinuous ring type pustules and necrotic lesion type pustules were observed among different samples obtained from different areas.

Among six different screening techniques studied in the laboratoryonly whole seedling inoculation technique was more reliable and convincing. This method was tried for screening for resistance in the laboratory, whereas a field inoculation screening technique was further successfully used for development of staghead infections.

Among the genotypes screened for resistance to white rust, exotic B. juncea sources such as BEC 107, 108,111, B.carinata PPSC 1, Jem 1 and Jem 2 were found to be resistant to white rust. Canadian B. campestris cv Tobin was found to be resistant to A. candida isolates in India. But Indian B. campestris cv Torch was found to be susceptible to a few isolates of A. candida from Pantnagar.

IV. PROJECTIONS

Technical Programme for the year 1992-93 (Breeding)

Project 1: Management of Alternaria blight

1. Growing of segregating generations and advance lines in the field under artificial epiphytotic conditions and selection of promising, resistant/tolerant plants/lines.

2. Evaluation of advance lines under epiphytotic conditions in glass house.

3. Advancing of F_1's to F_2.

4. Field evaluation of advance lines alongwith adopted varieties for yield and other important agronomical characters.

5. Fresh crosses involving new strains/varieties of mustard and identified sources would be made.

6. Development of set of crosses for the study of Alternaria blight resistance.

7. Multiple crosses among the intercrosses(crosses among the resistant sources made during 1991-92) would be made to concentrate the genes for Alternaria resistance.

Project 2: Management of white rust

1. Advancing of F_1 crosses of toria and mustard to F_2.

2. Growing of segregating generation of toria and mustard and selected plant progenies under artificial epiphytotic conditions in the field and further selection of resistant plants.

3. Evaluation of advance lines for white rust reacton under field and glass house conditions, by creating artificial epiphytotic conditions.

4. Yield evaluation of promising lines and selection.

5. Making of fresh crosses between resistant sources and new promising strains/varieties of toria andmustard.

6. Further back-crossing in toria and mustard backcrosses.

7. Study of disease reaction in F_1, F_2 and backcrosses of toria.

8. Screening of toria and mustard lines for downy mildew (staghead formation) under late sown conditions.

Project 3: Heterosis breeding

1. Maintenance of Diplotoxis male sterility system (in cultivar Tobin'A') thorugh crossing with Tobin 'B' and sibbing in Tobin 'B'.

2. Transfer of Diplotaxis cytoplasm from Tobin 'A' to PT 303 through backcrossing (BC_1).

3. Search of maintainer for the male sterility source available at Pantnagar by critical observation in male sterile x male fertile progenies.

4. Further back crossing with toria parents in in back crosse progenies derived through interspecific crosses followed by back crossing with toria. Initiate back crossing in fresh interspecific crosses.

5. Back crossing in Ogura CMS into toria varieties to develop new source of male sterility.

6. Bud pollination in S_1 and S_2 and new populations for the development of inbred lines.

7. Assessment of combining ability by evaluating a set of crosses involving 15 lines and 3 testors.

8. In order to continue recurrent selection in 2 populations, second cycle of selection would be practiced.

9. Fresh interspecific crossing and crossing of toria material with other male sterility sources would be done to develop new male sterility sources.

10. Evaluation of mustard hybrids developed at different centres of the country.

11. Identification of restorer line(s) from male sterile x male fertile crosses in mustard made during 1991-92.

12. Second back crossing in back cross progenies for transferring male sterility in Kranti and Varuna background.

13. Identification of maintainer and restorer line(s) for Polima and Ogura CMS systems.

Project 4 Quality Breeding

1. Yield evaluation promising selections made from exotic lines, entries contributed by different centres and exotic quality lines/varieties of toria, mustard and B. napus under new seed policy.

2. Advancing of F_1 to F_2.

3. Growing of segregating generations and selections based on quality characters.

4. Making of fresh crosses of toria and mustard involving identified sources and new high yielding varieties/strains.

5. Large scale screening of toria andmustard breeding material for low erucic acid and using paper chromatography would be done for low glucosinolate large scale screening of breeding material wiould be done by using test tape method.

6. Toria and mustard line identified for low erucic acid through paper chromatography and toria lines for low glucosinolate would be analysed for x respective quality character(s) by gas liquid chramatography.

V. PROJECTIONS

Technical programme for the year 1992-93 (Pathology)

Project-1 Management of Alternaria blight

PATHOLOGICAL ASPECTS

1. Cataloguing of A. brassicae isolates/races occuring in different geographical regions of India

Considering the results of the work done during 1990-91 and 1991-92, intensification of work in relation to identification of A. brassicae races in different rapeseed-mustard growing states will be continued. A. brassicae isolates will be categorized depending on their pathogenicity and morphology. Several differential hosts such as B.alba , B. campestris var rapifera, B. campestris var yellow sarson, B. campestris var brown sarson, B. campestris var toria , B. carinata cv PPSC$_1$ cv HC$_1$, B. juncea cvs Varuna, PHR$_1$, Pant ornam rai, PR-781, exotic, B. napus cv EA, B. napus cv HNS 3, regent, camelina sativa and Raphanus sativa and B. carinata x B. napus (ABCC) genone will be used.

