ANNUAL PROGRESS REPORT

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Department of Plant Pathology

College of Agriculture

Chaudhary Sarwan Kumar

Himachal Pradesh Krishi Vishvavidyalaya

PALAMPUR-176062 (HP)

ACKNOWLEDGEMENT

The 32nd Annual Progress Report of the department has been brought out with the co-operation of the professors/ scientists/ extension specialists deployed/ placed in the department, different Research and Extension Centers, Research-substations and Krishi Vigyan Kendras of the university located at different regions of the state. I express my appreciation to all of them. I am especially thankful to the committee comprising of Dr P N Sharma (Chairman), Dr B R. Thakur, Dr A K Sud, Dr Amar Singh and Dr Suman Kumar for editing and compilation of the report.

I express my deep sense of gratitude to the honorable Vice-Chancellor for the motivation and encouragement rendered to the scientists of the department. The sincere advice and guidance provided by Director of Research, Dean Post Graduate Studies, Dean College of Agriculture, and Director of Extension Education in the spheres of research, teaching and extension education is duly acknowledged.

I am grateful to the faculty members of the department for their necessary help and scientific co-operation whenever required. My thanks are also due for the staff of the department for their co-operation in printing/ photo stating and binding of the report.

Head of the Department

CONTENTS

INTRODUCTION

The Department of Plant Pathology has the mandate of teaching, research and extension education pertaining to plant diseases and mushrooms. Scientists work in different areas of specialization and the students admitted to M Sc and Ph D programmes are assigned research problems on different aspects of diseases of cereals, pulses, oilseeds and vegetable crops including mushrooms.

The research work in various projects is being carried out in the main department at Palampur, Hill Agriculture Research & Extension Centres (Bajaura, Dhaulakuan and Kukumseri), Mountain Agriculture Research & Extension Centre (Sangla), Shivalik Agriculture Research & Extension Centre (Kangra), Rice & Wheat Research Centre (Malan) and Research Stations (Berthin and Akrot). Research on wheat diseases is carried out at Malan, Dhaulakuan and Bajaura, on rice diseases exclusively at Malan and on maize diseases at Bajaura and Dhaulakuan, whereas, the research on diseases of pulses is carried out at Palampur, Sangla, Berthin and Dhaulakuan and on oilseed crops at Kangra and Palampur. Among the diseases of vegetable crops, bacterial wilt and canker, late blight and fruit rots of solanaceous crops; powdery mildew, white rot and root rot/wilt complex diseases of peas; fungal, bacterial and viral diseases of French bean and Phomopsis leaf blight & fruit rot of brinjal receive special attention.

The department also carries out research on different aspects of mushroom cultivation. The spawn laboratory at present is meeting the demand of Horticulture Department and private mushroom growers. Teachers/scientists/students of the department are actively participating in the various seminars and symposia conducted by different scientific societies from time to time.

Several *ad-hoc* research projects are being carried out in the department with financial support from different agencies viz., Government of Himachal Pradesh, ICAR, CSIR, DST, DBT and fungicide companies.

The department is engaged in various extension education activities such as advisory service to farmers for diagnosis and management of diseases, conducting on farm trials & field demonstrations, participation in district/ state level workshops/ seminars/ field days/ kisan melas and on & off campus trainings etc. The scientists of the department are also actively involved in training and disseminating mushroom cultivation technology to the mushroom growers.

STAFF POSITION

Position/ Designation	Name	E-mail
Department of Plant Pathology, Palampur - 176062		
Professor & Head	Dr S K Rana	skrana62@gmail.com
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Scientist	Vacant	-
Research Sub-Station, Lari - 172113		
Scientist	Vacant	-
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Krishi Vigyan Kendra, Una		
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FINANCIAL OUTLAY AND STAFF POSITION IN DIFFERENT SCHEMES OF THE DEPARTMENT

Name of the Scheme	Expenditure (Lac Rs.)	Staff
APL-001-17 "Creation of facilities for Postgraduate Studies in the Department of Plant Pathology", CSK HPKV, Palampur	29.29	Dr. A.K. Basandrai (Dean, PGS) Sh. Harbans Lal, Senior Assistant (Biotechnology) Sh. Shakti Chand, Junior Technician (COBS)
APL-010-17 "Facilities for teaching in the College of Agriculture and creation of facilities for Postgraduate Studies" in the Plant Pathology, CSK HPKV, Palampur	90.27	Dr. S. Dhancholia, Professor Dr. S. K. Rana, Principal Scientist Dr. A. K. Sud, Principal Extension Specialist Sh. Vijay Kumar, Chowkidar (Security Cell) Sh. Ravi Kumar, Senior Assistant
APL-21-17 "Strengthening of facilities for research of Plant Pathology" CSK HPKV, Palampur	32.15	Sh. Ramesh Kumar, Beldar Sh. Dalip Kumar, Beldar Sh. Desh Raj, Beldar Sh. Rattan Chand, Beldar
APL-59-17 "Facilities for research in the department of Plant Pathology" CSK HPKV, Palampur	4.97	Sh. Subhash Chand, Beldar
ICAR-017-17 Pt.-II" All India Coordinated Research Project on Seed Technology Research" under NSP	50.17	Dr. P. N. Sharma, Professor &Head Sh Anil Kumar (TAG-I) Dean COVAS Sh Atul Kumar- Agri Biotech

FINANCIAL OUTLAY OF AD HOC PROJECTS FOR THE YEAR 2017-18

Project No. & Funding Agency	Name of the Scheme & Duration	Allocation Rs. Lakh	Expdt Rs. Lakh	Staff
GOI Ad - hoc Misc 5023-17 (UGC)	Molecular Characterization of *Pepper Mild Mottle Virus PMMoV*) and its Management through host Resistance 2016-19	13.85	4,85637	Dr P N Sharma (PI) Dr S K Sharma (CoPI) Ms Nidhi Kumari (PF)
GOI Ad - hoc Misc 5022-17 (DBT)	Fine mapping of *Co-Ind* gene in common bean land race KRC5 possessing resistance to different races of *Colletotrichum lindemuthianum* 2016-19	49.38	13,68783	Dr P N Sharma (PI) Dr Anju Pathania Dr R Rathore Dr S K Sharma Ms Prakriti Kashap (JRF) Dr. Vivek Sharma (RA)
Misc 626-17 Pesticide Companies	Fungicides testing – New molecules/ brands under testing (2001- Cont.)	30.00	7,79548	Dr D K Banyal (PI)

COURSES TAUGHT (2017-18)

Ist Semester

Sr.No.	Course No.	Course Title	Cr. Hrs.	Name of Teacher
UG				
1	Pl Path 233 (O)	Diseases of Field Crops and their Management	2+1	Dr Suman Kumar
2	Pl Path 364(O)	Diseases of Horticultural Crops and their Management	2+1	Dr A K Basandrai
3	Experiential Learning	Mushroom Cultivation	0+10	Dr S Dhancholia Dr A K Sud
PG				
1	Pl Path 501	Mycology	2+1	Dr S Dhancholia
2	Pl Path 502	Plant Virology	2+1	Dr Anand Singh Dr P N Sharma
3	Pl Path 504	Principles of Plant Pathology	3+0	Dr B R Thakur
4	Pl Path 505	Detection and Diagnosis of Plant Diseases	0+2	Dr S K Rana
5	Pl Path 518	Epidemiology and Forecasting of Plant Diseases	2+1	Dr D K Banyal
6	Pl Path 591/ 691	Seminar	0+1	Dr Dr P N Sharma
Courses offered by other departments (but teacher associated from Pl Path)				
1	Bot 111	Biodiversity (Microbes, Algae, Fungi and Archegoniate)	4+2	Dr Suman Kumar
2	Experiential Learning	Nursery Management	0+1	Dr Amar Singh
3	Experiential Learning	Protected Cultivation	0+1	Dr Amar Singh

IInd Semester

Sr No	Course No	Course Title	Cr Hrs	Name of Instructor
UG				
1	Pl Path 121	Fundamentals of Plant Pathology	2+1	Dr Amar Singh
2	Pl Path 241	Crop Protection-1 (Plant Pathology)	0+1	Dr A K Sud
3	Pl Path 364	Diseases of Horticulture Crops and their Management	2+1	Dr S K Rana
4	Experiential Learning	Mushroom Cultivation	0+10	Dr S Dhancholia/ Dr A K Sud
M Sc				
5	Pl Path 506	Principles of Plant Disease Management	2+1	Dr B R Thakur
6	Pl Path 507	Diseases of Field & Medicinal Crops	2+1	Dr Suman Kumar
7	Pl Path 509	Diseases of Vegetable & Spices Crops	2+1	Dr D K Banyal
8	Pl Path 510/ SST 512	Seed Health Technology	2+1	Dr P N Sharma/ Dr Sachin Upmanyu
9	Pl Path 511	Chemicals in Plant Disease Management	2+1	Dr D K Banyal
10	Pl Path 513	Disease Resistance in Plants	2+0	Dr S K Rana
11	Pl Path 591	Master's Seminar	1+0	Dr P N Sharma
12	Pl Path 599	Master's Research	-	Major Advisors
Ph D				
13	Pl Path 601	Advanced Mycology	2+1	Dr S Dhancholia
14	Pl Path 602	Advanced Virology	2+1	Dr P N Sharma
15	Pl Path 603	Advanced Bacteriology	2+1	Dr Suman Kumar
16	Pl Path 691/692	Doctoral Seminar-I/ II	1+0	Dr P N Sharma
17	Pl Path 699	Doctoral Research	-	Major Advisors

STUDENTS ADMITTED DURING 2017-18

M.Sc Programme

Sr.No.	Name of student	Major Advisor	Title of Research Problem
1	Ms Priyanka Patel	Dr P N Sharma	Studies on mosaic disease of soybean and evaluation of host resistance
2	Ms Diyanshi Bhatti	Dr Suman Kumar	Biology and management of bacterial canker of tomato
3	Ms Harneet kaur	Dr A K Basandrai	Eco-Friendly management of wheat powdery mildew caused by *Blumeria graminis tritici*
4	Ms Himani Gupta	Dr P N Sharma	Impact of head blight on seed health of wheat and its management
5	Ms Khushwinder kaur	Dr B R Thakur	Eco Friendly management of pea root rot caused by *Fusarium solani f. sp.pisi*
6	Ms Jaina V patel	Dr Amar Singh	Biological management of damping off of okra (*Abelmoschus esculentus*)
7	Ms Pooja Kapoor	Dr S K Rana	Integrated management of sheath blight (*Rhizoctonia solani*) of Rice
8	Ms Prerna Thakur	Dr Arun Sud	Studies on cultivation of Golden Oyster Mushroom (*Pleurotus citrinopileatus*)
9	Mr Siddharth Anand	Dr D K Banyal	Etiology and epidemiology of collar rot complex of cowpea

Ph.D. programme

Sr.No.	Name of student	Major Advisor	Title of thesis
1	Ms Ashima Thakur	Dr D K Banyal	Epidemiology and management of Stemphylium blight of onion
2	Ms Priya Bhargava	Dr S K Rana	Epidemiology and management of flag smut *(Urocystis agropyri*) of wheat
3	Ms Dimple Rana	Dr B R Thakur	Studies on variability and management of fusarium wilt of chickpea

STUDENTS COMPLETED M Sc / Ph D PROGRAMME DURING 2017-18

Sr No	Name of the Student	Major Advisor	Title of thesis
	M Sc		
1	Mr. Amrit Pal Mehta	Dr Ashwani Basandrai	Variability studies in *Blumeria graminis* f sp tritici causing powdery mildew in wheat and evaluation of resistant sources
2	Ms. Arashika	Dr B R Thakur	Studies on white rot of pea caused by *Sclerotinia sclerotium* de Bary
3	Ms. Kavita Nawaliya	Dr Suman Kumar	Etiology and management of wilt complex of bottlegourd
4	Ms. Sonali Katoch	Dr Amar Singh	Studies on variability in *Phytophthora capsici* and evaluation of resistant sources in capsicum
5	Naiya Sharma	Dr PN Sharma	Virulence analysis of C*olletotrichum lindemuthianum* and its management in common bean

THESES ABSTRACTS

M Sc (2017-18)

1. Name of the student: Mr Amrit Pal Mehta
Title of thesis: "Variability study in *Blumeria graminis* f.sp. *tritici* (Bgt) causing Powdery Mildew in wheat and evaluation of resistant sources
Major advisor: Dr. Ashwani Kumar Basandrai
Abstract: The present investigation entitled "Variability study in *Blumeria graminis* f.sp. *tritici* (Bgt) causing Powdery Mildew in wheat and evaluation of resistant sources" was undertaken to study pathogenic variability of Bgt in Himachal Pradesh and identification of resistant sources, environmental factors affecting the disease development and disease management using fungicides and plant extracts. Pathogenic variation was studied in 45 conidial and 5 ascosporic isolates collected from different agroclimatic region of the state during 2016-17 based on the differential reaction on host differential series comprising of 34 known PM genes. The isolates were grouped into 36 pathotypes i.e. 31 of conidial and 5 of ascosporic origin. Pathotypes 22, 19 and 28 collected from Sarol (Distt. Chamba), Ghaghas (Dstt. Bilaspur) and Malan were more virulent attacking 25 resistant genes where as pathotype 2 identified from Kukumseri was the least effective attacking 13 genes i.e. *Pm3b, Pm3c*, Axminister (*Pm1a*), Asosan (*Pm3a*), Kolibri (*Pm3d*), Michigan amberxCc^{8} (*Pm3f*),Hope (*Pm5a*), Timgalin(*Pm6*), Norin (*Pm10*), Amigo (*Pm17*), Chancellor(*Pm 10,15*), Croc_1/*ae.squarrosa*(362) and Soissons. Powdery mildew resistant genes *Pm2,* Ulka (*Pm2*), Khapli (*Pm4a)* andcultivars/lines Maris Dove (*Pm2, mldb*), Normandie (*Pm1,Pm2,Pm9,*) and resistant breeding line SNIPE/YAV79//DACK/TEAL/3/ *ae.squarrosa* (877) were effective against all the isolates. Virulence frequency was high ranging from 96-100%on genes NIL (*Pm3b),* NIL (*Pm3c),* Norin (*Pm10*), Chancellor (*Pm 10, 15*), Chul Bidai and Michigan AmberxCc^{8}, (*Pm3d*), Hope (*Pm5a*), Amigo (*Pm17*), Soissons and CROC_1/ *Ae.squarrosa* (362). Out of 295 genotypes screened at seedling and adult plant stage. 14 genotypes were from disease at seedling stage whereas, 9, 14 and 27 entries were free from powdery mildew at Kukumseri Malan and Palampur, respectively at adult plant stage. Four genotypesi.e. HW1095 and triticale genotype TL 2969and TL 2942and Rye (*Secale cerale*) were free to powdery mildew both at seedling and adult plant stage at all three locations. Under field conditions at Kukumseri minimum andmaximum temperature of 13.4°C and 23.6°C and RH of 45.08 favored high disease severity 70%, however there was decrease in disease development in Malan and slow disease development at Palampur as the prevailing mean minimum, maximum temperature and RH were i.e. 7.81°C, 28.91°C and 63.51%, and 11.81°C, 23.28°C and 49.23%, respectively. Fungicides Tebuconazole (Folicur 250 EC) @0.1% and was effective against powdery mildew at both Malan and Dhaulakuan whereas Difenoconazole (Score 250 SC) @0.1%,, Tebuconazole 50%+ Trifloxystrobin 25% w/w (Nativo 75WG) @ 0.05% was the most effective against powdery mildew at at Dhaulakuan on var. HPW155 and HS240, and Propiconazole (Tilt 25 EC) @0.1%,Kresoxim methyl 44.3% (Eregon44.3% SC) @0.1% andAzoxystrobin (Amistar 325 SC) @0.1% was effective at Malan on var. HS240. In vivo evaluation of Eupatorium plant extract revealed that no conidial germination was observed in Bgt at 4% and 5% concentration whereas there were69.31 and 51.33% inhibition at 3% and 2% concentrations, respectively.

2. Name of the student: Arashika
Title of thesis: Studies on white rot of pea caused by *Sclerotinia sclerotiorum* (Lib.) de Bary
Major advisor: Dr B R Thakur

Abstract: Pea (*Pisum sativum* L.) is a high value cash crop grown as pulse and vegetable throughout the world. White rot of pea caused by *Sclerotinia sclerotiorum* (Lib.) de Bary has become a limiting factor in pea cultivation due to its monoculture and extensive cultivation in some parts of Himachal Pradesh. The variability in *S. sclerotiorum* and evaluation of management components have been studied in the present investigation to devise effective and economic management of the disease. Thirteen isolates of *S. sclerotiorum* were collected from pea, bean, chickpea, tomato and linseed growing areas of Himachal Pradesh. All the isolates of *S. sclerotiorum* were found cross pathogenic on pea, bean, chickpea, tomato and linseed verifying the polyphagus nature of the pathogen. Based on cultural characteristics isolates were divided into three groups whereas on the basis of morphological characteristics they were divided into two groups. On the basis of mycelial compatibility grouping (MCG), 13 isolates were placed in four groups *viz.* MCG-I, MCG-II, MCG-III and MCG-IV. Further, ISSR primers based analysis divided the isolates into three groups *viz.* Ss-I, Ss-II and Ss-III at 77 per cent similarity coefficient as cut-off point. However, no congruence was noticed between the groups formed on the basis of cultural, morphological, mycelial compatibility and ISSR primers. For management of the disease, different organic inputs *viz.* extracts of organic composts, organic products and botanicals along with bioagents were evaluated against the pathogen. The aqueous and alcoholic extracts of Himslurry at 25 per cent concentration yielded maximum mycelial inhibition of 84.66 and 89.63 per cent respectively. The aqueous extracts of Cow urine and Jiwamrit and the alcoholic extracts of Cow urine, Jiwamrit and Beejamrit at 10 per cent yielded cent per cent mycelial inhibition. In botanicals, the alcoholic extracts of *Vitex negundo* at 25 per cent test concentration showed mycelial inhibition up to 90.37 per cent whereas, the aqueous extract of this botanical at same concentration showed mycelial inhibition of 48.15 per cent. In bioagents, SMA-5 strain of *Trichoderma harzianum* showed maximum mycelial inhibition of 70.74 per cent against the pathogen. In host resistance, no pea line had shown resistance against *S. sclerotiorum*. The combination of best *in vitro* results were done to develop effective and economic module against the disease. The disease management module of soil amendment with Himslurry @ 50.0 l/ha + seed treated with (*Vitex negundo*) @5.0 ml/kg seed and spray of cow urine (10 per cent) at regular interval of 7 days was found most effective and economic against white rot of peas.

3. Name of the student: Kavita Nawaliya
Title of thesis: Etiology and Management of Wilt Complex of Bottlegourd
Major advisor: Dr Suman Kumar

Abstract: The present investigation entitled "Etiology and Management of Wilt Complex of Bottlegourd was undertaken to identify the pathogen associated with the disease, factors affecting disease development and evaluation of management practices against the disease. The wilt complex disease of bottlegourd was prevalent in all the four districts surveyed during 2015-16 *viz.*, Una, Bilaspur, Kangra and Hamirpur, in moderate to severe form but was predominantly present in Una and Hamirpur districts. Pathogenicity test was conducted with each of the three associated pathogens *viz.*, *Colletotrichum orbiculare*, *Fusarium oxysporum* and *Didymella bryoniae* (*Stagnosporopsis cucurbitacearum*) on the highly susceptible bottlegourd variety MHBG 8 and the Koch's postulates were proved by *Didymella bryoniae* thereby confirming the pathogenicity of the test pathogen. On the basis of symptomatology, morpho-cultural characteristics and molecular characterization, the test pathogen was identified and confirmed as *Didymella bryoniae* (*Stagnosporopsis cucurbitacearum*). Potato carrot agar was found to be the best medium both for radial growth as well as sporulation of this pathogen. Pin prick/ injury method was most effective in reproducing the disease by *Didymella bryoniae*. The 15 days old seedlings were found to be

most susceptible to *Didymella* infection and the time lapse between inoculation and symptom expression increased as plant matured. The aggressiveness of the pathogen was less during the initial period of fungus growth thereafter it increased. Fungicides benomyl, carbendazim, difenoconazole and carbendazim 12% + mancozeb 63% WP outperformed the other fungicides under *in vitro* evaluation conditions through poisoned food technique. Three foliar sprays of carbendazim 12% + mancozeb 63% WP along with soil application of boron resulted in the most effective disease control of 85.8 per cent followed by 82.2 per cent disease control by six foliar sprays of carbendazim 12% + mancozeb 63% WP alone under field conditions. Out of 10 germplasm lines evaluated none were found to exhibit resistance against the pathogen.

4. Name of the student: Ms Sonali Katoch

Title of thesis: Variability in *Phytophthora capsici* and evaluation of resistance sources in capsicum

Major advisor: Dr Amar Singh

Abstract: The investigation entitled "Variability in *Phytophthora capsici* and evaluation of resistance sources in capsicum" was conducted at Department of Plant Pathology, CSKHPKV Palampur during 2016 and 2017. More than 100 samples of Phytophthora root rot, leaf blight and fruit rot of capsicum/chilli were collected from six districts of Himachal Pradesh. Twenty isolates of *P. capsici* were recovered and further used to study morpho-cultural, physiological, pathogenic and molecular variability. On the basis of morpho-cultural characteristics, 20 isolates of *P. capsici* were categorized and placed in five groups. Distinct variability was not observed in mycelial growth at different temperature (15, 20, 25 and 30ºC) and on different solid media (Carrot agar, Oat meal agar, V8 juice agar, Corn meal agar and PDA) tested. However, considerable variability was observed at higher temperature as out of 20 only 9 isolates could grow (19.3-90 mm) at 35ºC with maximum mycelial growth (90 mm) in Pc-9 isolate. Maximum mycelial growth and sporulation was observed on Carrot agar medium. Only, 25 per cent isolates of *P. capsici* formed chlamydospores under submerged conditions. Oospore formation was observed in 19 isolates when paired with opposite mating type while one isolate Pc-9 formed oospores in solo culture. On the basis of average diameter of oospores 8 and 11 isolates were designated as A1 (> 32.5 µm) and A2 (< 30.2 µm) mating type, respectively. Oospore formation frequency was also varied as high (≥30 oospores), medium (≥20 oospores) and low (≤10 oospores). Low variability was observed among 20 isolates of *P. capsici* for metalaxyl sensitivity as 13 isolates were showing sensitive reaction and 7 were showing intermediate reaction. Virulence pattern of 20 isolates was determined on differential set comprising of six capsicum genotypes and study revealed the presence of four patho groups. Disease reaction of *P. capsici* isolates on capsicum fruits revealed that except two isolates (Pc-6 & Pc-9), all the isolates were found to be highly pathogenic on capsicum fruits. Molecular data generated by ISSR markers exhibited wide genetic diversity in *P. capsici* as 20 isolates have fallen in 8 variant groups keeping 49 per cent similarity cut off point and were more or less related to their geographical locations. To identify the resistant sources, 86 lines of capsicum were evaluated for root rot and leaf blight infection and six lines namely KTC-148, KTC-149, KTPL-19, Chilli Local, Pant Chilli and PBC-631 were found resistant.

PhD (2017-18)

Name of the Student: Naiya Sharma (A-2013-40-013)

Title of the thesis: Virulence analysis of C*olletotrichum lindemuthianum* and its management in common bean

Major advisor: Dr PN Sharma

Abstract: This study was aimed to determine pathogenic and molecular variability in *Colletotrichum lindemuthianum*, the casual organism of bean anthracnose; to evaluate bean germplasm to find out the sources of resistance against prevalent races; validation of R genes using molecular markers; and to identify suitable fungicide, biocontrol agents and botanicals for the management of disease. Virulence spectrum of 65 isolates determined on a set of 12 bean differential cultivars revealed the existence of 27 races in North Western Himalayas. Race 503 contained maximum number of 12 isolates from diverse geographic regions. Fifteen races *viz;* 5, 6, 7, 16, 18, 51, 87, 99, 145, 179, 211, 259, 337, 503 and 1395 were identified for the first time as none of them resembled with previously known races in Himachal Pradesh hence increasing the total number to 44 in the state. The isolates from J&K (3) and Uttrakhand (13) categorized into different races constitute their first record from these two states. The virulence analysis suggested 4 interaction types in accordance with the genetic origin of differential cultivars that were infected by a particular race. Twenty-one races having virulence for genotypes of both the gene pools showed Type IV interaction. Nine of 12 differential cultivars were found to be infected by one isolate suggesting 9 virulence factors among 65 isolates of *C. lindemuthianum.* RAPD data at 43 per cent similarity coefficient distinguished various isolates into 8 clusters, whereas, ISSR markers categorized test isolates into 5 clusters using 43 per cent similarity coefficient as a cutoff point. There was no congruence between the pathogenic variability and the molecular diversity data, showing no utility of such markers in differentiation of the physiological races whose identity is based on pathogenic behavior of the given isolate involving many pathogenicity factors. Out of 313 accessions, 45 were found resistant to race 0 (20), 17 (21), 503 (19) and 1395 (13), respectively. R-gene prediction analysis using SCAR marker linked to R genes showed the presence of 4 resistant genes *Co-2, Co-4, Co4^2, Co-6* in various resistant accessions. A maximum of 4 genes *Co-2, Co-4, Co4^2, Co-6* were detected in 6 accessions. In the fungicides evaluation tests, trifloxystrobin 25 per cent+ tebuconazole 50 per cent (Nativo), tebuconazole (Folicur), and carbendazim 12 per cent + mancozeb 63 per cent (SAAF) were found highly effective whereas, among the botanicals aqueous extracts of *M. azedarach* was more effective against the *C. lindemuthianum.* While *Trichoderma harzianum* was more effective than *Pseudomonas fluorescens* and *T. viride*. The seed treatment with carbendazim (2.5 g/kg) followed by two foliar sprays of trifloxystrobin 25 per cent+ tebuconazole 50 per cent (Nativo), and *T. harzianum* at 45th and 60th day after sowing were found very effective against the disease in field trials and resulted in higher seed yield.

RESEARCH

A. Survey and surveillance

The disease surveys were conducted by the sicentists posted at various research stations, KVKs and in the Department of Plant pathology at headquarter. The status of various diseases recoreded on different crops is described in the following sections.

Department of Plant Pathology

Surveys were conducted in different parts of districts Kangra, Mandi, Hamirpur, Bilaspur, Kullu and Solan to record the incidence and severity of different diseases and collection of disease samples for PG research and practicals.

In K***harif*** **2017-18**, the severity of Maydis leaf blight in maize ranged from 20-70%, incidence of brown spot ranged from 10-90% and incidence of BLSB varied between 10-60%. In rice, the severity of brown spot was 10-30% and 5-10% leaf blast was recorded at few locations. Downy mildew was recorded in severe form with severity up to 70% on Ram Tori at Bara, Hamirpur. In Capsicum, the attack of cercospora leaf spot was recorded at many locations and a severity of 10-30%. The incidence of root rot ranged from 5-15%. Phytophthora blight severity ranged between10-30% at many locations especially in Solan district, whereas the buck eye rot of tomato incidence was 10-30% in some locations of Solan district.

In R***abi*** **2017-18**, wheat yellow rust was prevlent in many locations with a severity of 10-80S, while the intensity of powdery mildew ranged from 3-5 on 0-9 scale and incidence of flag smut was between 2-17% at many locations in Hamirpur, Bilaspur, Mandi and Kangra districts. In barley, the severity of yellow rust and powdery mildew ranged from 40-80S and 5-7% and that of barley stripe form 3-5%. The incidence of pea root rot ranged from 10-40% in parts of Kullu and Mandi districts. The severity of Stemphyllium blight on garlic ranged was 5-10%. Garlic corms rot was also recorded at two locations with an incidence of 10-30%.

Hill Agricultural Research and Extension Centre, Bajuara

Systematic surveys were conducted and the status of diseases observed in different crops is given in the Table 1.

Table 1. Survey and Surveillance of different crops for diseases of importance

Crop	Disease	Disease Intensity	Area Surveyed
Tomato	Early Blight and Alternaria fruit Rot,	Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Late Blight and fruit Rot, Buck Eye Rot	Moderate - High	
	Septoria Blight, Bacterial Spots, Bacterial wilt,	Low - Moderate	
	Virus diseases and Disorders.		
Capsicum	Blight and Fruit Rot, Anthracnose	Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	bacterial wilt and virus diseases	Low	
Cabbage and Cauliflower	Black rot	High	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Alternaria leaf spot	Low - Moderate	
French Bean	Angular leaf spot	Low - Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh

Peas	Wilt & root rot, Powdery Mildew,	Low-Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Bacterial blight	Moderate	
Cucumber	Powdery mildew, Downey mildew.	Moderate-High	Kelhali, Garsa, Jia,Ruaru, Nagwain, Panarsa, Aut, Haat, Piridi, Mohal, Khokhan
Garlic	Stemphylium blight & purple blotch in garlic.	Moderate	Nahalach, Pirdi, Khokhan, Chheol, Garsa, Mohan, Dhaman, Shalouri, Ratwa, Targali, Sai Ropa, Banjar
	Rust	Low	
Onion	Purple blotch, downy Mildew.	Moderate	-
	Bulb rot	Low	
Urd Bean	cercospora leaf spot,	Low - Moderate	-
	Leaf crinkle virus	Low	
Maize	Turcicum leaf blight, Maydis leaf blight, Banded leaf & sheath blight	Moderate	Nahalach, Pirdi, Khokhan, Garsa, Mohan, Dhaman, Shalouri, Ratwa, Targali, Banjar, Panarsa, Nagwain, Jia,
Wheat	Yellow rust	Moderate	Bhekhali, Nahalach, Pirdi, Khokhan, Garsa, Mohan of Kullu Block, Dhaman, Shalouri, Ratwa, Targali, Sai Ropa, Banjar of Banjar block.
	Loose smut, Hill Bunt	Low	
Barley	Stripe rust	Moderate	Bhekhali, Nahalach, Pirdi, Khokhan, Garsa, Mohan of Kullu Block, Dhaman, Shalouri, Ratwa, Targali, Sai Ropa, Banjar of Banjar block.
	Covered Smut, Barley stripe	Low	

Hill Agricultural Research and Extension Centre, Dhaulakuan

Survey and surveillance programme was undertaken to record diseases of field crops at farmers' field in Sirmour district **(**Table 2).

Table 2. Occurrence of different diseases of major crops in Sirmour district

Crop	Variety	Disease	Incidence/ Severity/ Score
Paddy	PR 116	Brown leaf spot	5-20%
	Hybrid 6444	False smut	15-50 %
	Kasturi Basmati	Leaf and neck blast	10-30%
	Hybrid 6444	Sheath blight	10-15%
	Hybrid 6444	Bacterial leaf blight	5-30%
Chilli	Local	Fusarium wilt	10-40%
Tomato	Hybrid Him Sona	Fruit rot	10-60%
Capsicum	Califonia wonder	Sclerotium collar rot	Traces
Tomato	Hybrid	Bacteial wilt	5- 40%
Chilli & brinjal	Local	Bacterial wilt	5-30%
Potato	Kufri Jyoti	Early blight	Traces
Pea	Arkel	White rot	Traces
	Lincoln	White rot	Nil
	Arkel	Ascochyta blight	Traces
	Palam Priya	Root rot complex	5-20%
	Lincoln	Powdery mildew	Traces
Okra	Local	Cercospora blight	5-50 %
Mash	Local	Leaf spot	20-50%
Wheat	HPW236	Yellow rust & Karnal bunt	Nil
	HD2967	Yellow rust; Karnal bunt	20S; 4.6%
	HPW 249,HPW 349	Yellow rust, Karnal bunt	Nil
	PBW 343	Yellow rust & Karnal bunt	Yr 60S; 10.2%
	Raj 3777	Yellow rust & Karnal bunt	20S; 0.85%

	Raj 3777	Powdery mildew	Traces
	Raj3765	Flag smut	Traces
	HD2967	Flag smut	Traces
Onion & Garlic	Local	Downy mildew Purple blotch *Stemphylium* blight	Nil 10-50% 10-40%
Ginger	Local	Rhizome rot	5-30 %

Diseases of cereal crops

i) Rice

Surveys in major rice growing districts of Himachal Pradesh namely, Kangra, Mandi and Una districts was conducted under **Production Oriented Survey (POS)** programme of AICRIP during *kharif* 2017 and the relts are presented in Table 3.

Table 3. Prevalence of diseases of rice in Himachal Pradesh during *kharif* 2017

	Diseases									
District	**LBL**	**NBL**	**BS**	**GD**	**FS**	**LS**	**NBLS**	**SHBL**	**SHR**	**BLB**
Kangra	L-M	L-M	L-M	L-M	L-M	L	L	L	L	-
Mandi	L-M	L-M	L-M	L	M	L-M	L	L-M	T	-
Una	L	L	L-M	L	L-M	L	L	L	L	-

LBL: Leaf blast, NBL: Neck blast, BS: Brown spot, GD: Grain discolouration, FS: False smut, LS: Leaf scald, NBLS: Narrow Brown leaf spot, SHBL: Sheath blight, SH.R: Sheath rot. BLB: Bacterial leaf blight, L: Low, M: Moderate, S: Severe, T: Traces Disease Intensity, L = 2-5%; L-M = 6-15%; M = 16-25%; M-S = 26-50%; S = 51-100%.

Kangra: Thirty five villages from nine blocks of district Kangra were covered under production oriented survey during *kharif* 2017 at different crop stages. Some farmers used Bavistin 50 WP as seed treatment (2-2.5 g/ kg seed) as well as foliar application (1g/ L) against blast while Tilt 25EC @1 ml/ L was used against false smut.

Mandi: Farmers from rice bowl of Balh block were contacted for production oriented survey in this district. Diseases such as false smut and neck blast appeared in moderate forms while leaf blast, grain discolouration, sheath rot, sheath blight and brown spot appeared as low. However, severe outbreak of false smut and neck blast (Intensity ≥ 50%) was observed in Nalsar and Bheora villages, respectively. Very few farmers adopted the control measures against false smut.

Una: Survey was conducted in lower hills of Una distirct comprising Jankor, Fatehpur, Nandgran, Basal, Santokhgarh, Majra and Nangalkalan (Tahliwal) areas. Diseases like false smut, narrow brown leaf spot, neck blast and sheath rot were low to moderate while leaf blast, grain discolouration and sheath blight were recorded as low. Brown spot was observed in severe form (>50%) on Pusa 1121 at Nangalkalan. Pesticides like Tilt 25 EC against false smut were used by some farmers.

ii) Wheat

Wheat crop health was monitored by conducting survey and surveillance tours in parts of Dehra, Pragpur, Lambagaon, Fatehpur and Indora blocks of District kangra. 36 locations were visited, varieties grown were HPW 368, HPW360, HS 542, HS 308, HS 507, DPW 621, PBW621, HD 8086, HD 2967, DPW 621. Incidence of **yellow rust** was noticed on variety HD 2967 in 'Rey" village of Fatehpur block. A single focus of disease in 1m2 was observed. 22 farmers' were visited and sensitized about symptoms and management of yellow rust of wheat keeping in view conducive climatic conditions prevailing in these areas. An awareness interaction was also organized in collaboration with Department of Agriculture to sensitize the farmers and extension workers about the diseases of wheat and their control measures.

Campaign for management and survey of yellow rust of wheat

The wheat growing villages *i.e* Kolar,Puruwala, Majra, Fatehpur, Pipliwala, Bhagwanpur, Haripur Tohana , ,Jagatpur and Shivpur etc. of Paonta Sahib, Block were surveyed by the team(Drs. Akhilesh Singh, J. S. Thakur ,Project Director, ATMA, Nahan,Ashok Chandel DPD ATMA Sirmour,Ms. Bindu Kumari BTM and Sh Narender kumar ATM,Paonta). Most of the farmers have grown HD-2967, HD-2985, HPW-236, HPW-211, HPW-249, HPW349, VL-829, DBW 621-50 and local. During these surveys (Table 4) the farmers were sensitized regarding rust symptoms, proper spray schedule for the control of Karnal Bunt as per recommendation at the initiation of ear head emergence stage, spray of recommended fungicide at proper time, stage with accurate dose for effective control of yellow rust and Karnal bunt. They were also advised to be vigilant and contact the Department officers or HAREC Dhaulakuan in case of disease appearance.

Table 4. Occurrence of different diseases of wheat in Sirmour district at farmers field

S. No.	Name of the village	Severity	
		Yellow rust score	Powdery mildew score
1	Matak Majri	-	3
2	Sainwala	-	2
3	Gondpur	-	2
4	Pardooni	-	3
5	Puruwala	-	2
6	Kundio	-	5
7	Jwalapur	-	3
8	Kedarpur	-	3
9	Patalion	-	2
10	Surajpur	-	3
11	Bata mandi	-	3
12	Bhagwan pur	-	5
13	Jagatpur	-	2
14	Pipli wala	-	2
15	Majra	-	5
16	Fatehpur	-	2
17	Rukhri	-	3
18	Satiwala	-	3
19	Behrewala	-	3
20	Haripur tohana	-	4
21	Misserwala	-	5
22	Kansipur	-	3
23	Shivpur	-	2
24	Rampur Bharapur	10S (HD-2967)*	3
25	Kolar	20S(HD-2967)*	2

*Disease appeared very late and was controlled by the Propiconazole (0.1%) sprays

The farmers of the area were also advised about management practices of this disease i.e. Spray of Tilt (0.1%) or Contaf (0.2%) in the crop

Diseases of oilseed crops

i) Rapeseed-Mustard

Alternaria blight and white rust remained the major diseases of rapeseed-mustard crops in different locations of Himachal Pradesh during the crop season of 2017-18(Table 5). Severity of *Alternaria* blight ranged from 5-44%, whereas white rust severity varied from 5-36% in mustard crop, whereas gobhi sarson remained free from white rust disease.

Table 5: Occurrence of different diseases in rapeseed-mustard during 2017-18

Locations	Crop/Variety	Disease severity (%)	
		Alternaria blight	White rust
District Kangra			
Kangra	Mustard	44	36
Jakhara, Fatehpur	Gobhi sarson	15	0
Kuthera, Jwali	Gobhi saraon	10	0
Kuthera, Jwali	Mustard	25	20
Nagrota Surian	Gobhi sarson	20	0
Gummer	Gobhi sarson	5	0
Sunhet, Dehra	Mustard	30	10
District Chamba			
Dulahara, Sihunta	Brown sarson	25	5
Thulel, Sihunta	Brown sarson	10	0
District Hamirpur			
Bharoli, Nadoun	Gobhi sarson	15	0
Bhumpal	Mustard	25	20
Galore	Brown sarson	10	0
District Una			
Amb	Mustard	30	20
Bangana	Gobhi sarson	10	0
Panjoa	Mustard	25	15

ii) Linseed

Although rust is major disease of linseed crop in Himachal Pradesh, but the crop escaped rust in most locations except Kangra during 2017-18.The severity of rust also remained low at Kangra. However, wilt and powdery mildew were observed to affect the linseed crop in major linseed growing areas of district Kangra and Mandi during the crop season. Variety Kangra local was infected by wilt and powdery mildew at all the locations. Highest severity of wilt (70%) was observed at Kangra followed by Chountra (15%) (Table 6). The severity of powdery mildew ranged from 5-50%, being highest at Palampur.

Table 6: Occurrence of different diseases in linseed during 2017-18

Locations	Variety	Disease severity (%)		
		Rust	Wilt	Powdery mildew
District Kangra				
Kangra	T-397, Chambal	10	70	10
Rajiana (53 miles)	Local	0	10	25
Palampur	Local	0	15	50
Shera Thana	Local	0	5	15
Shahpur	Local	0	10	5
District Mandi				
Chountra	Local	0	15	20
JoginderNagar	Local	0	10	25

iii) Sesame

In sesame, Cercospora leaf spot, *Phytophthora* blight and phyllody remained major disease problems at the farmer's fields in districts Kangra and Hamirpur. *Cercospora* leaf spot severity ranged from 25-50%. The overall disease pressure of *Phytophthora* blight was low

and varied from 2-25% (Table 7). Phyllody was also observed to affect the sesame crop at all the locations and up to 10% severity was observed at Kangra in variety Brajeshwari.

Table 7: Occurrence of different diseases in Sesame during *Kharif* 2017

Locations	Variety	Disease severity (%)		
		***Cercospora* leaf spot**	***Phytophthora* blight**	**Phyllody**
District Kangra				
Kangra	Brajeshwari	50	10	10
Gummer	Local	30	5	2
Bharoli	Local	25	25	5
Daulatpur	Local	50	10	2
Lanj	Local	40	2	5
District Hamirpur				
Nohangi	Local	30	5	5
Galore	Local	50	5	2

iv) Soybean

Mainly four diseases *viz*., frog eye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*), bacterial pustule (*Xanthomonas campestris* pv. *glycines*) and yellow mosaic virus (YMV) were found to occur in areas surveyed in Kangra and Mandi districts. Diseases were scored on 0-9 scale. Location wise disease index (PDI) is presented in the Table 8.

Table 8. Occurrence of soybean diseases in major soybean areas in Himachal Pradesh

District/ village	Variety grown	Percent disease index			
		Frogeye leaf spot	Pod blight	YMV	Bacterial pustule
Kangra district					
Baijnath	Hara Soya	55.55	11.11	0.0	0.0
Bir	Hara Soya	55.55	11.11	0.0	0.0
Pantehar	Hara Soya	55.55	33.33	0.0	0.0
	Him Soya	77.77	33.33	0.0	0.0
Nagri	Hara Soya	55.55	33.33	0.0	11.11
Kangra	Hara Soya	33.33	11.11	33.3	11.11
	Shivalik	77.77	33.33	00	0.0
Palampur	Hara Soya	55.55	33.33	0.0	0.0
	Bragg	33.33	55.55	0.0	0.0
Mandi district					
Chauntra	Hara soya	55.55	11.1	0.0	0.0
	Palam soya	11.11	33.3	0.0	0.0
Dohag	Hara soya	55.55	11.11	0.0	0.0
	Him soya	77.77	11.11	0.0	0.0
Jogindernagar	Hara soya	33.3	11.11	0.0	0.0

Frog eye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*) and bacterial pustule (*Xanthomonas campestris* pv. *glycines*) were mainly observed on Hara Soya, Him Soya, Palam Soya and Bragg varieties of soybean in Himachal Pradesh. Brown spot (*Septoria glycines*) and powdery mildew (*Microsphaera diffusa*) diseases were observed in moderate intensity while collar rot (*Sclerotium rolfsii*) in low intensity only at Palampur, from experimental farm. Incidence of mosaic disease was also observed at low intensity at Palampur and YMV was prevalent in Kangra area.