2. Evaluation and establishmentof correlation between different inoculation techniques for efficient screening of resistance

The correlation coefficients for determining the relationship among the components of resistance will be established. Relationship between leaf and pod inoculation technique will be studied in relation to what should exactly be happening under field conditions for assessment of resistance of different genotypes. More new genotypes will be included in this study.

3. Evaluation of germplasm

Any such new material, as rapeseed-mustard germplasm will be screened under field and galsshouse conditions with reference to prevalence of most predominant A. brassicae isolate. Newly generated breeding lines segregating material will be particularly more important in this study.

4. Standardization of the new rating scale for assessment of AB resistance in rapeseed-mustard.

As seen in 1990-91, some selected differential hosts will be used in determining the reaction of the host to pathogen and help in standardization of new sating scale based on the lesion type etc. Relationship between lesion type and defoliation etc. reflecting in yield etc. will be studied. Such a scale will be useful in inheritance studies of resistance.

5. Studies on mechanism of resistance

Beaides studying biochemical an morphological basis of resistance of Brassica oilcrop species, studies on correlation among components of resistance will be done. The lesion type size and colour of the lesion perhaps help in determining resistance. Correlation among these components will be worked out.

6. Studies on genetics of AB resistance

Moderately resistant x susceptible parents were crossed and the segregating population was screened for resistance to AB. This will be continued with a view to determining the genetics of resistance to AB.

7. Crosses, back-crosses and segregating lines will be advanced, and tested for resistance to both leaf and pod infection.

8. Resistant selections and homogeneous lines will be tested for superior performance across locations as part of the regular testing programme in India.

The stability performance of newly developed early dwarf mustard "PPMS-1" will be compared with toria varieties as was done in 1991-92 on all India basis. Similarly the performance of this material will be compared with mustard varieties under normal sown conditions in different agroclimatic zones of India.

Project 2: Management of white rust

1. Cataloguing of A. candida races in different geographical regions of India

As in the previous years, leaves or racemes affected with white rust will be obtained from different areas and isolates will be obtained as single pustule generation fro for inoculation of differential hosts.

2. Identification of different infection types and standerdization of rating scale for white rust resistance

As reported in 1990-91, different pustules types viz. pinhead pustule type, smooth raised pustule type, broad circular discontinuous ring type and necrotic lesion type are seen on different genotypes. The would could not be done

in 1991-92 season and hence it will be taken up in 1992-93. Such a scale could be useful in determining inheritance resistance to white rust particularly on the basis of true-leaf infection. Similarly, there is need to standardize rating scale on the basis of staghead phase of white rust infection. Attempts will be made to standardize staghead infection scale.

3. Evaluation of newer germplasm for resistance to white rust

As we have now standardize the field inoculation technique after field screening and whole seedling inoculation technique for evaluation of resistance, these techniques will be used for evaluation of newer germplasm and breeding material for resistance to white rust.

4. Study of correlations mamong components of resistance to white rust

Ten total cruciferous host crop species differenting in reaction to white rust will be selected and correlations among components of resistance. e.e. pustules size, no of pustules/leaf, pustule type, incubation period intersity of sporulation etc will be studied. Such a study should help in selecting for resistance in a more efficient manner.

5. Studies on inheritance of white rust resistance

This will be continued, as in 1991-92 in collaboration with Dr. J.N. Sachan.

6. Inter cross between alternaria and white rust resistant sources and adapted lines will be made. This is necessary for the development of improved cultivars possessing multiple disease resistance.

Financial report for the period from April 1,1991- March 1992

Items	Year I (1989-90)			Year II(1990-91)			Year III (1991-92)		
	Budget	Actual Expenses	Variance	Budget	Actual Expense	Variance	Budget	Actual Expenses	Variance
Salaries									
Research Fellow(1)	20,000.00	Nil	20,000.00	20,000.00	9,098.35	10,951.65	20,000.00	16,548.00	+ 3,452.00
Research Expenses									
Casual labour printing & Stationery Field supplies,local travel, small tool& implements workshops	55,000.00	10,111.15	44,888.85	55,000.00	49,764.70	5,235.30	55,000.00	67671.00	-12671.00
Non-recurring									
	1,94,000.00	16,402.50	1,77,597.50	1,77,597.50	154,464.00	23,133.50	23,133,00	5,112.00	+18,021.00

Estimate for next year i.e. IV (1992-93)

	Budget requirement
1. Salaries(RF)	20,000.00
2. Contincency(as per sanctioned	55,000.00
3. Additional requirement	55,000.00
Total	1,30,000.00

SUBMITTED BY

PROJECT LEADER

Dy. COMPTROLLER
EXPERIMENT STATION

G. B. Pant Univ. of Agric. & Technology
PANTNAGAR (Nainital)

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