Diseases of vegetable crops

Pea

In pea the severity of powdery mildew at Sangla & Chitkul was found 50 - 75%, in Hangrang valley (Hango & Chulling) the severity of powdery mildew was 50%. The incidence of root rot complex ranged between30-40 percent at Sangla & Pooh whereas it was 40-50 per cent in major pea growing areas (Nako & Chango).

Bottle gourd and cucumber

The incidence and seversity of sudden wilt of bottlegourd and **cucumber a**nthracnose in different areas ranged between 60-75 and 35-78%. The disease severity was quite high in case of sudden wilt, whereas it was moderate in anthacnose.

Disease scenario in different crops in organic farming

The disease scenario in organic farming experiments were observed during 2017-18 crop season. In organic farming experiments were conducted under Sub Project – I and Sub Project – II having different cropping systems. Sub Project-I have cropping systems viz. CS – 1 (Tomato (kharif) – Cauliflower (Rabi) – French Bean (Summer)), CS-2 (Tomato (Summer) – Cauliflower (Rabi)), CS-3 (Black Gram (Kharif) – Cauliflower (Rabi) – Summer Squash (summer), CS-4 (Lady's Finger (kharif) – Pea (Rabi), whereas in Sub Project-II varieties/hybrids of different vegetable crops (tomato, cauliflower, peas and okra) were evaluated for suitability in organic farming conditions. Disease incidence and severities were recorded in crops grown in these cropping systems by using standard procedures. Incidence of Buckeye rot, phytophthora blight, Alternaria blight and fruit rot, Septoria leaf spot, Bacterial spot/ canker in tomato; root rot and wilt in Peas; Angular leaf spot in French bean; Black rot and Curd rot in cauliflower; cercospora leaf spot and leaf crinkle in black gram and powdery mildew in lady's finger were observed (Table 9).

Table 9: Disease scenario in different crops in organic farming.

Crops	Disease	Incidence
Tomato	Buck Eye rot and other fruit rot diseases	Moderate
	Alternaria Blight	Moderate
	Late Blight	Moderate
	Septoria Leaf spot	Low
	Bacterial spot/ canker	Low- Moderate
Pea	Root rot	Low
French Bean	Angular leaf spots	Moderate
Cauliflower	Curd Rot	Low
	Black Rot	Moderate
Black Gram	Cercospora leaf spot	Moderate
	Leaf crinkle	Low
Okra	Powdery mildew	Moderate

Diseases of fodder crops

The incidence of diseases and insect-pests of different *Kharif* & *Rabi* fodder crops are given the Table 10 as below.

Table 10. Diseases and Insect-pests of different *Kharif* & *Rabi* fodder crops

Crop	Diseases and insect pest	Severity (%)
***Kharif* 2017**		
Cowpea	Wilt/root rot (*Fusarium, Rhizoctonia*)	55
	Leaf spot and blight (*Phytophthora Ascochyta, Phyllostricta*)	40

Maize	Blight (*Helminthosprium maydis* and *H. Tercecium*)	22
	Banded leaf & sheath blight (*Rhizoctonia*)	15
Sorghum	Zonate leaf spot (*Gloeocercospora sorghi)*	47
Bajra	leaf blight (*Helminthosporium*)	27
***Rabi* 17-18**		
Oats	Powdery mildew	75
	Leaf blights	27
	Loose smut	3
Berseem	Root rot	5
	Leaf spot	15
Lucerne	Leaf spot	10

B. Cereals

Rice

Screening for leaf and neck blast resistance:
Rice germplasm consisting of 1413 entries from various screening nurseries viz. National Screening Nursery 1 (NSN1=354), National Screening Nursery 2 (NSN2=753), National Screening Nursery-Hills (NSN-H=99), National Hybrid Screening Nursery (NHSN=127) and Donor Screening Nursery (DSN=90) were screened under natural epiphytotic conditions at RWRC, Malan. Two sets of all the 1413 entries were prepared of which one set was sown for leaf blast screening under Uniform Blast Nursery (UBN) Pattern and the other was transplanted for neck blast screening. The test entries were scored based on leaf blast severity following Standard Evaluation System for Rice (SES) scale as per the technical programme of All India Coordinated Plant Pathology Trials (2017-18).

Out of these nurseries, 42 entries from NSN-1, 148 from NSN-2, 16 from NSN-H, 18 from NHSN and 6 entries from DSN were found promising against leaf blast whereas 13 entries from NSN-H, 10 from NHSN and 2 from DSN were found promising against neck blast.

Monitoring of field virulences in *Pyricularia oryzae*:
To characterize the virulence spectrum in the population of *Pyricularia oryzae* in different rice ecosystems, a set of 25 differentials consisting of international differentials, donors and commercial cultivars was planted across 24 locations across the country adopting UBN pattern including Malan. The observations revealed that differentials namely Raminad STR-3, Tadukan, C101 LAC, Tetep and NP 125 showed resistant reaction while IR 64 was found susceptible to leaf blast. The difference in disease reaction score of susceptible and resistant checks revealed a shift in pathogen population. The reaction pattern of genotypes at all test locations was grouped into seven distinct groups wherein reaction pattern of Malan was included in group one.

Integrated disease management:
To test the effect of Integrated Disease Management practices against major diseases like blast, a trial was laid out in RBD design with three replications during *kharif* 2017 (Table 11). The treatments comprised of cultivation of a highly susceptible variety, HPU 2216 with 11 different components of IDM. Seedlings (25 days old) of HPU 2216 were transplanted and the application of fertilizer was done as per the requirement of the treatments. Single spray application of tricyclazole @ 0.06 % (M10) was done on September 20, 2017 at panicle emergence stage while neem based product (M11), NEEMARIN 300 (Azadiractin 0.03%) was applied on September 6 and 18, 2017 at tillering and booting stages, respectively. Observations on leaf blast severity were recorded from 10 hills/ plot following 0-9 scale of Standard Evaluation System for Rice, Philippines (2013) at flowering and that on neck blast incidence were recorded a week before harvest by counting the infected over total panicles from 3 sampling units of 1 x 1 m area in each plot. The grain yield was recorded on plot basis and was converted to q/ha.

The perusal of data (Table 12) revealed that among different treatments, the application of *Trichoderma viride* along with FYM during field preparation and neem based product at the time of tillering and booting stage (T1) proved to be the best reducing leaf blast severity to 16.6 per cent followed by treatment T6 with 19.8 per cent severity resulting in 63 and 56 per cent reduction in leaf blast severity over control and both these treatments were at par with each other. The treatment T6 was again most effective and reduced neck blast incidence to 2.8 per cent resulting in 96 per cent disease control. Treatments T5 and T1 were

the next most effective treatments to reduce the neck blast incidence to 7.5 and 9.5 per cent, respectively and were statistically at par with each other.

Table 11. Components for integrated Disease Management trial

Components	Details of component
N-1 (Nursery)	Incorporation of FYM @ 1 kg/m^2 in the nursery
N-2 (Nursery)	Seed treatment with carbendazim (2 g/kg) alone or along with one applicationof carbendazim (@1 g/m2) 7 days before uprooting the seedlings. (**Procedure for seed treatment**: Soak the required quantity of seeds in a bucket of water overnight, decant the water and mix the soaked seeds thoroughly with the required quantity of fungicides and then put the treated seeds in wet cloth bag, tie the bag(s) properly with a thread and incubate in a warm and humid place for 1-2 days for initiation of germination; use these seeds for raising the seedlings)
N-3 (Nursery)	Apply DAP @ 108 g/10 m^2 nursery area (to supply 20 and 50 kg /ha of nitrogen and phosphorus) before sowing the seeds. Apply muriate of potash (MOP) @ 85 g/10 m^2nursery area (to supply 50 kg/ha potassium)
M-4 (Main field)	Application of FYM just before transplanting (@ 1 kg/m2) in plots.
M-5 (Main field)	Application of FYM (@ 1 kg/m^2 + *Trichoderma* formulation (2 g /kg of FYM) just before transplanting in the plots
M-6 (Main field)	Cultural practices (cleaning of bunds i.e no weeds/infected straw on bunds and main field)
M-7 (Main field)	**Apply 100% RDF** (Recommended dose of fertilizers). Apply fertilizers @ 120 kg N/ha, 60 kg P2O5/ha, 40 K2O/ha and ZnSO4 @ 25 kg/ha (N:P:K: Zn- 120:60:40:25). Apply entire P and K and ½ N as basal dose and the remaining 1/2 N at maximum tillering stage. Apply additional 25% N at booting to make the plants more prone to the disease. Apply ZnSO4 as basal dose.
M-8 (Main field)	(N:P:K: Zn-90:450:30:18) + micronutrient solution @ 0.5 litre /10 m2 area [micronutrient solution should be made by mixing 2 g or 2 ml micronutrient product/litre of water)] Micronutrient should be sprayed 15-20 days after transplanting. Micronutrient application should be repeated after 15 after the first application.
M-9 (Main field)	One blanket application of granular insecticide (cartap hydrochloride or fipronil) at 15 DAT
M-10 (Main field)	After booting stage, if any of the following diseases appear, the give one spray of the recommended chemical specific for that disease: • In areas which are endemic for neck blast, give one spray of tricyclazole 75 WP (Beam or Sivic) @ 0.6 g/l or iprobenphos 48 EC (Kitazin) @ 2g/l or isoprothiolane 40 EC (Fiji-One) @ 1.5 ml/l during panicle emergence • In case of brown spot/sheath rot/grain discoloration: Give one spray of carbendazim 50 WP (Bavistin) @ 1g/l or combination of carbendazim (12%) and mancozeb (63%) (Saaf) @ 1.5-2 g/l. • In case of bacterial blight: Spray twice with 250 ppm of Agrimycin-100 or any other suitable antibiotic at 10 days interval • One blanket application of propiconazole at booting stage
M-11 (Main field)	Two times spray of neem based product @ 3 ml/l at the time of tillering and booting stage.

Treatment T5 and T4 were most effective IDM treatments in enhacing the grain yield and resulted in 36.3 and 33.5 q/ ha grain yield, respectively in comparison to control (20.4 q/ ha) and were statistically at par followed by treatment T6 resulting in 29.2 q/ ha grain yield.

Table 12. Integrated management of leaf and neck blast of rice

Treatment	Leaf blast severity (%)	Per cent reduction in LB	Per cent Neck blast incidence	Per cent reduction in neck blast	Grain yield (q/ ha)	Per cent increase over control

T1= N1+M5+M11	16.6 (23.9)	63.3	9.5 (17.9)	86.8	26.0	27.5
T2= N3+M4+M7	36.2 (36.9)	19.9	71.6 (57.8)	0.1	21.2	3.9
T3= N2+N3+M7+M9+M10	31.9 (34.4)	29.4	25.4 (30.2)	64.6	26.2	28.4
T4= N1+N2+N3+M4+M7+M10	26.9 (31.1)	40.5	23.9 (29.2)	66.7	33.5	64.2
T5=N1+N2+N3+M5+M7+M9+M10	23.9 (29.2)	47.1	7.5 (15.8)	89.5	36.3	77.9
T6=N1+N2+N3+M5+M6+M8+M9+M10	19.8 (26.4)	56.2	2.8 (9.3)	96.1	29.2	43.1
T7= Control (N3+M7)	45.2 (42.2)	-	71.7 (57.9)	-	20.4	-
CD (*P = 0.05*)	4.8	-	3.7	-	3.5	-

Figures in parentheses are arcsine transformed values

Evaluation of new fungicides against location specific diseases:

A field trial was conducted during *kharif* 2017 in randomized block design to evaluate the efficacy of some new fungicide formulations against blast using a susceptible variety 'HPU 2216'. Fungicides namely, flusilazole 12.5% + carbendazim 25% SC, azoxystrobin 18.2% w/w + difenoconazole 11.4 w/w SC, azoxystrobin 11% + tebuconazole 18.3% w/w SC, tricyclazole 18% + mancozeb 62 % WP, zineb 68% + hexaconazole 4% WP, trifloxystrobin 25% + tebuconazole 50% WG, mancozeb 50% + carbendazim 25% WS and fluxapyroxad 62.5g/l + epoxyconazole 62.5g/l EC including untreated control were evaluated for their efficacy against neck blast (Table 13). In all, two sprays were applied first on September 9, 2017 and second spray was applied on September 26, 2017 at the time of flowering and dough stages, respectively.

A perusal of the data revealed that all the fungicides significantly reduced the disease as compared to control during *kharif* 2017. Of these, tricyclazole 18% + mancozeb 62 % WP proved to be most effective fungicide and reduced neck blast incidence to 17.7 per cent resulting in 70 per cent reduction over control. This was followed by azoxystrobin 18.2% w/w + difenoconazole 11.4 w/w SC and trifloxystrobin 25% + tebuconazole 50% WG which were at par with each other restricting neck blast incidence to 27.0 and 27.1 per cent, respectively resulting in over 54 per cent reduction over control. Azoxystrobin 11% + tebuconazole 18.3% w/w SC, mancozeb 50% + carbendazim 25% WS and fluxapyroxad 62.5g/l + epoxyconazole 62.5g/l EC were the next in order of efficacy. Zineb 68% + hexaconazole 4% WP hexaconazole was the least effective fungicide against neck blast but was significantly superior over control.

All the fungicides significantly enhanced the grain yield over control but tricyclazole 18% + mancozeb 62 % WP resulted in maximum (61.5 q/ ha) grain yield being statistically at par with rest of the fungicides except fluxapyroxad 62.5g/l + epoxyconazole 62.5g/l EC.

Table 13. Evaluation of new fungicides for the management of rice blast

Fungicide	**Dose (g or ml / L)**	**Neck blast incidence (%)**	**Per cent reduction in neck blast**	**Grain yield (q/ha)**	**Per cent increase in yield over control**
Flusilazole 12.5% + carbendazim 25% SC	1 ml	34.4 (35.8)	41.8	59.4	35.3
Azoxystrobin 18.2% w/w + difenoconazole 11.4 w/w SC	1 ml	27.0 (31.3)	54.3	58.3	32.8
Azoxystrobin 11% + tebuconazole 18.3% w/w SC	1.5 ml	29.4 (32.8)	50.3	58.0	32.1
Tricyclazole 18% + mancozeb 62 % WP	2.5 g	17.7 (24.9)	70.1	61.5	40.1

Zineb 68% + hexaconazole 4% WP	2.5 g	37.2 (37.6)	37.1	59.9	36.4
Trifloxystrobin 25% + tebuconazole 50% WG	0.4 g	27.1 (31.3)	54.1	59.9	36.4
Mancozeb 50% + carbendazim 25% WS	2.5 g	30.5 (33.6)	48.4	56.2	28.0
Fluxapyroxad 62.5g/l + epoxyconazole 62.5g/l EC	1.5 ml	32.8 (35.0)	44.5	52.4	19.4
Control	-	59.1 (50.2)	-	43.9	-
CD (*P = 0.05*)		3.8		5.6	

Figures in parentheses are arcsine transformed values

Wheat

Screening of wheat germplasm against major diseases (HAREC Bajaura)

Stripe rust: A total of 409 wheat lines/ genotypes received from ICAR-IIWBR under PPSN AVT and PPSN NIVT/ Special Trials were screened against yellow rust at HAREC, Bajaura during *rabi* 2017-18. The details of promising genotypes are given below:

PPSN AVT: A total of 57 genotypes out of 149 tested were found resistant to Stripe rust. The promising genotypes with yellow rust resistance were NHESZ-1702, NHESZ-1704, NHESZ-1705, NHESZ-1707, NHESZ-1708, NHTSZ-1701, NHTSZ-1705, NHTSZ-1707, NHLSZ-1701, NHLSZ-1703, NHLSZ-1704, NHLSZ-1708, NHLSZ-1709, NHLSZ-1710, BRW 3792, PBW 763, PBW 766, DBW 233, HD 3226, PBW 801, PBW 800, WH 1124 (C), HD 3059 (C), PBW 752*, DBW 173 (I) (C), PBW 773, DBW 237, WH 1142 (C), BRW 3806, WH 1080 (C), HI 1620*, HD 3043 (C), DBW 252, HI 1628, NIAW 3170, DBW 233, HD 3254, PBW 769, DBW 187, PBW 762, HI 1612 (I) (C), WH 1235, HI 8737 (d) (C), UAS 465 (d), DDW 47 (d), MACS 3949 (d) (C), UAS 428 (d) (C), AKDW 2997-16 (d)(C), MPO 1336 (d), UAS 446 (d) (c), HI 8802 (d), HD 3271, PBW 757, HI 1621, DBW 14 (C), PBW 777 and HD 3298.

PPSN NIVT/ special trials: A total of 110 genotypes out of 260 tested were found resistant to Stripe rust. The promising genotypes with yellow rust resistance were PBW 783, UP 3002, UP 3003, UP 3004, DBW 257, WH 1239, PBW 781, PBW 784, HD 3280, HD 3281, HD 3277, WH 1237, NW 7041, DBW 256, WH 1238, UP 3001, PBW 785, HD 2967 (C), HD 3276, PBW 787, HD 3286, HD 3285, K 1703, PBW 788, UP 3005, WH 1243, NW 7028, DBW 258, UP 3006, DBW 260, WH 1242, HUW 829, WH 1241, DBW 261, HD 3284, DBW 262, RAJ 4536, NW 7049, MACS 6222 (C), WH 1244, MP 1350, RAJ 4532, MP 1349, UP 3008, JW 5154, RAJ 4535, DBW 90 (C), HD 3290, NW 7033, PBW 792, K 1707, DBW 267, UP 3010, UP 3011, HUW 830, PBW 791, DBW 269, DBW 265, DBW 266, RAJ 4534, WH 1245, NW 7034, WH 1246, HUW 831, RAJ 4533, UP 3009, PBW 794, NIAW 3354, MP 1351, DBW 270, HI 8807, MACS 6726, HI 8808, DDW 48, HI 8813, HI 8737 (C), HI 8809, WHD 963, RKD 331, MACS 4083, NIDW 1171, UAS 469, PDW 355, DDW 49, NIDW 1158, MACS 3949 (C), GW 1349, WH 1250, DBW 274, HD 3295, HD 3294, WH 1142 (C), PBW 795, HUW 832, K 1711, HD 3293, HI 8815 (d), UAS 466 (d) (C), HI 8627 (d) (C), HP 1970, NHIVT-1702, NHIVT-1703, NHIVT-1704, NHIVT-1705, NHIVT-1707, NHIVT-1709, NHIVT-1711, NHIVT-1713 and NHIVT-1715.

Hill Bunt: Twenty nine wheat genotypes were screened against hill bunt under artificially inoculated conditions and two Genotypes NHLSZ-1702 and NHLSZ-1705 were found free from hill bunt infection. Genotypes NHESZ-1710, NHESZ-1711, NHTSZ-1703 and NHLSZ-1701 showed less than 5% infection.

Trap Plot Nursery: Trap nursery was received from Regional Station, Directorate of Wheat Research (ICAR), Flowerdale, Shimla to monitor the appearance and progress of yellow rust. A total of 20 lines of wheat and one line of barley were planted in this nursery and yellow rust appeared in 12 lines of wheat and one line of barley. Disease samples were sent to Flowerdale, Shimla as soon as the disease appeared for pathotype analysis.

Screening of wheat germplasm against major diseases (HAREC, Dhaulakuan)

During *Rabi* 2017-18 crop season, 2065 entries were screened under artificial inoculation conditions against major diseases viz. Karnal bunt, yellow rust, powdery mildew and head scab in various plant pathological nurseries under AICW&BIP at HAREC, Dhaulakuan. The results are summarized as below (Table 14)

Table 14. Number of wheat stocks resistant to different diseases in plant pathological nurseries

Sr. No.	Name of nursery	Total entries	No. of free entries			
			Yellow rust	Powdery mildew	Karnal bunt	Head scab
1	IPPSN	1156	886			
2	PPSN	149	85	-	-	-
3	NIVT	260	185	-	-	-
4	MDSN AVT-II	53	39	27		
5	MDSN (YR and PM)	53	42	16	-	-
6	PMSN	149	27	-	-	-
7	KBSN	149	-	-	15	-
8	Head Scab Screening nursery	149	-	-	-	-
9	SAARC	20	6	-	-	-
10	TPN	20	2	-	-	-

Karnal bunt: Under All India Coordinated Wheat and Barley Improvement Project, 149 wheat entries were evaluated against local isolates of *Tilletia indica* under artificial inoculation conditions. Fifteen entries (NHESZ-1710,-1711, NHLSZ-1707, CZ-TS-104,-108,-109CZ-RI-305, PZ-TS-110, PZ-RI-305,-309, DIC-101,-103 to -106) were found free from Karnal bunt.

Powdery mildew: PMSN constituting of 149 genotypes were screened against powdery mildew under artificial inoculation conditions .27 genotypes were found free, while 50 gentoypes were resistant and 32 were found moderately resistant

Head scab: Ninety one entries were screened by artificial inoculation of head scab pathogen *(Fusarium graminarium*) and 8 entries (NWLS-209, NWRI 301,-305, CZ-TS-102, -107, CZ-RI-301, DIC-105 and VLS-104) were resistant to head scab.

Multiple disease resistance: Out of 53 genotypes evaluated against yellow rust and powdery mildew. Thirty nine and 27 genotypes were found free from yellow rust and powdery mildew, respectively.

Evaluation of advanced breeding material against major diseases (RWRC, Malan)

Yellow rust: In all, 1669 entries comprising Plant Pathological Screening Nursery (260), Elite Plant Pathological Screening Nursery (51), Initial Plant Pathological Screening Nursery (1156), AVT (149) and Multiple Disease Screening Nursery (53) were evaluated against yellow rust at RWRC, Malan. The results are given in Table 15. It has been observed that out of 1669 entries from various screening nurseries, 843 entries were free from yellow rust while 248 entries were highly resistant (DS=<5S). The information about the resistant entries is given below.

Table 15. Stripe rust resistant entries in stable wheat breeding material

Nursery	No. of entries	Resistant entries with reaction to yellow rust	
		Free	Severity ≤ 5
EPPSN	51	39	6
IPPSN	1156	532	170

PPSN (NIVT)	260	153	38
AVT	149	87	18
MDSN	53	32	16
Total	1669	843	248

Initial Plant Pathological Screening Nursery (IPPSN):

Disease Severity (Free): 532 entries
Highly resistant (Disease severity ≤5S): 170 entries

Plant Pathological Screening Nursery (PPSN):

AVT

YR Disease Severity 0 (Free): NHESZ-1704, NHESZ-1705, NHESZ-1706, NHESZ-1707, NHESZ-1708, NHESZ-1709, NHESZ-1710, NHTSZ-1701, NHTSZ-1702, NHTSZ-1703, NHTSZ-1705, NHTSZ-1706, NHTSZ-1707, NHLSZ-1701, NHLSZ-1703, NHLSZ-1704, NHLSZ-1706, NHLSZ-1707, NHLSZ-1708, NHLSZ-1709, NHLSZ-1710, NWTS-101, NWTS-102, NWTS-105, NWTS-106, NWTS-107, NWTS-108, NWTS-109, NWTS-110, NWTS-112, NWTS-114, NWLS-201, NWLS-202, NWLS-203, NWLS-206, NWLS-208, NWLS-209, NWRI-301, NWRI-302, NWRI-303, NWRI-304, NWRI-306, NWRI-308, NE-IR-101, NE-IR-103, NE-IR-106, NE-IR-108, NE-IR-111, NE-IR-112, NE-IR-113, NE-IR-114, NE-IR-302, NE-IR-303, NE-IR-304, NE-IR-305, NE-IR-306, NE-IR-307, CZ-TS-101, CZ-TS-103, CZ-TS-104, CZ-TS-105, CZ-TS-108, CZ-TS-109, CZ-RI-301, CZ-RI-302, CZ-RI-304, CZ-RI-305, CZ-RI-306, PZ-TS-104, PZ-TS-110, PZ-TS-111, PZ-TS-115, PZ-RI-303, PZ-RI-304, PZ-RI-305, PZ-RI-306, PZ-RI-307, PZ-RI-309, PZ-RI-313, VLS-103, VLS-104, VLS-105, VLS-106, VLS-107, VLS-108, VLS-109 and VLS-110. (87)

YR Disease severity ≤ 5S (Highly resistant): NHESZ-1702, NHESZ-1711, NHLSZ-1705, NWTS-103, NWTS-104, NWTS-113, NWTS-115, NWLS-204, NWLS-207, NWRI-305, NE-IR-109, NE-IR-115, NE-IR-309, CZ-RI-303, CZ-RI-307, PZ-TS-106, DIC-102 and VLS-101. (18)

NIVT

YR Disease Severity 0 (Free): N-102, N-104, N-105, N-109, N-110, N-112, N-114, N-115, N-117, N-118, N-119, N-120, N-124, N-125, N-126, N-127, N-128, N-129, N-131, N-132, N-133, N-134, N-136, N-201, N-202, N-203, N-205, N-207, N-208, N-210, N-212, N-213, N-215, N-216, N-218, N-219, N-220, N-221, N-222, N-224, N-225, N-226, N-227, N-229, N-230, N-231, N-232, N-233, N-302, N-303, N-304, N-311, N-314, N-318, N-320, N-322, N-326, N-328, N-335, N-401, N-403, N-404, N-405, N-406, N-407, N-408, N-409, N-410, N-411, N-412, N-414, N-416, N-417, N-418, N-419, N-421, N-422, N-423, N-425, N-426, N-427, N-428, N-429, N-430, N-431, N-433, N-434, N-435, N-436, N-505, N-506, N-509, N-511, N-512, N-519, N-520, N-521, N-522, N-523, N-601, N-602, N-603, N-604, N-606, N-607, N-608, N-610, N-611, N-612, N-613, N-615, N-616, N-619, N-620, N-621, N-622, N-623, N-624, N-625, N-702, N-703, N-705, N-706, N-707, N-708, N-709, N-710, N-711, N-715, N-720, N-721, N-722, N-723, N-725, N-805, N-806, N-813, N-816, N-823, N-824, N-825, NHIVT-1701, NHIVT-1702, NHIVT-1703, NHIVT-1704, NHIVT-1705, NHIVT-1707, NHIVT-1709, NHIVT-1711, NHIVT-1712, NHIVT-1713, NHIVT-1714 and NHIVT-1715. (153)

YR Disease severity ≤ 5S (Highly resistant): N-101, N-107, N-111, N-113, N-116, N-121, N-122, N-130, N-206, N-209, N-211, N-228, N-234, N-301, N-313, N-315, N-323, N-332, N-336, N-413, N-415, N-420, N-424, N-507, N-516, N-517, N-524, N-609, N-614, N-701, N-704, N-712, N-713, N-714, N-803, N-817, NHIVT-1706 and NHIVT-1708. (38)

Powdery Mildew Screening Nursery (PMSN):

Free (Disease reaction = 0): NIL
Highly resistant (Disease reaction = 1): CZ-RI-302
Resistant (Disease reaction = 2-3): NHTSZ-1705, NWTS-110, NWRI-308, NE-IR-111, NE-IR-112, NE-IR-115, NE-IR-303, CZ-TS-109, DIC-106. (9)

Multiple Disease Screening Nursery (MDSN):

Yellow rust

Free: HI 8759 (d), HI 8774 (d), HPPAU 05, HPW 423, HPW 433, HS 622, HS 623, HS 626, PBW 725, PBW 760, RKD 283 (d), TL 3006 (T), TL 3007 (T), TL 3008 (T), TL 3009 (T), VL 3012, WH 1216, WH 1310, HS 627, WB 2, DBW 216, DBW 217, DBW 219, RKD 292 (d), VL 4001, DBW 220, PBW 757, HPPAU 10, HPW 424, NW 6046, PDW 344 (d), UAS 459 (d).
Highly resistant (Disease severity ≤5S): HS 628, PBW 756, VL 3002, WH 1181, RAJ 4015, DBW 179, DDK 1051, WH 1215, UP 2955, VL 3011, UP 2954, DBW 88, HD 2967, HD 3171, HD 3043.

Powdery mildew

Free: NIL
Resistant (Disease reaction = 2-3): HPW 433, HS 622, HS 623, HS 626, RKD 283 (d), TL 3006 (T), TL 3007 (T), TL 3008 (T), TL 3009 (T), WH 1310, HS 627, WH 1184, WB 2, DBW 216, DBW 219, MACS 5044, WH 1215, UP 2955, HD 2967, HD 3171 and HD 3043.
Hence, from overall performance of 53 entries it was found that entries HPW 433, HS 622, HS 623, HS 626, RKD 283 (d), TL 3006 (T), TL 3007 (T), TL 3008 (T), TL 3009 (T), WH 1310, HS 627, WB 2, DBW 216, DBW 219, WH 1215, UP 2955, HD 2967, HD 3171, HD 3043 were resistant both against yellow rust and powdery mildew at Malan.

Elite Plant Pathological Scren Nursery (EPPSN):

Yellow rust
Free: HI 1612, HI 8791 (d), HS 611, PBW 777, PBW 778, TL 3011, TL 3012, TL 3013, TL 3014, TL 3015, UAS 462 (d), UP 2993, VL 1011, VL 1012, VL 3013, VL 3014, HPW 449, HS 644, HS 646, MACS 5049, MACS 6677, DBW 246, HI 1620, HD 3271, HD 3272, HI 1619, HPW 439, HS 645, HS 648, KRL 370, PBW 750, PBW 780, VL 1013, WH 1233, WH 1316, B 662, HG 110, IWP 5019, LINE 1172
Highly resistant (disease severity ≤5S): DBW 251, WH 1232, HD 3219, HPW 448, MP 1318 and BRW 3773.

Hill Bunt Screening Nursery (HBSN):

Out of 29 entries from northern hill zone (NHZ) evaluated against hill bunt at Malan, entries namely NHLSZ-1702 and NHLSZ-1709 showed lesser incidence of hill bunt i.e. 9 and 10.7 per cent, respectively. Whereas, entries NHESZ-1708, NHTSZ-1707, NHESZ-1706, NHESZ-1701, NHTSZ-1701 were found highly susceptible to hill bunt with incidence above 40 per cent (Table 16).

Table 16. Reaction of entries from Hill Bunt Screening Nursery (2017-18) to hill bunt at Malan

Entry	Hill Bunt Incidence (%)	Entry	Hill Bunt Incidence (%)	Entry	Hill Bunt Incidence (%)
NHESZ-1701	45.9	NHESZ-1711	15.2	NHLSZ-1702	9.0
NHESZ-1702	29.7	NHESZ-1712	15.2	NHLSZ-1703	16.1
NHESZ-1703	16.9	NHTSZ-1701	48.0	NHLSZ-1704	26.9
NHESZ-1704	34.1	NHTSZ-1702	30.5	NHLSZ-1705	22.1
NHESZ-1705	14.3	NHTSZ-1703	27.8	NHLSZ-1706	19.8
NHESZ-1706	43.7	NHTSZ-1704	35.6	NHLSZ-1707	24.0
NHESZ-1707	30.9	NHTSZ-1705	18.1	NHLSZ-1708	30.4
NHESZ-1708	40.8	NHTSZ-1706	37.1	NHLSZ-1709	10.7
NHESZ-1709	22.7	NHTSZ-1707	42.0	NHLSZ-1710	14.9
NHESZ-1710	16.3	NHLSZ-1701	15.3	HPW 373	37.6
				VL 892	25.5

Evaluation of Recombinant inbred lines from cross PBW 373 x PBW 703 against powdery mildew: 333 RILs received from PAU were evaluated against powdery mildew and the resistance RILs at seedling and adult plant stage included: Free from disease at seedling at adult plant and seedling stage: 6; Free at seedling and resistant (DR=3) at adult plant stage: 8; Free at adult plant and resistant (IT=2) at seedling stage: 4; Resistant at adult plant stage and free at seedling stage: 1; Resistant at adult plant stage and free at seedling stage: 2; Resistant (DR=3) at adult plant stage and free at seedling stage: 9; Resistant (DR=3) at adult plant stage and free at seedling stage: 6; Moderately Resistant (DR=4) at adult plant stage and free at seedling stage: 9; Moderately Resistant (DR=4-5) at adult plant stage and moderately resistant (IT=2) at seedling stage: 13

Evaluation of CIMMYT Linked top cross material from CYMMIT against stripe rust and powdery mildew Set I: Two hundred seventy eight lines generated from Linked Top Crosses involving land races, elite germpasm and wild species were generated at CIMMYT. These were evaluated at RWRC, Malan against stripe rust and powdery mildew and results are: **Free from yellow rust:** 8; **Highly resistant (DR=5S):** 37; **Resistant (DR=10S):** 47; Free from powdery mildew (1): 10; Resistant to powdery mildew (DR=2-3): 60; Moderately resistant (DR=4): 80

Evaluation of CIMMYT Linked top cross material from CYMMIT against stripe rust and powdery mildew Set II: Seven hundred ninety seven (797) lines generated from Linked Top Crosses

involving land races, elite germpasm and wild species were generated at CIMMYT. These were evaluated at Palampur and Dhaulakuan against powdery mildew and yellow rust. It was observed that 275 genotypes were free from yellow rust whereas 120 and 100 were highly resistant (5S) and resistant (10S). Further at Palampur, 17, 4, 6, 33 and 7 genotypes were free, highly resistant (DR=1) resistant (DR=2-3) and moderately resistant (DR=4) to powdery mildew.

Evaluation of RILs against powdery mildew: Five hundred fourteen Recombinant inbred lines (RILs) generated from the crosses PBW 114/Tb 5088/PBW 343; PDW 274/Tb5088/PBW 343; PBW 114/Tb 5088/PBW 621 and PDW 274/Tb 5088/PBW 621 were evaluated at adult plant stage against powdery mildew. It was observed that 58 lines were free from powdery mildew whereas 4 lines were highly resistant, 10 lines were resistant and 15 lines were moderately resistant.

European lines: More than 200 Eupean varieties were evaluated for powdery mildew resistance at Palampur. It was observed that 78 varieties were free from powdery mildew whereas 19 and 4 varieties were resistant and moderately resistant, respectively.

Disease Management

Evaluation of BAS 751 04 EC against stripe rust: A new fungicide BAS 751 04 F EC was tested for its bio-efficacy for the control of stripe rust of wheat (Table 17). Two sprays of test fungicide was found effective for the management of stripe rust at 1.6 ml/l giving 91.6 per cent control followed by doses 1.4 ml/l, 1.2 ml/l and 1.0 ml/l which gave 88.0, 88.0 and 87.0 per cent stripe rust control, respectively as compared to untreated check. An increase in yield was also observed with all doses of test fungicides as compared to control. However, test fungicide @ 1.6 ml/l proved at par in effectiveness with Propiconazole 25% EC in controlling stripe rust of wheat. No phyto-toxic symptoms could be observed on 1, 3, 7, 10 & 15 days after spray at all doses of test fungicide

Table 17. Evaluation of BAS 751 04 F EC against stripe rust of wheat

Treatment	Dose (ml/l)	Rust Severity (%)	% Disease Control	Yield (q/ha)
T1: BAS 751 04 F EC	1.0	9.7 (18.1)	87.0	39.3
T2: BAS 751 04 F EC	1.2	9.0 (17.4)	88.0	40.7
T3: BAS 751 04 F EC	1.4	9.0 (17.4)	88.0	43.8
T4: BAS 751 04 F EC	1.6	6.3 (14.5)	91.6	43.7
T5: BAS 750 02 F SC	0.35	13.0 (21.1)	82.6	43.5
T6: Propiconazole 25% EC	1.0	7.6 (16.1)	89.8	43.0
T7: Untreated control		74.7 (59.7)		28.1
	CD (0.05)	2.4		2.2
	CV (%)	5.8		6.1

Evaluation of BAS 750 02 F EC against stripe rust: A new fungicide BAS 750 02 F SC was tested for its bio-efficacy for the control of stripe rust of wheat (Table 18). Two sprays of test fungicide was found effective for the management of stripe rust at 0.8 ml/l giving 92.2 per cent control followed by other doses as compared to untreated check. An increase in yield was also observed with all doses of test fungicides as compared to control. However, test fungicide @ 0.8 ml/l proved at par in effectiveness with Propiconazole 25% EC in controlling stripe rust of wheat. No phyto-toxic symptoms could be observed on 1, 3, 7, 10 & 15 days after spray at all doses of test fungicide.

Table 18. Evaluation of BAS 750 02 F SC against Stripe rust of wheat

Treatment	Dose (ml/l)	Rust Severity (%)	% Disease Control	Yield (q/ha)
T1: BAS 750 02 F SC	0.5	9.2 (17.6)	87.6	36.4
T2: BAS 750 02 F SC	0.6	8.2 (16.5)	88.9	48.8
T3: BAS 750 02 F SC	0.75	7.0 (15.3)	90.5	53.7
T4: BAS 750 02 F SC	0.8	5.8 (13.9)	92.2	51.2
T5: Propiconazole 25% EC	1.0	6.5 (14.7)	91.2	43.0
T6: Untreated control		74 (59.4)		28.1

	CD (0.05)	3.5		2.6
	CV (%)	8.4		6.3

Evaluation of Azoxystrobin 7.5% + Propiconazole 12.5% SE against stripe rust: A new fungicide Azoxystrobin 7.5% +Propiconazole 12.5% SE was tested for its bioefficacy for the control of stripe rust of wheat (Table 19) during *Rabi* 2017-18. Two sprays of test fungicide was found effective for the management of stripe rust at 3.0 ml/l giving 97.7 per cent control followed by other doses as compared to untreated check. An increase in yield was also observed with all doses of test fungicides as compared to control. No phyto-toxic symptoms could be observed on 0, 1, 3, 5, 7 & 10 days after spray at all doses of test fungicide.

Table 19. Evaluation of Azoxystrobin 7.5% + Propiconazole 12.5% SE against Stripe rust of wheat

Treatment	Dose (ml/l)	Rust Severity (%)	Per cent Disease Control	Yield (q/ha)
T1 : Azoxystrobin 7.5% +Propiconazole 12.5% SE	2.0	2.8 (9.6)	96.2	44.5
T2 :Azoxystrobin 7.5% +Propiconazole 12.5% SE	2.5	2.2 (8.4)	97.0	47.6
T3 :Azoxystrobin 7.5% +Propiconazole 12.5% SE	3.0	1.7 (7.3)	97.7	48.0
T4 :Azoxystrobin 23% SC	1.6	5.0 (12.8)	93.2	37.7
T5 :Propiconazole 25% EC	1.6	4.3 (11.8)	94.2	41.4
T6 :Azoxystrobin 11% +Tebuconazole 18.3% SC	2.5	3.7 (10.8)	95.0	47.9
T7 :Control		74.0 (59.3)	-	25.8
CD (0.05)		2.2		3.3
CV (%)		7.4		4.4

Evaluation of Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) as seed treatment against Loose smut (*Ustilago nuda tritici*) and Karnal bunt (*Tilletia indica*): Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS) was tested as seed treatment @ 0.5 g/Kg, @1.0 g/Kg, @1.5 g/Kg, and 3g/kg and Sedaxane 500FS @ 0.1 ml/kg ,Fludioxonil 100FS @ 0.5 ml/kg alonwith Carbendazim 25% + Mancozeb 50% vs @ 3.5 g/kg and Thiram 75 % WS 30 g/kg , Tebuconazle 5.36 % FS @ 0.33 ml/kg of seed for bio-efficacy and for phyto-toxicity evaluation (Table 20). Data were recorded on disease incidence of loose smut and Karnal bunt as per standard procedure. All the treatments were significantly effective in controlling loose smut / Karnal bunt of wheat when compared with control (Table 19). Seed treatment with Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS) at 3.0 g/Kg of seed , was significantly effective in controlling loose smut (97.79 %) / Karnal bunt (94.56%) per cent disease control over check along with 54.33 per cent increase in the grain yield. Among other tested fungicides Carbendazim 25% + Mancozeb 50% vs @ 3.5g/kg of seed treatment was found most effective with 87.01 and 75.78 per cent loose smut and Karnal bunt , respectively along with 42.34 % increase in yield. None of the treatment showed phytotoxicity.

Table 20. Evaluation of Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS) as seed treatment against important soil and seed borne diseases of wheat

Treatments	Dose (ml/g per Kg of seed)	Karnal bunt		Loose smut		Grain yield		1000 grain wt (g)
		Incidence (%)	Control over check (%)	Incidence (%)	Control over check (%)	Yield (kg/ha)	Per cent Increase (kg/ha)	

Untreated check	-	6.07 (14.25)	-	7.7 (16.08)	-	2709	-	35.33
Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS)	0.5	2.33 (8.76)	61.61	1.27 (6.36)	83.50	3829	41.34	40.67
Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS)	1.0	1.67 (7.37)	72.49	0.43 (3.52)	94.42	4373	61.42	40.0
Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS)	1.5	0.60 (4.28)	90.11	0.20 (2.56)	97.40	4304	58.87	38.67
Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS)	3.0	0.33 (3.19)	94.56	0.17 (2.13)	97.79	4181	54.33	41.33
Sedaxane 500 FS	0.1 ml	2.27 (8.64)	62.60	1.33 (6.60)	82.72	3669	35.44	38.0
Fludioxonil 100FS	0.5	2.27 (8.62)	62.60	1.20 (6.19)	84.41	3547	30.93	36.33
Carbendazim 25% + Mancozeb 50% vs	3.5	1.47 (6.90)	75.78	1.0 (5.72)	87.01	3856	42.34	38.67
Thiram 75 % WS	30.0	2.13 (8.68)	64.90	1.53 (7.09)	80.13	3813	40.75	37.33
Tebuconazle 5.36 % FS	0.33	1.93 (7.97)	68.20	1.70 (7.56)	77.92	4016	48.24	38.67
CD (P=0.05)	-	(6.87)	-	(5.28)	-	305	-	2.18

*Data in the parentheses are arc sin transformed values.

Evaluation of fungicides against loose smut: All the treatments were significantly effective in controlling loose smut of wheat when compared with control (Table 21). Seed treatment with Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) at 3.0 ml/ Kg of seed was most effective giving 97.8 % disease control and resulting in an increase of 24.7% in the grain yield. It was closely followed by Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) at 1.5 ml/ Kg of seed with 97.2 % disease control and 23.6% increase in yield and both were statistically at par for the control of loose smut. Among other tested fungicides, Carbendazim 25% + Mancozeb 50% WS @ 3.5g/ kg of seed was found very effective giving 86.7% per cent disease control and 23.5% increase in yield and followed by Tebuconazle 5.36 % FS and Thiram 75 % WS, respectively. All the treatments were non-significant with respect to grain yield over the check however, maximum increase in yield was obtained with Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) @ 3.0 ml/ kg seed. None of the treatments showed phytotoxicity.

Table 21. Evaluation of Sedaxane 2.5% w/v +Fludioxonil 2.5 % w/v (50FS) as seed treatment against important soil and seed borne diseases of wheat

Treatments	**Dose (ml/ g per Kg of seed)**	**Loose smut**		**Grain yield**		**1000 grain wt (g)**
		Incidence (%)	Control (%)	Yield (kg/ha)	Per cent Increase (kg/ha)	
Untreated check	-	9.00 (17.45)	-	14.62	-	30.2
Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS)	0.5	1.50 (7.03)	83.3	15.34	4.9	31.0
Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS)	1.0	0.52 (4.14)	94.2	16.92	15.7	31.7
Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS)	1.5	0.25 (2.87)	97.2	18.07	23.6	32.5
Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS)	3.0	0.20 (2.55)	97.8	18.23	24.7	32.6

Sedaxane 500 FS	0.1	1.62 (7.31)	82.0	17.57	20.2	32.0
Fludioxonil 100FS	0.5	1.41 (6.82)	84.3	16.90	15.6	31.5
Carbendazim 25% + Mancozeb 50% WS	3.5	1.20 (6.78)	86.7	18.05	23.5	32.3
Thiram 75 % WS	3.0	1.98 (8.09)	78.0	17.59	20.3	32.2
Tebuconazle 5.36 % FS	0.33	1.79 (7.68)	80.1	17.87	22.2	32.0
CD (P=0.05)	-	0.48	-	NS		NS

*Data in the parenthesis are arc sin transformed values.

Barley

Identification of resistant sources

Yellow rust: A total of 661 barley lines/ genotypes constituting Initial Barley Disease Screening Nursery (IBDSN), National Barley Disease Screening Nursery (NBDSN) and Elite Barley Disease Screening Nursery (EBDSN) were screened against yellow rust under artificial inoculation. The results are summarized in the Table 22.

Table 22. Barley stocks/ genotypes resistant to yellow rust

Nursery Name	Total entries	Resistant entries
IBDSN	417	396
NBDSN	163	161
EBDSN	81	0

The details of promising genotypes for YR under different nurserieas are given below:

Initial Barley Disease Screening Nursery (IBDSN): A total of 137 genotypes out of 417 tested were found resistant to Stripe rust. The promising entries with yellow rust resistance were BL1492, BL1491, BL1474, BL1429, BL1421, BL1413, BL1411, BL1404, BL1420, BL1378, BL1400, BL1403, BL1363, BL1322, BL1325, BL1340, BL1313, BK1701, BK1702, BK1703BK1704, BK1705, BK1706, BK1708, BK1709, BK1710, BK1711, BK1713, BK1714, PKB1709, PKB1743, PKB1706, HUBL1713, HUBL1714, HUBL1715, UPBM9, BH1702, BH1708, BH1709, BH1713, BH1733, BH1740, BH1741, BH1742, BH1743, BBM770, BBM771, BBM772, BBM773, BBM774, BBM775, BBM776, BBM777, BBM779, BBM781, BBM782, BBM784, BBM786, BBM787, BBM788, BBM789, BBM790, BBM791, BBM794, HB863, HB860, HB858, HB857, HB856, HB855, HB854, HB853, HB852, HB851, HB850, HB849, HB848, HB847, HB846, HB845, HB844, HB843, HB842, JB372, JB373, JB374, JB375, JB379, JB380, JB383, NDB1709, BD1755, BD1756, BD1757, BD1758, BD1759, BD1760, BD1761, BD1762, BD1763, BD1764, BD1765, BD1766, BD1767, BD1768, BD1769, BD1770, BD1771, BD1772, BD1773, BD1774, BD1775, BD1776, BD1778, BD1779, BD1780, BD1781, BD1782, BD1783, BD1784, BD1785, BD1786, BD1787, BD1788, BD1790, VB1725, VB1715, DWRFB10, DWRFB11, DWRFB12, DWRFB13,DWRFB14, DWRFB15, DWRFB19, DWRFB20, DWRFB21, DWRFB28 and DWRFB29.

National Barley Disease Screening Nursery (NBDSN): A total of 108 genotypes out of 163 tested were found resistant to Stripe rust. The promising entries with yellow rust resistance were ABI Voyager, Andreia, BH1020, BH1021, BHS461, BHS462, BHS463, BHS464, BHS465, BHS466, BHS468, DWRB160, DWRB180, DWRB181, DWRB182, DWRB183, DWRB184, DWRB185, HBL789, HBL793, HBL797, HBL802, HBL804, HBL812, HBL818, HBL822, HUB253, HUB260, HUB262, HUB263, JB357, KB1605, KB1616, KB1633, NDB1682,NDB1683, NDB1699, PL891, PL892, PL898, PL900, PL902, PL903, PL904, Planet, RD2969, RD2974, RD2976, RD2977,RD2978, RD2979,RD2980, RD2984, RD2988, UPB1070, VLB155, VLB156, VLB157, VLB158, VLB160 and Xanadu.

Elite Barley Disease Screening Nursery (EBDSN): A total of 46 genotypes out of 81 tested were found resistant to Stripe rust. The promising entries with yellow rust resistance were DWR47, BK1601, DWRB137, PL890, PL892, PL895, BH1009, BH1011, BH1013, BH1014, BH1017, BH1018, BH1019, HBL113, HBL764, KB1531, RD2786, RD2794, RD2899, RD2917, RD2947, RD2948, RD2949, RD2951, RD2954, RD2955, RD2956, RD2957, RD2959, RD2961, JB350, DWRB150, DWRB152, BK1518, BK1525, HBL757, HUB247, BCU7746, BCU7811, BCU7819, DWRB101, RD2941, BHS459, VLB150, VLB153 and PL751.

Maize

Evaluation of Germplasm

A total of 300 maize and 85 specialty corn (QPM, Pop Corn, Sweet Corn and Baby Corn) genotypes comprising of various maturity groups were evaluated against **Turcicum leaf blight (TLB)** during *kharif*, 2017. The screenings of these genotypes were carried out under artificial epiphytotic conditions. The details of promising genotypes under various maturity groups and speciality corn are given below:

Resistant maize genotypes in NIVT late maturity

A total of 31 genotypes out of 84 tested were resistant to turcicum leaf blight. Promising genotypes resistant against TLB were JH 16118, CP 858, BH 415017, NS 8282, GIN-04, VEH-17-1, IMHBG-17K-25, OMH16-2, DKC 9185 (IR8449), IMHBG-17K-24, AYN716443, IIMRNH 1701, QMH-1420, JH 16031, GH 160224, KMH 463, CMH 14-720, JH 13346, SVMH-66, Rasi-2432, IMHBG-17K-20, CMH 15-005, MAH-2014-3, DKC 9182 (IR8513), PM17104L, GH-1301, VNR-35379, AMH-15119, PM17106L, IMHBG-17K-23, IIMRNH 1704. Fourty seven genotypes viz. CP 777, OMH16-3, AH-1608, MFH 16-22, JH 16081, JKMH 150375, KH-2193, JH 16041, KNMH-4513, AH-8183, JH 16209, JH 16054, VEH-17-1, MAH-2014-19, PM17105L, GH 160131, JH 16046, KNMH-4410, IIMRNH 1705, QMH-1353, Super-1818, TMMH 2840, AH-1645, IIMRNH 1703, ADV 1390164, TS 2505, NMH-4530, CMH 14-714, JH 16034, B-57, MFH 16-21, CCH 2829, QMH-1347, JH 13336, CMH 14-721, PM17101L, ADV 1390064, DAS-MH-115, DKC9189 (IR8545), OMH16-1, BIO 218, DAS-MH-114, TA 5084, GK 3211, JH 16040, HT 17169, Rasi-3499 were found moderately resistant against TLB.

Resistant maize genotypes in NIVT medium maturity

A total of 15 genotypes showed resistant reaction to turcicum leaf blight out of 100 genotypes. Promising genotypes resistant to TLB were EH 2898, IMHBG-17K-6, 16402-008-01-01-03-5-2, WH-1094, DKC7181 (IR8003), ADV 140235, AH-7067R, IMHBG-17K-18, BH 415158, IMHBG-17K-10, MMH 16-11, EH 2870, GH 160295, AH-1606, IMHBG-17K-5. However, seventy seven genotypes viz. HKH 364, KMH 16-2, BLH 122, AH 6017, BLH 121, LMH 1017, IIMRNH 1702, RCRMH3(CAH156), BLH 120, VaMH 15036, SYN716725, IMHBG-17K-19, JH 16029, HKH 361, UDMH-132, KH 103, IMHBG-17K-3, LMH 817, JASL-2033, IMHBG-17K-2, LMH 917, IMHBG-17K-12, UDMH-131, IMHBG-17K-4, IMHBG-17K-16, JH 16045, LMH1117, IMHBG-17K-14, AH 6008, KMH 16-40, K-27, IMHBG-17K-8, STAR-X-16, STAR-X-20, DAS-MH-311, BRMH-10 (CAH-1566, AMH-14258, HKH 363, WH-1010, GK 3215, MMH 16-12, KMH 16-42, IMHBG-17K-13, PM17102M, KMH 16-29, BLH 119, DH-314, GK 3213, IMHBG-17K-21, PM17103M, IMHBG-17K-22, JKMH 15303, NMH-4053, CCH 1818, BLH 118, BH 415012, STAR-X-14, NMH-4139, VaMH 15005, AH 6009, IMHBG-17K-11, JH 32055, IMHBG-17K-17, IMHBG-17K-1, AH 6007, REH 2013-21, IMHBG-17K-9, RCRMH 4-1, BH 415100, GIN-03, ADV 140187, KMH 16-25, DKC8181 (IR8004), IMHBG-17K-15, BLH 117, STAR-X-18, OMH16-4 showed moderately resistant reaction against TLB

Resistant maize genotypes in NIVT early and extra early maturity

A total of 2 genotypes JH 32010 and FH 3816 showed resistant reaction against Turcicum leaf blight out of 40 genotypes tested. Sixteen genotypes viz. IH-1002, AH-7188, MEH 16-1, DH-313, EH 2878, JH 31947, FH 3823, MEH 16-2, LMH 1115, AH-7080, AH 9003, REH 2013-17, IH-0652, FH 3837, EH 2891, JH 32013 were found moderately resistant against TLB.

Resistant maize genotypes in QPM

A total of 14 genotypes viz. IIMRQPMH 1704, IIMRQPMH 1701, APH-1, APQH-7, QPM MH 27, IIMRQPMH 1602, QPM MH 30, IIMRQPMH 1706, FQH 106, IIMRQPMH 1605, OPQMH 15-1, IIMRQPMH 1709, IIMRQPMH 1606, APH 27 showed resistant reaction against TLB out 45 genotypes screened. Twenty three genotypes viz. IIMRQPMH 1711, DQH 111, BQPMH 16, IIMRQPMH 1609, APQH-5, LQPMH 415, IIMRQPMH 1508, IIMRQPMH 1708, VEQH-16-1, IIMRQPMH 1712, EHQ 64, IIMRQPMH 1710, IIMRQPMH 1603, IIMRQPMH 1705, DQH 112, OQPMH-14191, IIMRQPMH 1702, IIMRQPMH 1608, IIMRQPMH 1703, IIMRQPMH 1713, IIMRQPMH 1601, IMHQPM 1530, IIMRQPMH 1707 were found moderately resistant against TLB.

Screening of association panel against different diseases of maize

A total of 296 genotypes were screened artificially against Turcicum leaf blight (TLB). One hundred Thirty two genotypes were found resistant against TLB. Some of the promosing genotypes are BML 7, BML-45, BRASIL-117, DML-112, DML-119, DML-16, DML-170, DML-181, DML-19, DML-221, DML-242, DML-310, DML-346, DML-37-1, DML-416, DQL-1017-2, HKI 42050, UMI 1201, UMI 1230, V-373, DQL-609(dark purple)-1-3, DQL-610-12-4, DQL-780-2, DQL-781-2, DQL-621-1-1A, DQL-565 (V)-5-2 (Orange), DQL-626 (ORANGE)-2-3, DQL-574-2, DQL-602-2, DQL-609-5, DQL-614-6, CM 120, CM 140, CM202XE57, CM 210, CM 212, CM 213, CML 171, CML 282, CML 29, CML 295BBB, CML 304, CML 409, CML 40BBB, CML

422, CML 451XE62, CML 452, CML 494, CM 108, CML 208BBB, CML 218BBB, CML 248, CML 269, CML 271BBB 2, CML 278,CML 279, CML 322, CML 37 3, CML 195, CML 493BBB, CML 542 W, CML 549 W, CML 551, CML 556 W, CML 557 W, CML 559 W, LM 14, HKI 193-2, HKI 1344, HKI 1348-6-2, HKI 1352, MAI-105, CML 170, CML 175,CML 319, WOXY 418, IML12-2, IML12-9, IML12-52, IML12-74, IML12-116, IML12-133, IML12-135, IML12-143, IML12-161, IML 12-166, IML12-212, IML 12-213, IML12-215, IML13-62, IML 13-84, IML15-2, IML15-48, IML15-97, IML15-131, IML15-186, IML15-202, IML15-244, IML15-288, IML16-27, IML16-28, IML16-134, IML16-143, IML16-108, IML16-146, IML16-162, IML16-183, IML16-188, IML16-193, IML16-210, IML16-230, IML16-231, IML16-269, IML16-282, DML-187-2, CM 123, CML 33, CML 334(W), CML 373, DML 281, DML 339, DML 57-2, DQL 364-1-4, HKI 1040-7, HKI 484-5, P 19 (IML-16-19), P 14 (IML- 16-14), DML 36, V 335, CML 161/CML 16.

Phenotyping for Turcicum Leaf blight

A total of 461 genotypes were screened artificially against Turcicum leaf blight (TLB). Out of them, 190 genotypes showed resistant reaction.

Screening of maize hybrids of public and private sector

Seventeen maize hybrids of public and private sectors were screened against Turcicum leaf blight (TLB) and Maydis leaf blight (MLB) under artificial epiphytotic conditions conditions. All the maize hybrids were found resistant/ moderately resistant against both the diseases. Maize hybrids PG-2400 Ruby, P 3542, Yuvraj Gold and P 3436 were found resistant against both diseases (Table 23).

Table 23. Evaluation of maize hybrids against Turcicum and Maydis Leaf Blights

Hybrid	TLB		MLB	
	Disease Score (1-9 scale)	Reaction Type	Disease Score (1-9 scale)	Reaction Type
DKC 8164	3.5	MR	2.5	R
Bisco 855	5	MR	3	R
PG-2400 Ruby	2.5	R	2.5	R
Sarvani 20 M 20	5	MR	3	R
P 3542	3	R	2	R
PMZ 4 (C)	3.5	MR	2	R
DKC 9179	2.5	R	4	MR
Yuvraj Gold	2.5	R	2	R
Sumo-292	3	R	4.5	MR
AB 6786	5.5	MS	2.5	R
Palam Shankar Makka 2 (C)	2	R	5	MR
AB 6741	5	MR	3.5	MR
DKC 9164	4	MR	2	R
KH 2595	4	MR	2.5	R
LG 34.05	3.5	MR	4.5	MR
P 3436	3	R	2	R
HP 333 Gold	4.5	MR	2.5	R

Screening of QPM and normal maize lines against TLB

A total of 18 lines DQL 2048, DQL 2063-1, DQL 2070, DQL 2087, DQL 2157, DQL 2159, DQL 2105-1, DQL 2160, DQL 2238, DQL 2293, DQL 2294, DQL 2295, DQL 2298, DQL 2301, DQL 2302, DQL 2304, DQL 2111and DQL 2015-1 showed resistant reaction against Turcicum leaf blight out of 51 tested. Twenty one lines were found moderately resistant against TLB.

C. Pulses

Chickpea

Evaluation of International Chickpea Ascochyta Blight Screening Nursery (2018): Thirty lines of chickpea were evaluated against Ascochyta rabiei at Palampur. It was observed that lines ICWA 1633, 1640, 1641, 1642, 1643, 1644 and ICWA 05529 with disease reaction (3.5-4.0) were resistant.

Screening of Rajmash germplasm against major diseases

During 2017-18 cropping season in total 190 genotypes/ lines were screened under natural conditions against BCMV, angular leaf spot and anthracnose of Rajmash at MAREC, Sangla. Most of the entries were found susceptible to BCMV and Angular leaf spot. Lines EC61323, EC316088, SR 6-1, KRC 22 , KR-280, AK-64, K-243 , Naggar Local, KR-16 found resistant to anthracnose whereas entries SR7-3, Rakchum local, SBG211, KR248, Hans, K 16, EC61323 & KR-227 were found resistant(scoring 1 to 3 in 0-9 scale) to anthracnose & ALs. Lines KR-82, KR-205, KR-148, KR-307, KR-15, HPR-224, EC-93800, KRC-22, SBG-88, HPR-396 and HPR-339 were found resistant to BCMV. In Rajmash variety, Hans and Kailash were found moderately susceptible to root rot disease at Sangla.

Common bean lines selected on the basis of performance from germplasm evaluation were advanced to IVT-I & IVT- II trial. In AVT-I, Lines JK5-95-2, JHR-4 & JK5-49 were found resistant to BCMV & angular leaf spot. In AVT II lines, JK22-6-1-1-5, JKS71, &EC530913 were resistant to angular leaf spot and BCMV whereas lines JK22-29-1-4-1and JLR-250-1 were moderately resistant to anthracnose.

Screening of Pea and lentil nurseries

Fifty four pea lines were screened for Powdery mildew and root rot incidence under natural epiphytotic conditions at Sangla. Powdery mildew severity ranged between 1-5 (on 0-5 scale) whereas, root rot incidence ranged between 50-60 per cent.

In lentil 92 lines were screened for Aschochyta, Powdery mildew, wilt and root rot incidence at MAREC, Sangla.

D. Oilseeds

1. Soybean

Evaluation of germplasm for resistance sources

IVT entries: Field trial of forty two entries of Initial Varietal Trial (IVT) 2017 was planted on 20.06.2017. The disease incidence was recorded when the diseases were at terminal condition. The data were recorded based on 0-9 scale. The lines were categorized into different resistance categories. The entries; SL 1068 & AUKS 174 and JS 21-15, & KDS 992 were found absolute and highly resistant, respectively against FLS (*Cercospora sojina*). The entries; NRC 128, TS 53, NRC 136, CSB 10112 & PS 1613 and SL 1068, AUKS 174, MACS 1493, SL 1123, NRC 132, KDS 992, NRCSL 1, NRC 134, RSC 11-03, & SKF-SPS-11 were found absolutely and highly resistant, respectively against pod blight (*Colletotrichum truncatum*). The entries SL 1068, AUKS 174, MACS 1493, TS 53, SL 1123, CSB 10112, KDS 992, NRCSL 1, and RCS 11-03 were found having moderate to high multiple disease resistance.

AVT-I entries: Sixteen entries of AVT-I were sown in two replications along with five checks on 20.06.2017 in RBD. Data were recorded on 0-9 scale and disease reaction to the diseases is presented in table 4. Line KDS 1045, NRC 125, RSC 10-52 and RVS 2009-9 were found free from FLS (*Cercospora sojina*) while AMS MB 5-18, DSb 32, KDS 921were highly resistant. For pod blight (Ct), KDS 921, MACS 1520, NRC 126 and RVS 2009-9 were found disease free while AMS-MB 5-18, NRC 125, NRC 127 and SL 1104 were highly resistant. RVS 2009-9 was observed free from both the diseases (Table 23).

AVT-II entries: Two replications of 10 entries of AVT-II 2017 along with five checks were sown on 20.06.2017 in RBD. Data were recorded on 0-9 scale and disease reaction to the disease was given against each entry. The line JS 20-116 was observed free from frogeye leaf spot (*Cercospora sojina*) while PS 1572 was highly resistant. PS 1556 and PS 1572 lines were found free from pod blight (Ct) while RVS 2010-1 and SL 1074 were found highly resistant (Table 24).

Table 24: Disease reaction of soybean breeding materials AVT-I & II entries against various diseases

S. No.	Entry	FLS		PB(Ct)		BS	
	AVT I	Score	Reaction	Score	Reaction	Score	Reaction
1	AMS–MB 5-18	1	HR	1	HR	3	MR
2	DSb 32	1	HR	3	MR	3	MR
3	DS 3105	5	MS	3	MR	3	MR
4	DS 3106	5	MS	5	MS	3	MR
5	KDS 921	1	HR	0	AR	3	MR
6	KDS 980	5	MS	3	MR	3	MR
7	KDS 1045	0	AR	3	MR	3	MR
8	MACS 1520	3	MR	0	AR	1	HR
9	NRC 125	0	AR	1	HR	3	MR
10	NRC 126	5	MR	0	AR	1	HR
11	NRC 127	5	MS	1	HR	3	MR
12	RSC 10-52	0	AR	3	MR	3	MR
13	RSC 10-70	3	MR	3	MR	3	MR
14	RSC 10-71	3	MR	3	MR	3	MR
15	RVS 2009-9	0	AR	0	AR	1	HR
16	SL 1104	9	HS	1	HR	3	MR
	AVT-II						
17	JS 20-94	3	MR	3	MR	3	MR

18	JS 20-116	0	AR	5	MS	1	HR
19	PS 1556	5	MS	0	AR	3	MR
20	PS 1572	1	HR	0	AR	3	MR
21	RSC 10-46	3	MR	3	MR	3	MR
22	RVS 2007-6	3	MR	3	MR	3	MR
23	RVS 2010-1	3	MR	1	HR	3	MR
24	SL 1028	5	MS	1	HR	3	MR
25	SL 1074	7	S	1	HR	5	MS
26	VLS 89*	3	MR	3	MR	3	MR
	Checks						
27	Shivalik	7	S	3	MR	5	MS
28	JS 335	5	MS	7	MS	3	MR
29	VLS 58	3	MR	**3**	MR	3	MR
30	VLS 63	3	MR	1	HR	3	MR
31	PS 1092	1	HR	5	MS	5	MS
32	VLS 59	1	HR	3	MR	3	MR

FLS= Frogeye leaf spot (*Cercospora sojina*) PB (Ct) =Pod blight (*Colletotrichum truncatum*), BS= Brown spot (*Septoria glycines*); AR= Absolute resistant, HR= Highly resistant, MR= Moderately Resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible,

Performance of the previous year's resistant entries (FLS and Pod blight (Ct)

Thirty one lines found resistant in IVT, AVT and AVT-II during 2016 *kharif* season either against frogeye leaf spot (*Cercospora sojina*) and pod blight(*Colletotrichum truncatum*) were sown along with two susceptible checks (JS 335 and Shivalik) in two replication on 22.06.2017. Two rows of 3.5m were kept in each line. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS), anthracnose (pod blight) and brown spot (BS) and the each entry was categorised into different disease reaction as presented in Table 25. Twenty five lines maintained their high resistance status against frogeye leaf spot. Twenty six lines maintained their high resistance status against pod blight. Fifteen lines have shown high to absolute resistance against both the diseases.

Table 25: Disease reaction of previous resistant entries against various diseases

S. No.	Entry	Year of testing	FLS		PB(Ct)	
			Score	Reaction	Score	Reaction
1	AMS–MB 5-18	First year	1	HR	1	HR
2	AMS MB 5-19	First year	0	AR	0	AR
3	DSb 32	First year	1	HR	3	MR
4	Himso 1685	First year	0	AR	0	AR
5	Himso 1687	First year	1	HR	0	AR
6	JS 20-116	First year	0	AR	5	MS
7	JS 20-87	First year	0	AR	0	AR
8	JS 20-96	First year	0	AR	0	AR
9	JS 20-98	First year	3	MR	0	AR
10	KDS 869	First year	1	HR	0	AR
11	KDS 921	First year	1	HR	0	AR
12	KDS 980	First year	5	MS	1	HR
13	KDS 1045	First year	0	AR	3	MR
14	MACS 1520	First year	1	HR	1	HR
15	MACS 1543	First year	3	MR	1	HR
16	NRC 117	First year	1	HR	1	HR
17	NRC 124	First year	1	HR	0	AR
18	NRC 125	First year	0	AR	1	HR

19	NRC 126	First year	5	HR	0	AR
20	NRC 127	First year	5	MS	1	HR
21	PS 1572	First year	1	HR	1	HR
22	PS 1587	First year	0	AR	0	AR
23	PS 1589	First year	1	HR	0	AR
24	RSC 10-52	First year	0	AR	3	MR
25	RVS 2008-24	First year	3	MR	1	HR
26	RVS 2009-9	First year	0	AR	0	AR
27	RVS 2010-1	First year	5	MR	3	HR
28	SL 1028*	First year	5	MS	1	HR
29	SL 1074	First year	7	S	1	HR
30	SL 1113	First year	0	AR	0	AR
31	TS 70	First year	3	MR	1	HR
	JS 335 Check		5	MR	7	S
	Shivalik Check		9	S	3	MR

Integrated management of pod blight complex of soybean

An experiment comprising eight treatments i.e. seed treatment alone with chemicals / bio-agent and in combination with foliar sprays with chemical/bio-agent along with check, was conducted with three replications in RBD. Experiment was planted on 22.06.2017. Data was recorded on % germination, plant stand (30 DAS), % pod infected, per cent disease Index, 100 seed weight and seed yield (kg/ha). Pooled data for 2015, 2016 and 2017 is given in Table 26. Soybean seed treatment with fungicide carboxin + thiram (Vitavax power) @ 2g/kg seed and two foliar sprays with thiophanate methyl @ 0.1% at 55 and 75 days after sowing effectively manage the pod blight and resulted higher seed yield (15.3q/ha) as comparisons to control (11.3 q/ha). Seed treatment with fungicide and two foliar sprays with thiophanate methyl effectively manage the pod blight and resulted higher seed yield.

Table 26: Effect of seed treatment and foliar application of chemicals and bio-agent on the pod blight of soybean (pooled data analysis 2015, 2016 and 2017)

Treatment	Germination (%)	Plant stand (%)	Per cent Disease Index (PDI)	% pod infected (Ct)	100 seed weight (g)	Seed yield (kg/ha)	B:C
T1: Seed Treatment (ST) with Carboxin + Thiram @ 2g/kg seed (Vitavax Power)	71.95	62.86	43.7	28.40	12.5	1345.33	0.96
T2: ST with carbendazim + mancozeb (Saaf) @ 2g/kg seed	68.59	62.11	38.8	29.60	12.5	1327.56	1.02
T3: ST with *Trichoderma viride* @ 5 g/kg seed	64.96	58.36	36.5	29.07	12.4	1293.17	0.97
T4: T1 + spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	71.93	62.51	6.9	7.67	13.5	1583.85	1.28
T5: T2 + spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	68.34	63.45	8.9	9.53	13.1	1517.68	1.19
T6: T3 + spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	64.59	57.78	10.6	10.17	13.1	1441.31	1.08
T7: spray with thiophanate methyl @ 0.1% at 55 and 75 DAS	58.64	54.02	11.6	9.47	13.0	1548.73	1.2
T8: Spray with *Trichoderma viride* @ 5g/L at 55 and 75 DAS	58.44	54.56	31.8	15.64	12.8	1344.31	0.87
T9: Control	60.69	56.15	49.6	34.34	12.1	1134.25	0.75
CD (P=5%)	5.22	4.44	4.612	5.78	0.389	121.19	-

Evaluation of germplasm for multiple disease resistant sources

Fifty soybean germplasm lines received from ICAR IISR, Indore were sown on 22.06.2017. Two rows of 3 meter length of each line were sown in augmented design. After every 10 lines two checks were sown. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS), anthracnose (pod blight) and brown spot (BS) and the each entry was categorised into different disease reaction. Eighteen lines; CAT 1328, CAT 1453, CAT 1878, CAT 2026, CAT 2034B, CAT 2090, CAT 233, CAT 292, CAT 313A, CAT 407, CAT 408, CAT 411A, CAT 411B, CAT 473B, CAT 992, CAT DSb-1, PS 1347 and SQL 89 were observed having multiple disease resistance against frogeye leaf spot, pod blight and brown spot.

2. Rapeseed-Mustard

Screening of *Brassica* germplasm and breeding material against different diseases

Forty three entries of rapeseed-mustard were screened against *Alternaria* blight and white rust diseases under natural conditions as per guidelines provided in the technical programme. Data on severity of diseases on leaves was recorded on 107 DAS at the time of maximum disease appearance, whereas *Alternaria* blight on pods was recorded at the time of crop maturity. Severity of Alternaria blight on leaves ranged from 33.9(DLSC-1) to 66.6 % (RH-923 and KMR (L) 15-5). The overall disease pressure of Alternaria blight on pods was low. The severity of *Alternaria* blight on pods varied from 5.6% (RH-919) to 47.7% (TH 1402 and PT 2010-5).

White rust appeared in moderate form during the crop season. Highest severity of white rust on leaves (48.8%) was recorded in RGN 400 and RH-761. Two entries namely DLSC-1 and GSL-1 belonging to *B. carinata and B. napus*, respectively remained free from white rust disease. Similarly severity of white rust was also low (< 10%) in entries like RH-1573 and RAUDT 10-33. There was negligible formation of stagheads.

National Disease Nursery for white rust resistance

Forty four entries of rapeseed-mustard were screened against white rust under severe epiphytotic conditions in this trial. *Alternaria* blight severity on leaves and pods was also recorded under natural conditions.

White rust severity up to 48.9 % was recorded in entries like RH 1599-7 and Rohini. Three entries namely DRMRIJ 12-28, DRMRJA 35 and DRMRIJ 12-41 remained free from white rust disease at leaf stage. Apart from these, the entries coded DRMRIJ 12-26, DRMRIJ 12-37, DRMRIJ 12-39 and DRMRIJ 12-40 showed less than 10% disease severity of white rust on leaves. Staghead formation was not observed in anyone of the entry.

Moderate to high severity of *Alternaria* blight on leaves was recorded in most of the entries. It ranged from 31.1% (DRMRIJ 12-41) to 67.2% in (RH 1590) on 107 DAS. *Alternaria* pod blight remained low and it varied from 3.3% (DRMRSJ-31-2-2) to 43.3% (NDYS 424). All the entries except NPJ 220 and NDYS 424 showed disease severity below 25%.

3. Linseed

Screening of linseed germplasm against major diseases

Seventy nine entries of linseed received from linseed breeder, Department of Crop Improvement, CSKHPKV, Palampur were screened against prevailing diseases under natural conditions at Kangra. Rust didn't appear in any of the entry at Kangra during 2017-18. However, wilt was observed in this trial and percent wilt incidence was recorded. The various entries were categorized on the basis of disease incidence as:

Highly Resistant (Disease free): nil
Resistant (Disease incidence 1-5%): KL-213, KL-242, KL-252, KL-253, KL-254, KL-256, KL-257, KL-259, KL-260, KL-261, KL-262, KL-263, KL-264, KL-265, KL-266, KL-268, KL-269, KL-273, KL-274, KL-275, KL-276, KL-278, KL-281, KL-282, KL-285, KL-286, Hermes, Nataza, Giza-7, Giza-8, Ayogi, Faiking, Flak-1, B-509, JRF-4 and Giza-6

Uniform Disease Nursery Trial (Natural conditions)

Fifty four entries were screened against prevailing diseases under natural field conditions at Kangra. Traces of rust were observed in few entries like NL-356, DLV-4, DLV-5, RLC-164, OL-09-215-09, OL-09-286-23, T-397 and RLC-143 in the mid of March, but disease could not progress because of unfavorable weather conditions during subsequent period. Wilt affected most of the entries and they were categorized on the basis of disease incidence as:
Highly Resistant (Disease free): nil
Resistant (Disease incidence 1-5%): RLC-164 and RLC-92
Moderately Resistant (Disease incidence 5.1-15.0%): LMS-2015-11, LMS-2015-14, RLC-163, NDL-2015-08, LMS-2015-31, RLC-167, RLC-168, NDL-2015-03, Priyam, Divya, RLC-143, RLC-161 and PKDL-165.

Uniform Disease Nursery under Artificial conditions (UDNA)

Twenty two entries of linseed were sown for screening against rust under artificial field conditions at Kangra. Rust appeared very late during the second week of March (11th standard week) at Kangra and it didn't appear at any other location. Disease couldn't progress under field conditions because of unfavorable weather conditions during subsequent period. Wilt appeared in most of the entries and they were categorized on the basis of disease incidence as: Highly Resistant (Disease free): nil; Resistant (Disease incidence 1-5%); RLC-161; Moderately Resistant (Disease incidence 5.1-15.0%); RLC-155, RLC-156, PKDL-165, RLC-157, RLC-153.

Evaluation of promising entries/ elite materials under high inoculum pressure (Rust)

Thirty nine entries were screened against prevailing diseases at Kangra. Rust couldn't develop and progress under field conditions because of unfavorable weather conditions during period of disease development. Wilt affected most of the entries and they were categorized on the basis of disease incidence as: Highly Resistant (Disease free): nil; Resistant (Disease incidence 1-5%): RLC-157, NDL-2014-1; Moderately Resistant (Disease incidence 5.1-15.0%):J-23, Nagarkot, Binwa, DPL-19, PKDL-65, LCK-9320, T-397, Surbhi, BAU-08-07, LCK-2002, PKDL-62, KL-221, Polf-5,LCK-1404, R-1007, RLC-155,RLC-156.

Management of linseed rust

A field experiment was conducted during *rabi* season of 2017-18 at Kangra to evaluate eight different treatment combinations of fungicides and bio-agents against linseed rust using susceptible variety T-397. However, rust didn't appear at Kangra during 2017-18 and no information could be generated.

Studies on the variability of linseed rust

Regular surveys were made in Kangra and surrounding areas for recording of rust appearance in linseed and collection of rust isolates from different locations for variability studies during the crop season of 2017-18. Rust appeared very late during the second week of March (11th standard week) at Kangra and it didn't appear at any other location. Weather conditions were quite unfavorable for disease progress during subsequent weeks because of rise in temperature and fall in relative humidity. Testing of Kangra isolate on differential set revealed the presence of already reported race 43, virulent on the variety Bombay and attacking resistant gene N.

E. Vegetables

Management of early blight of potato

A new molecule of fungicide; Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC) was evaluated along with the commonly used chemicals against early blight of potato during 2017-18. All the treatments were significantly effective in controlling early blight of potato when compared with control (Table 27). The test chemical i.e. Pydiflumetofen 7.5% + Difenoconazole 12.5% at all the three concentrations and Difenoconazole (Score) were very effective in controlling early blight of potato. The test chemical provided 70.8 and 73.8 per cent control with 13.7 and 10.9 per cent increase in yield as compare to control at 500 and 600 ml/h dose. Difenoconazole and Pydiflumetofen ideally also provided effective control and increase in the yield

Table 27: Bio-efficacy of Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC) against Early blight of potato during 2017-18

Treatments		Dose		Early blight		Tuber yield	
		a.i. (g/ha)	Form.(ml or g /ha)	% severity	(%) Control	Yield (q/ha)	(%) Increase
T_1	Control	-	-	65.0 (53.9)	-	299.0	-
T_2	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	80 (30+50)	400	26.3 (30.8)	59.5	326.7	9.3
T_3	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	100 (37.5+62.5)	500	19.0 (25.8)	70.8	331.7	10.9
T_4	Pydiflumetofen 7.5% + Difenoconazole 12.5% w/v (200 SC)	120(45+75)	600	17.0 (24.3)	73.8	340.0	13.7
T_5	Pydiflumetofen 20SC	45	225	27.3 (31.5)	58	315.3	5.5
T_6	Difenoconazole 25% EC	75	300	21.3 (27.5)	67.2	311.7	4.2
T_7	Ziram 80% WP	1600	2000	28.7 (32.3)	55.8	306.3	2.4
T_7	Kitazin 48% EC	500	1000	27.0 (31.3)	58.5	308.7	3.2
CD at 5%				5.82		11.74	

Deciphering diversity at *er* loci for diversification for powdery mildew resistance in pea

Allelic diversity at er1 locus was determined by sequencing *er1* alleles of different powdery mildew resistant lines. As MLO gene is responsible for resistance mechanism against the powdery mildew disease in pea so, sequence of PsMLO gene was analyzed for haplotype diversity. Both DNA and its mRNA of PSMLO gene were used. Pre- submitted sequence of *Pisum sativum* sub sp *sativum* cultivar Frilene MLOI protein (MLO1) gene, complete cds and mRNA sequence were retrieved from NCBI database with accession number KC466597.1. PsMLO gene specific primer for DNA and mRNA were design using primer 3 software and used for PCR amplification (Table 28).

Table 28: List of primers used for RNA amplification

Primer Name	Sequence (5'-3')
PsMLO 1 FP	ATGGCTGAAGAGGGAGTTAAGGA
PsMLO1RP	CTAATTGCTCCCTAAGTGGCG CT
PsMLO2FP	CCTCGGAGAATTCTTGCTAC
PsMLO2RP	TCCACAAATCAAGCTGCTACC
PsMLO3FP	TCTGGCTCTTCACAGTGCTT
PsMLO3RP	TGTGGAAGCAAGAGGTTATGG
PsMLOEx5FP	ATGAGGAAGTGGAAGACTTGGGA
PsML015ExRP	GCTTTTTGGCTGTGTGGTGCCAG

The amplification product of *er-1* gene DNA of 4000 bp size was obtained. Due to large size of this gene we go further for RNA isolation, as shorter fragments targeted the *er-1* gene. Extraction of total RNA of pea lines was done using trizol method represented in Figure 1.

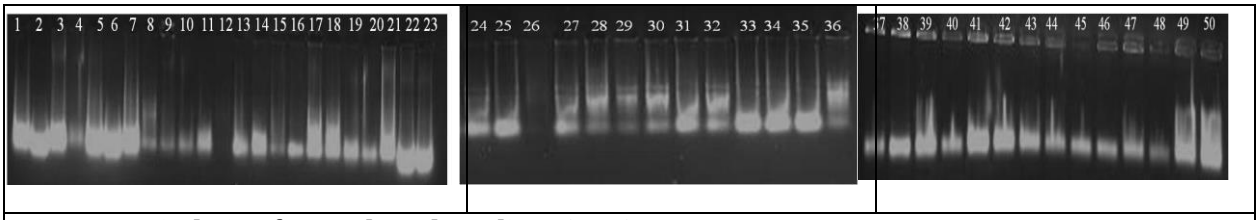


Fig.1 RNA isolation from selected pea lines (1-50)

PCR amplification of cDNA: To standardize the protocol for cDNA amplification by all primers, many times repeated PCRs were carried out in all the samples with the above mentioned primers. Fair positive results indicate that PsMLO gene was expressed after infection of *E. pisi* whether after 4 days and after 8 days of infection with primer 3F and 3R. Out of 50 lines amplification was possible up to 40 lines targeted that the *er-1* gene was present only in these lines. (Table 29 and Fig 2).

Table 29. List of amplified pea lines

S.No.	Genotypes	S. No.	Genotypes
1.	P-1287	21.	P1610-2
2.	P-995	22.	P-1506
3.	P-1395-2	23.	P-1811
4.	P-1301	24.	P-1440-20
5.	P-1805	25.	P-1516
6.	HFP-4	26.	P-179
7.	P-1806	27.	IPF-99-25
8.	P-1804	28.	KMNR-400
9.	P-1820	29.	DPP-139-3
10.	P-1440-10	30.	DPPMR-09-1
11.	P-1280-4	31.	LFP-517
12.	P-668-1	32.	LFP-575
13.	P-1707	33.	LFP-571
14.	P-48	34.	LFP-577
15.	P-1610-9	35.	PB-29B
16.	P-1436-9	36.	DPP-362
17.	P-1813	37.	ACACIA
18.	P-1377	38.	MR BIG
19.	P-1422-1	39.	KMNR-894
20.	P1436-8	40.	DMR-11

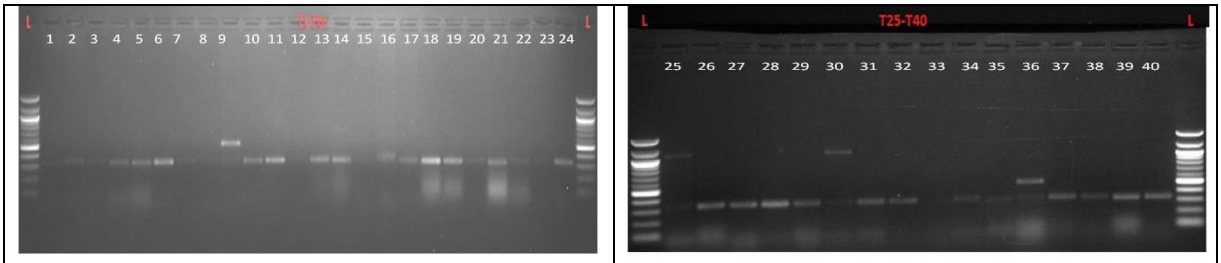


Fig.2 Amplification profile of selected pea lines (1-40) using MLO gene primers

F. Forage/ Fodder Crops

Evaluation of germplasm

During *Kharif*, 15 entries of maize and 27 entries of cowpea were evaluated and 2 and 8 entries of maize were found resistant and moderately resistant respectively, to leaf blight. In cowpea none of the entry was found resistant to root rot, however 2 entries were found moderately resistant. During *Rabi* the 48 lines of oats were evaluated and 14 entries were found moderate resistant against powdery mildew under different breeding experiments of oats. In berseem trial 8 entries were evaluated and all were found either resistant or moderately resistant to root rot during the season. In white clover and red clover 3 and 2 entries were found moderately resistant for powdery mildew, respectively (Table 30).

Table 30. Field screening of *Kharif* & *Rabi* breeding material

Crop	Name of Trial	Entries	No of Resistant	Moderate Resistant
Maize (Leaf blights)	IVTM	15	IVTM-1 & 2	IVTM-3,4,6,9,10,11,13 & 14
Cowpea (Root rots)	IVTC	11	-	IVTC-6 & 7
	AVTC 2-1	8	-	-
	AVTC 2-1 (seed)	8	-	-
Oats (Powdery mildew)	IVTO SC	14		IVTO (SC)-3 & 7
	IVTO-1(MC)	9		IVTO(MC)-5
	AVTO(SC)-1	11		Nil
	AVTO(SC)-2	7		AVTO(SC)-2: 2,3,4,6 & 7
	AVTO(SC)-2 (Seed)	7		AVTO(SC Seed)- 2-2,3,4,5 and 6
Beseem(root rot)	IVTB	8	-	All
Clovers (Powdery mildew)	White clover (VTWC)	6	-	VTWC-1,2 &3
	Red clover (VTRC)	6	-	VTRC-6 &7

Integrated disease management of BLSB in fodder maize

Seed treatment with carbendazim followed by two foliar sprays with tryfloxystrobin + tebuconazole was found highly effective with 86.9% disease control and 17.2% increase in yield over check. This treatment was followed by seed treatment with carbendazim and foliar sprays with two sprays of carbendazim provided 84.9% disease control and 16.7% increase in yield over check with non-significant differences. As non-chemical method seed treatment with *T. viride* followed by two foliar sprays with *P. fluorescens@* provided 43 per cent disease control with 7.8 per cent increase in the yield over control (Table 31).

Table 31. Integrated Management of BLSB of forage Maize (Modified)

Treatment	BLSB		GFY	
	Incidence (%)	Control (%)	(q/h)	Increase over check (%)
T1	14.0	8.5	271.3	2.3
T2	8.7	43.1	278.7	5.0
T3	4.0	73.8	303.7	14.5
T4	8.7	43.1	286.0	7.8
T5	4.3	71.9	304.7	14.8
T6	2.3	84.9	309.7	16.7
T7	2.0	86.9	311.0	17.2
T8	5.7	62.7	283.7	6.9
T9	5.3	66.0	294.0	10.8
T10	5.0	67.3	292.0	10.5
T11	5.3	66.0	295.7	11.4
T12	12.3	19.6	274.0	3.3
T13	15.3	-	265.3	-

CD	1.7	-	9.5	-

Treatments:

T_1 = Seed treatment with *T. viride* @ 5g/kg
T_2 = Seed treatment with carbendazim@ 2 g/kg seed
T_3 = T_1 + Two spray of carbendazim @ 1g/l
T_4 = T_1 + Two foliar sprays with *P. fluorescens*@ 5g (CFU 10^7) /l
T_5 = T_1 + Two foliar sprays with (tryflosystrobin +tebuconazole) @ 1g/1l
T_6= T_2 + Two spray of carbendazim @ 1g/l
T_7= T_2+ Two foliar sprays with (tryfloxystrobin + tebuconazole) @ 1g/1l
T_8 = T_2 + Two foliar sprays with *P. fluorescens*@ 5g (CFU 10^7) /l
T_9= T_1 + One spray each of carbendazim@ 1g/l and *P. fluorescens*@ 5g (CFU 10^7) /l
T_{10}= T_2 + One spray each of carbendazim@ 1g/l and *P. fluorescens*@ 5g (CFU 10^7) /l
T_{11} = T_2 + One spray each of (tryfloxystrobin +tebuconazole) @ 1g/1l and *P. fluorescens* @ 5g (CFU 10^7) /l
T_{12}= Stripping of lower leaves
T_{13} = Control

Integrated disease management of foliar diseases of forage sorghum

Seed treatment with carbendazim followed by two sprays of propiconazole was found highly effective which gave 86.4% disease control with 20.9% increase in the yield over check. two spray of propiconazole which gave 84.8% disease control with 19.6% increase in the yield over check (Table 32). Hence, the combination of bio- agent & chemical *i.e.* seed treatment with *T. viride* with one spray each of propiconazole and Achook (bio pesticide) was effective in controlling of zonate leaf spot and gave 67.8% disease control with 9.7 % increase in the field.

Table 32: Integrated disease management of foliar diseases of forage sorghum

Treatment	Zonate leaf spot		GFY	
	Disease severity * (%)	Control (%)	(q/h)	Increase over check (%)
T1	40.8 (39.7)	16.2	267.3	4.8
T2	38.4 (38.3)	21.1	274.7	7.7
T3	36.0 (36.8)	26.1	274.0	7.5
T4	11.4 (19.7)	76.6	287.0	12.5
T5	31.7 (34.2)	34.9	276.3	8.4
T6	7.4 (15.8)	84.8	305.0	19.6
T7	27.5 (31.6)	43.5	278.7	9.3
T8	6.6 (14.8)	86.4	308.3	20.9
T9	15.7 (23.3)	67.8	279.7	9.7
T10	14.6 (22.4)	70.0	282.0	10.6
T11	48.7 (44.2)	-	255.0	-
CD	1.6	-	9.1	-

Treatments:

T_1 = Seed treatment with *T. viride* @ 5g/kg
T_2 = Seed treatment with carbendazim @ 2 g/kg seed
T_3 = Two foliar sprays with neem bio-pesticide (Achook) @ 3%
T_4 = Two foliar sprays with propiconazole @ 1g/l
T_5 = T_1 + Two foliar sprays with neem bio-pesticide (Achook) @ 3%
T_6 = T_1 + Two foliar sprays with propiconazole @ 1g/l
T_7 = T_2 + Two foliar sprays with neem bio-pesticide (Achook) @ 3%
T_8= T_2 + Two foliar sprays with propiconazole @ 1g/l
T_9= T_1 + One spray each of neem bio-pesticide (Achook) @ 3% and propiconazole @ 1g/l
T_{10}= T_2 + One spray each of neem bio-pesticide (Achook) @ 3% and propiconazole @ 1g/l
T_{11}= Control

Management of soil bonre and powdery mildew diseases in red clover seed crop

It was observed that integrated management i.e. seed treatment with carbendazim @ 2 g/kg seed followed by three foliar spray of hexaconazole @ 0.1 % gave best management of powdery mildew having 4.2 percent disease severity and 92.8 per cent disease control of powdery mildew and 2.7% disease incidence with 78.7 % disease control of soil borne disease with 46.0 per cent increase in yield as compared to control (Table 33).

Table 33. Management of soil bonre and powdery mildew diseases in red clover seed crop

TREATMENT	% Severity / incidence				Yield	
	Powdery mildew	% control	Soil borne disease	% control	(q/ha)	% increase
T_1 =Seed treatment with *Trichoderma* @ 5g/kg seed	56.3 (48.6)	3.5	7.1	43.2	0.8	11.4
T_2 = Seed treatment with carbendazim @ 2 g/kg seed	50.4 (45.2)	13.5	3.3	73.3	0.9	27.2
T_3= T_1 + Three foliar spray of *Trichoderma* @ 0.5%	47.5 (43.5)	18.6	6.6	47.5	0.8	22.8
T_4= T_2 + Three foliar spray of *Trichoderma* @ 0.5%	43.6 (41.3)	25.3	3.5	72.3	0.9	32.7
T_5= T_1 + Three foliar spray of wettable sulphur@ 0.3%	16.6 (24.0)	71.5	6.6	47.2	0.8	24.8
T_6 = T_2 + Three foliar spray of wettable sulphur@ 0.3%	15.8 (23.4)	72.9	3.2	74.1	0.8	25.2
T_7 = T_1 + Three foliar spray of hexaconazole @ 0.1 %	4.4 (12.1)	92.5	6.5	48.0	0.9	35.1
T_8 = T_2 + Three foliar spray of hexaconazole @ 0.1 %	4.2 (11.8)	92.8	2.7	78.7	1.0	46.0
T_9 = T_1 + One spray each of *Trichoderma*, wettable sulphur and hexaconazole	7.3 (15.6)	87.5	6.8	45.6	0.9	30.7
T_{10} =T_2 + One spray each of *Trichoderma*, wettable sulphur and hexaconazole	6.8 (15.1)	88.3	3.3	73.6	0.9	38.6
T_{11} =Control	58.3 (49.8)	0.0	12.5	0.0	0.7	0.0
CD (5%)	2.25		1.18		0.79	

Screening of Oat germplasm against *Blumeria graminis f.* sp. *avenae*

Total of 347 lines were screened *in vivo* under field conditions during 2017-18 using scale given by Mayee and Datar (1986), out of 347 lines evaluated, 10 lines were found to be resistant i.e. PLP-1, JPO-40, OL-1847, OL-1689, OS-6, HFO-864, OS-10 and HFO-125. Among these lines PLP-1 was found to be highly resistant.

Biological management of powdery mildew of oats

Three foliar spray of hexaconazole @0.1% gave best control of powdery mildew caused by *Blumeria graminis f.* sp. *avenae* (13.3 % disease severity and 77.1 % disease control) with maximum increase (15.9%) in the seed yield over the check. However, among the biological management treatments three foliar spray of *Trichoderma viride* @ 0.5% or three foliar spray of *Trichoderma harzianum* @ 0.5% were found effective giving 48.6 and 45.7 % powdery mildew control with 10.5 and 10.4 % increase in the seed yield respectively over check (Table 34).

Table 34. Biological management of powdery mildew of oats caused by *Blumeria*

Treatment	Powdery mildew		Yield	
	% Severity	% control	(q/ha)	% increase
T1: Three foliar spray of *Trichoderma viride* @ 0.5%	30.0 (33.2)	48.6	19.9	10.5
T2: Three foliar spray of *Trichoderma harzianum* @ 0.5%	31.7 (34.2)	45.7	19.9	10.4
T3: Three foliar spray of *Psuedomonas flourescens* @ 0.5%	40.0 (39.2)	31.4	19.2	6.7
T4: Three foliar spray of extract of *Eupatorium adenophorum* @ 10%	40.0 (39.2)	31.4	19.0	5.2
T5: Three foliar spray of Azadirachtin 3000 ppm @ 0.3%	41.7 (40.2)	28.6	18.6	3.1
T6: Three foliar spray of NSE 5%	43.3 (41.1)	25.7	18.2	1.1
T7: Three foliar spray of Eucalyptus @ 10%	38.3 (38.2)	34.3	19.2	6.5
T8: Three foliar spray of Vitex @ 0.1%	38.3 (38.2)	34.3	19.3	7.0
T9: Three foliar spray of hexaconazole @0.1% (Chemical control)	13.3 (21.3)	77.1	20.9	15.9
T10: Control	58.3 (49.8)	0.0	18.0	0.0
CD (5%)	3.06		0.73	

G. Seed Pathology

Monitoring and detection of rice bunt, false smut and bacterial leaf blight in processed, unprocessed and farmers seed sample: 86 rice seed samples were collected from five districts of Himachal Pradesh to assess rice bunt status in farmers saved seeds. Rice bunt was observed in 5 samples with an incidence ranging between 0.2 to 2.4 percent, maximum being in variety VL-221 at Malan location of district Kangra. Grain discolouration incidence was recorded in 66 samples with an incidence of 0.1 to 2.8 per cent. In different seed samples, 13 fungi viz. *F. solani (4 to 12 %), Penicillium Sp (4 to 34 %)., Alternaria Alterata (4 to 16%), Curvularia Lunata (4 to 28 %) , Dreschslera Oryzae (4 to 12 %), Aspergllus Sp.(4 to 16 %), Chaetomium Sp. (4 to 8%), Helminthosporium Sp.(4 to 8%), Pyricuania Sp (4 to 12%). Phoma Sp.(4 to 12 %) Rhizopus sp. (8 to 48%), Rhizoctonia sp. (4 to 20 %), Trichoderma sp. (4 to 12%)* were recorded.

Status of loose smut in framers own saved wheat samples collected from different locations

The loose smut incidence in farmers own saved seed was assessed in 355 samples collected from different wheat growing areas of the state using grow out test. Out of 355 samples, 20 samples were found to possess loose smut infection with overall incidence ranging between 0.0 to 1.13 per cent with a maximum of 1.13 % in Joginder Nagar area of district Mandi on local cultivar. However, overall incidence was low in the state.

District wise and variety wise karnal bunt detected in unprocessed farmers wheat seed sample and seed production plots in Himachal Pradesh

During the year 2017-18, 161 samples were collected from six district of Himachal Pradesh to know the status of karnal bunt disease in wheat seed used by the farmers to cultivation in the state. Karnal bunt was recorded in only 49 seed samples with an incidence ranging from 0.1 to 2.8 percent with a maximum incidence of 2.8% in Bhalana area of district Hamirpur. However, 35 samples showed infection above the certification level, though much less over previous years.

Status of seed borne diseases in Hybrid Rice Varieties cultivated by farmers

The observations made on occurrence of diseases on hybrid rice and some improved varieties of rice showed wide distribution of false smut in different varieties across the locations surveyed with severity ranging between 3-7 on 0-9 point scale with an average incidence of 7.5 to 32.5% (Table 35). The rice hybrid Raja showed maximum incidence of 32.5% in Nalsar area of district Mandi. The hybrid grown in Bheora area of Mandi showed very high incidence (62.5%) of neck blast. The sheath blight incidence was upto 7.5% ehrereas that of brown spot was between 3.5 – 5.0% in different areas. BLB was not observed on hybrids this year again.

Table 35. Status of seed borne diseases in Hybrid Rice Varieties cultivated by farmers in Himachal Pradesh during *Kharif* 2017

Location District/ region	Variety	False Smut Incidence (%)	False Smut Incidence (Scale 0-9)	BLB Severity (%)	Neck Blast	Sheath Rot	Sheath Blight Incidence	Brown Spot(%)
Kangra								
Nagrota Bagwan	Raja, PAC 807, Hyb 2266	12.5	5	-	7.5	5.0	5.0	T

Rait	Arize 6129	7.5	3	-	-	-	-	-
Baijnath	Arize 6129, Adventa 834	7.5	5	-			T	-
Saloh	PAC 807, Sri Ram Khushbu	7.5	3	-	-	T	T	-
Panchrulkhi	PAC 807, US 312	7.5	3	-	7.5	-	-	-
Gangath	Dhanya 111	12.5	-	-	-	-	7.5	3.5
Bhogarwan	PA 6444	12.5	3	-	-	T	T	-
Mandi								
Nalsar	Raja	32.5	7	-	-	-	5.0	3.5
Bheora	Hybrid	7.5	3	-	62.5	12.5	-	-
Kummi	US 312	7.5	3	-	-	T	-	5.0
Chatraur	US 312	7.5	3	-	-	5.0	T	-
Una								
Jankor	Hyb. 57	7.5	3	-	3.5	T	-	4.0
Nangalkalan	Hyb. 1067, Arize 6444	12.5	5	-	5.0	5.0	-	5 .0
Basal	Hyb. 257, Hyb. 25P35	7.5	3	-	T	T	-	3.5

***T=** Traces

Development of PCR based protocol for the detection of *Pepper mild mottle virus* (PMMoV) from chili seeds

The RT- PCR based protocol designed to detect the PMMoV from chili seeds during 2016-17 was repeated for its authenticity and robustness. The Coat Protein (CP) gene specific primer pair developed in our laboratory (CPF: CCAATGGCTGACAGATTACG, CPR: CAACGACAACCCTTCGATTT, Expected product size: 743 bp) was further used in this experiment. The virus infected seeds harvested from the artificially inoculated capsicum plants were used in this experiment. The seeds from healthy plants were used as control. To isolate the total RNA from seeds, one sample (20 seeds) the infected and healthy seeds lots was dipped in Trizol buffer overnight and total RNA was isolated in the next morning. In another sample the seeds were simply crushed in chilled pestle mortar using Trizol reagent following the manufacturer's instruction. The cDNA was synthesized and further subjected to RT-PCR using CP specific primers. The cDNA was amplified using the viral coat protein specific primers (F5'CCAATGGCTGACAGATTACG-3' and R5'CAACGACAACCCTTCGATTT-3') with initial denaturation of 94°C for 4 min followed by 35 cycles of 94°C for 15 sec, 48°C for 40 sec and 72°C for 1 min and final extension of 7 min at 72°C to confirm the presence of PMMoV. The PCR product resolved on 1.2 % Agarose gel using ethidium bromide stain showed an amplicon of ~740 bp product was observed in both the seed sample and positive control while no band was observed in negative control (Fig. 3). The work on improvement of this protocol is in progress.

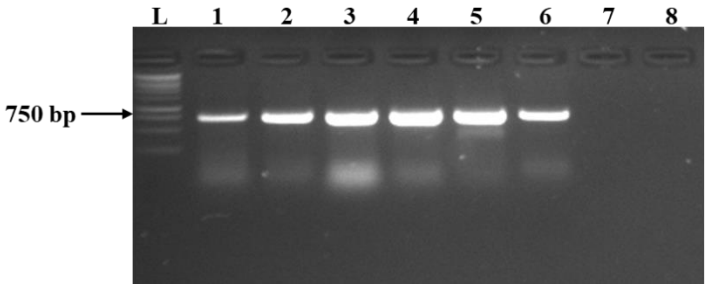


Fig. 3: RT-PCR of PMMoV infected seeds using total RNA isolated from infected seeds. L: 1 kb ladder, 1-2: RNA isolated from seeds dipped in Trizol reagent for overnight, 3-4: RNA isolated from infected seeds using standard protocol, 5-6: positive control, 7-8: Negative control.

Non chemical management of seed borne infection of bean anthracnose

To find out the suitable non-chemical method for bean anthracnose management, an experiment was conducted on susceptible variety Jawala using bioagents, organic inputs like panchgabya, Jeevamrit and bijamrit (Table 36a, b, c). Over all seed germination in different treatments over the period of storage ranged between 77.33 to 100 % though it was maximum in treatment *Trichoderma viride + Pseudomonas fluorescence* and bijamrit (Table 36a). The data recorded on seed rot revealed maximum rotting in infected seed samples (3.33 to 10.67%) as compare to the healthy seeds (0.00 to 2.67%), while treatment with panchgavya resulted minimum (1.33 to 2.00%) seed rot as compare to the other treatments and found to be effective bijamrit (Table 36b). Whereas maximum seedling rot was observed in case of infected seed samples ranged between (2.00 to 10.67%) and minimum in healthy seed samples (0.00 to 2.00%) and among all the treatments, Bijamrit followed by Bavistin and Pachgavya + *P. fluorescence* were found to be effective (Table 36c).

Table 36a: Effect of various biagents and organic inputs on seed germination of common bean in *C. lindemuthianum* infected seeds during storage

Treatment	Seed Germination (%) during storage						
	5.07.17	5.08.17	5.09.17	6.10.17	6.11.17	6.12.17	5.01.18
Trichoderma harzianum	96.00 (80.52)	99.33 (87.28)	92.00 (73.62)	94.00 (78.34)	99.33 (87.28)	95.33 (79.78)	94.00 (78.50)
Trichoderma viride	98.67 (84.56)	99.33 (87.28)	91.33 (75.98)	89.33 (70.93)	98.00 (83.42)	92.00 (73.62)	90.67 (75.65)
Pseudomonas fluorescence	99.33 (87.28)	93.33 (77.70)	88.00 (73.45)	96.67 (81.41)	96.00 (80.66)	96.67 (81.71)	94.00 (76.13)
Trichoderma harzianum + Trichoderma viride	99.33 (87.28)	98.00 (83.42)	96.00 (80.66)	97.33 (82.54)	92.00 (76.65)	90.67 (72.20)	98.67 (86.14)
Trichoderma harzianum+ Pseudomonas fluorescence	97.33 (82.29)	99.33 (87.28)	90.00 (71.54)	98.00 (83.42)	93.33 (77.75)	90.67 (73.68)	94.00 (78.50)
Trichoderma viride +Pseudomonas fluorescence	100.00 (90.00)	100.00 (90.00)	91.33 (72.87)	96.67 (81.41)	92.67 (77.08)	98.67 (84.56)	98.67 (86.14)
Panchgavya only	98.67 (84.56)	100.00 (90.00)	94.00 (78.50)	98.67 (84.56)	98.00 (83.42)	93.33 (75.25)	98.00 (83.42)
Panchgavya+ *Trichoderma harzianum*	69.33 (81.14)	98.00 (83.42)	93.33 (78.28)	79.33 (68.74)	96.67 (81.41)	80.00 (69.49)	92.67 (74.37)
Panchgavya+ *Trichoderma viride*	97.33 (82.29)	83.33 (90.00)	86.00 (71.84)	96.67 (81.41)	98.67 (84.56)	100.00 (90.00)	95.33 (79.99)
Panchgavya+ *Pseudomonas fluorescence*	98.67 (84.56)	79.00 (78.36)	93.33 (77.75)	96.67 (81.79)	98.00 (83.42)	93.33 (77.75)	92.00 (73.62)
Bavistin	98.67 (86.14)	80.33 (79.99)	100.00 (90.00)	96.67 (81.41)	98.67 (84.56)	92.67 (77.08)	90.00 (74.98)
Healthy seed	98.67 (86.14)	80.67 (82.54)	100.00 (90.00)	100.00 (90.00)	96.00 (78.89)	88.00 (69.70)	92.00 (77.28)
Infected seed	97.33 (82.54)	75.33 (74.37)	90.67 (75.47)	86.00 (71.84)	92.00 (73.54)	93.33 (78.28)	92.00 (76.47)
Bijamrit	98.67 (86.14)	77.33 (78.36)	100.00 (90.00)	96.00 (80.66)	99.33 (87.28)	92.67 (74.50)	94.67 (79.38)
Jeevamrit	98.00 (83.42)	82.00 (83.42)	98.67 (84.56)	95.33 (79.78)	100.00 (90.00)	98.00 (83.42)	90.00 (71.78)
CD	NS	NS	NS	NS	NS	NS	NS

Table 36b: Effect of various biagents and organic inputs on seed rot of common bean in *C. lindemuthianum* infected seeds during storage

Treatment	Seed Rot (%) during storage						
	05.07.17	**05.08.17**	**05.09.17**	**06.10.17**	**06.11.17**	**06.12.17**	**05.09.17**
Trichoderma harzianum	4.00 (2.10)	0.33 (1.14)	8.00 (2.99)	6.00 (2.44)	0.67 (1.24)	6.67 (2.53)	6.00 (2.42)
Trichoderma viride	1.33 (1.49)	0.67 (1.24)	8.67 (2.81)	10.67 (3.41)	2.00 (1.66)	7.00 (2.77)	9.33 (2.86)
Pseudomonas fluorescence	0.67 (1.24)	6.67 (2.54)	12.00 (3.20)	3.33 (1.96)	4.00 (2.08)	3.33 (1.96)	6.00 (2.60)
Trichoderma harzianum + *Trichoderma viride*	0.67 (1.24)	4.00 (2.08)	4.00 (2.08)	4.00 (2.21)	8.00 (2.71)	8.00 (2.96)	1.33 (1.41)
Trichoderma harzianum+ *Pseudomonas fluorescence*	2.00 (1.66)	0.00 (1.00)	10.00 (3.32)	2.00 (1.66)	6.67 (2.54)	7.33 (2.44)	6.00(2.42)
Trichoderma viride +*Pseudomonas fluorescence*	0.00 (1.00)	0.00 (1.00)	8.67 (3.11)	3.33 (1.96)	7.33 (2.64)	1.33 (1.49)	1.33 (1.41)
Panchgavya only	1.33 (1.49)	0.00 (1.00)	2.00 (1.66)	1.33 (1.49)	2.00 (1.66)	1.33 (1.49)	2.00 (1.66)
Panchgavya+ *Trichoderma harzianum*	0.67 (1.24)	2.00 (1.66)	6.67 (2.45)	7.33 (2.62)	3.33 (1.96)	4.67 (2.22)	7.33 (2.87)
Panchgavya+ *Trichoderma viride*	2.00 (1.66)	4.00 (1.87)	14.00 (3.45)	3.33 (1.96)	1.33 (1.49)	0.00(1.00)	4.67 (2.18)
Panchgavya+ *Pseudomonas fluorescence*	1.33 (1.49)	6.00 (2.44)	6.67 (2.54)	3.33 (1.91)	2.00 (1.66)	6.67 (2.54)	12.00 (3.52)
Bavistin	0.67 (1.24)	4.67 (2.18)	0.00 (1.00)	3.33 (1.96)	0.67 (1.24)	7.33 (2.64)	10.0(2.97)
Healthy seed	0.67 (1.24)	2.67 (1.79)	0.00 (1.00)	0.00 (1.00)	2.00 (1.66)	2.00 (1.66)	2.67 (1.79))
Infected seed	3.33 (1.96)	10.67 (3.36)	9.33 (2.89)	10.00 (2.99)	8.00 (3.00)	6.67 (2.45)	8.00 (2.73)
Bijamrit	0.67 (1.24)	6.00 (2.44)	0.00 (1.00)	4.00 (2.08)	0.67 (1.24)	6.00 (2.44)	8.67 (3.05)
Jeevamrit	1.33 (1.49)	2.00 (1.66)	1.33 (1.49)	2.00 (1.66)	0.00 (1.00)	2.00 (1.66)	4.67 (2.22)
CD	NS	NS	NS	NS	NS	NS	NS

Table 36c: Effect of various biagents and organic inputs on seedlin rot of common bean in *C. lindemuthianum* infected seeds during storage

Treatment	Seedling Rot (%)						
	05.07.17	**05.07.17**	**05.07.17**	**05.07.17**	**05.07.17**	**05.07.17**	**05.07.17**
Trichoderma harzianum	0.00 (1.00)	1.33 (1.41)	6.67 (14.33)	4.00 (2.21)	4.00 (2.21)	4.00 (2.21)	2.00 (1.65)
Trichoderma viride	0.00 (1.00)	4.00 (2.21)	4.00 (11.28)	6.00 (2.63)	0.00 (1.00)	1.33 (1.41)	2.00 (1.55)
Pseudomonas fluorescence	1.33 (1.24)	0.67 (1.24)	6.00 (14.04)	0.00 (1.00)	3.33 (1.96)	0.67 (1.24)	0.00 (1.00)
Trichoderma harzianum + *Trichoderma viride*	0.67 (1.24)	2.00 (1.55)	2.00 (1.73)	2.00 (1.66)	4.00 (2.21)	6.00 (2.63)	1.33 (1.48)
Trichoderma harzianum+ *Pseudomonas fluorescence*	1.33 (1.66)	0.00 (1.00)	6.67 (14.33)	2.33 (1.82)	2.00 (1.66)	3.33 (2.07)	1.33 (1.41)
Trichoderma viride +*Pseudomonas fluorescence*	0.67 (1.00)	0.00 (1.00)	6.00 (14.04)	1.33 (1.47)	4.67 (2.22)	4.00 (2.21)	4.00 (2.20)
Panchgavya only	1.33 (1.49)	0.67 (1.24)	1.33 (5.42)	2.60 (1.82)	0.67 (1.24)	0.67 (1.24)	1.33 (1.41)
Panchgavya+ *Trichoderma harzianum*	2.00 (1.24)	1.33 (1.49)	0.00 (1.00)	4.00 (2.21)	0.00 (1.00)	2.00 (1.66)	2.67 (1.90)
Panchgavya+ *Trichoderma viride*	1.33 (1.66)	4.00 (2.21)	2.00 (6.55)	0.00 (1.00)	0.00 (1.00)	3.33 (1.96)	0.00 (1.00)
Panchgavya+ *Pseudomonas fluorescence*	2.00 (1.49)	2.00 (1.66)	1.33 (3.84)	0.67 (1.24)	1.33 (1.49)	0.00 (1.00)	0.00 (1.00)
Bavistin	0.67 (1.24)	0.67 (1.24)	0.67 (2.71)	1.33 (1.49)	2.00 (1.66)	4.67 (2.37)	4.00 (2.23)
Healthy seed	0.00 (1.24)	0.00 (1.00)	2.00 (1.73)	0.00 (1.00)	0.67 (1.24)	0.00 (1.00)	2.00 (1.730.
Infected seed	2.00 (1.96)	6.00 (2.62)	4.67 (12.02)	6.00 (2.63)	6.00 (2.63)	8.00 (2.99)	10.67 (18.80)
Bijamrit	0.67 (1.24)	0.67 (1.24)	1.33 (3.84)	2.67 (1.79)	0.00 (1.00)	1.33 (1.49)	0.00 (1.00)
Jeevamrit	1.33 (1.49)	2.67 (1.80)	1.33 (5.42)	2.00 (1.66)	2.67 (1.82)	0.67 (1.24)	1.33 (1.48)
CD	NS	NS	8.23	0.82	0.89	0.77	0.82

H. Molecular Plant pathology

Fine mapping of *Co-Ind* gene in common bean land race KRC5

i) Maintenance of *C. lindemuthianum* race (s) cultures and confirmation of race identity

Fungal cultures of *C. lindemuthianum* races 3, 211, 537 and 935 are being maintained on Mathur media under *in vitro* conditions after confirming their identity on differential bean varieties (Table 37).

Table 37. Virulence pattern of *C. lindemuthianum* isolates on CIAT differential bean varieties used for population phenotyping

No. of isolate	Reaction of common bean cultivars												Race designation
	A (Co-11)	B (Co-1)	C (Co-1^3)	D (Co-2)	E (Co-15)	F (Co-12)	G (Co-3)	H (Co-4^3,Co-9)	I (Co-4)	J (Co-5)	K (Co-6, Co-8)	L (Co-42, Co-52, Co-7)	
CL-231	+	+	-	-	+	-	+	+	-	-	-	-	211
Cl 186a	+	+	-	-	-	-	-	-	-	-	-	-	3
Cl-74	+	-	-	+	+	-	-	-	-	+	-	-	537
Cl 46b	+	+	+	-	-	+	-	+	+	+	-	-	935

ii) Phenotyping of mapping population and inheritance of resistance in KRC5

The inheritance pattern of anthracnose resistance gene in landrace KRC-5 of common bean was confirmed by inoculating F_2 plants with 4 races viz., race-3 (96), race-211 (100), race-537 (87 seeds) and 935 (96 seeds) (Table 38). Based on the observed segregation of resistance in F_2 population against four races of *C. lindemuthianum*, a null hypothesis was formulated that, the resistance in different F_2 progenies of various crosses (Table 39) segregated in monohybrid ratio of 3:1 and deviation of the observed data is not real.

Table 38. Segregation of resistance in progenies of the cross between resistant landrace KRC5 and susceptible genotype Jawala against races 3, 537, 211 and 935 of *C. lindemuthianum*

Parents/ Pathogen	Generation	Number of seedlings		Expected ratio (R:S)	(χ 2)	P-value
		[a]R	S			
Race 3						
KRC5	P_2	10	-			
Jawala	P_1	-	10			
	F_2	77	19	3:1	1.12	0.25 < P < 0.5
Race 211						
KRC-5	P_2	10	-			
Jawala	P_1	-	10			
	F_2	69	31	3:1	0.96^{NS}	0.30-0.50
Race 537						
KRC5	P_2	10	-			
Jawala	P_1		10			
	F_2	67	22	3:1	1.99	0.1 < P < 0.5
Race 935						
KRC5	P_2	10	-			
Jawala	P_1	-	10			
	F_2	67	29	3:1	0.87	0.25 < P < 0.5

NS: non significant

The segregation data of F_2 showed a good fit to 3R:1S ratio, thereby indicating that the resistance in KRC5 against all the four races is controlled by a single dominant gene tentatively designated here in as '*Co-ind'*. Chi-square analysis of all of the F_2/RILs showed a good fit of 3:1/1:1 ratio, thereby confirming that resistance in KRC5 against race 3 and race 211 is governed by single dominant gene. In order to fine map the resistance gene '*Co-ind'*, a mapping population of 359 F_2 plants and 213 RILs were inoculated with race 3 under greenhouse conditions. Out of 359 F_2 plants, 276 plants were resistant and 83 plants showed susceptible reaction (Table 40), whereas out of 213 F_{2-8} plants, 115 were resistant and 98 were susceptible (Table 40). The segregation data of F_2 and F_{2-8} showed a good fit to 3R:1S and 1R:1S ratio, thereby indicating that the resistance in KRC5 against all the four races is controlled by a single dominant gene tentatively designated here in as '*Co-ind'*. The leaf samples for genotyping were collected from both F_2 and F_{2-8} progeny.

Table 39. Segregation of resistance in F_2 and RIL progenies of the cross between resistant landrace KRC5 and susceptible genotype Jawala against race 3 of *C. lindemuthianum*

Generation	Number of seedlings		Expected ratio (R:S)	(χ 2)	P value
	[a]R	S			
F_2 (359)	276	83	3:1	0.244	0.50-0.90
F_{2-8} RILs	115	98	1:1	1.356	(0.10-0.50)

Polymorphism survey of parental genotypes

A total of 357 SSR markers were used for the polymorphism survey on Jawala and KRC-5 genotypes. Out of these, only 70 primers were found to be polymorphic distinguishing the resistant and susceptible parents (Table 40).

Table 40. Summary of polymorphism survey of parental lines Jawala and KRC5 with simple sequence repeat markers

Primer name	Reference	Primers evaluated	Polymorphic primers
BM, GATS, AG, PV	Gáitan-Solis et al. 2002 Caixeta et al. 2005, Yu et al. 2000	212	BM53, BM138, BM140, BM143, BM146, BM148, BM149, BM154, BM157, BM160, BM167, BM172, BM184, BM187, BM189, BM195, BM211, PV-gtat001, PV-att004, PV-ct002, PV-taca001, PV-atgc001
BMa, CAC, ATA	Blair et al. 2008, 2011		BMa03, BMa10, BMa27, BMa145, BMa154, BMa241, ATA10, ATA154,
BMb	Córdoba et al. 2010		BMb57, BMb182, BMb213, BMb247, BMb290, BMb339, BMb341, BMb356, BMb405, BMb513,
BMd	Blair et al. 2003		Bmd42, Bmd56, Bmd70, Bmd12, Bmd76, Bmd45, Bmd3, Bmd4, Bmd22, Bmd92, Bmd96
SSRCHR1, SSRCHR5, SSRCHR7	Developed from chromosome 1, 5 and 7	58	SSRCHR 7 (2, 3, 7, 9, 14, 18), SSRCHR5 (4, 6, 10, 11, 12, 15, 16)
In- del markers	Developed from bean map	48	6 Indel markers (NDSU-IND)
PvBR series	Grisi *et al*., 2007	18	NIL
IAC series	Campos *et al*., 2011	21	NIL
Total		357	70

Among the BM, BMa, BMb, BMd and PV- series SSR markers, 51 were found polymorphic (Table 40; Fig. 4), whereas out of 48 in-del markers, only six primers showed polymorphism (Fig. 5). 13 RAPD markers were found to be polymorphic on parents out of 48 RAPD markers screened (Fig. 6). Out of 18 PvBR and 21 IAC series markers (Fig. 7) screened on parents, none of the primer was able to distinguish the parents. Whereas, among 58 SSRs developed from Chromosome 1, 5 and 7, only 13 primers were polymorphic (Fig. 8).

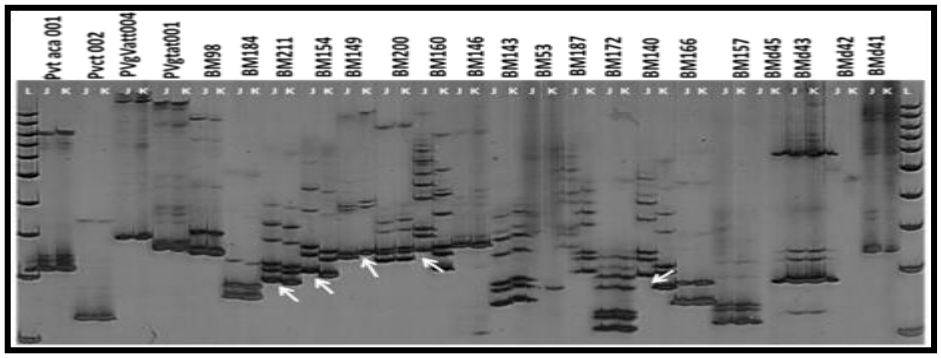


Fig. 4. Polymorphism survey of susceptible (Jawala) and resistant (KRC5) parent using simple sequence repeats (SSR) markers on 6 per cent denaturing polyacrylamide gel electrophoresis where L: 100bp molecular marker

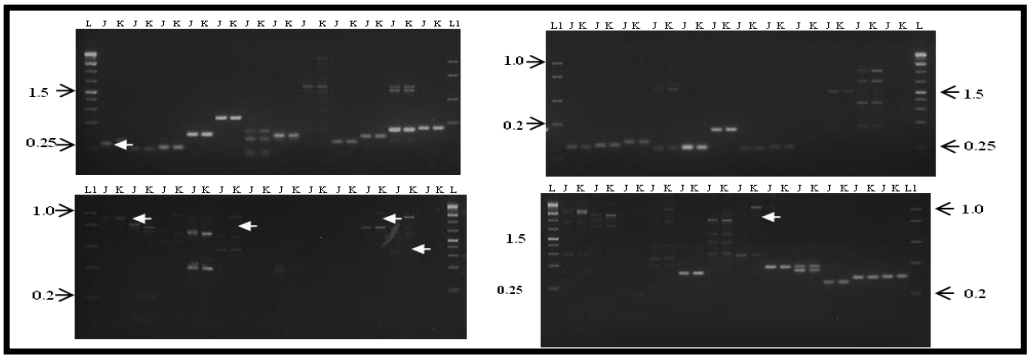


Fig. 5. Screening of a panel of 48 In-del markers on Jawala (J) and KRC-5 (K) on 3% agarose gel. White arrows indicated polymorphic markers; L- 1kb DNA ladder and L1- low molecular weight marker

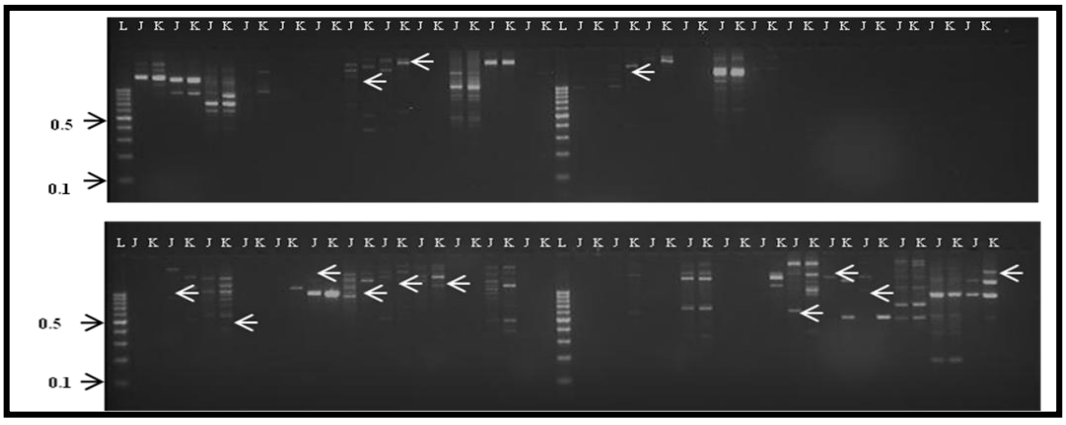


Fig. 6. Screening of a panel of 48 RAPD primers on susceptible Jawala (J) and resistant KRC5 (K) parents on 3% agarose gel. (White arrows indicate polymorphic markers; L- represents 100 bp marker)

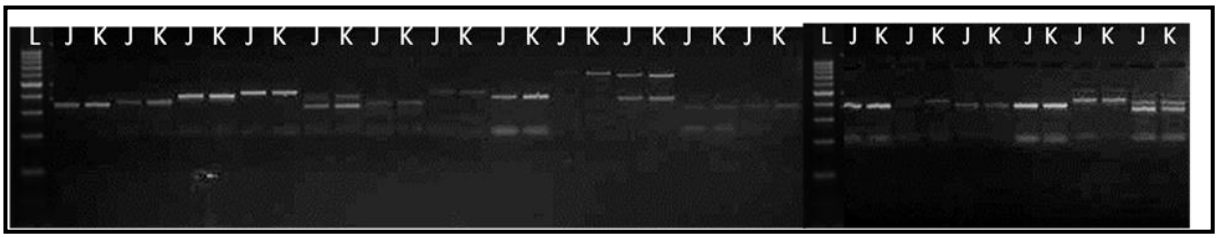


Fig. 7. Screening of Pv-series SSR markers (PvBR35, PvBR46, PvBR167, PvBR242, PvBR269, PvBR61, PvBR69, PvBR82, PvBR93, PvBR125, PvBR229, PvBR236, PvBR92, PvBR112, PvBR128, PvBR182, PvBR31, PvBR54) for polymorphism on susceptible Jawala (J) and resistant KRC5 (K) parents

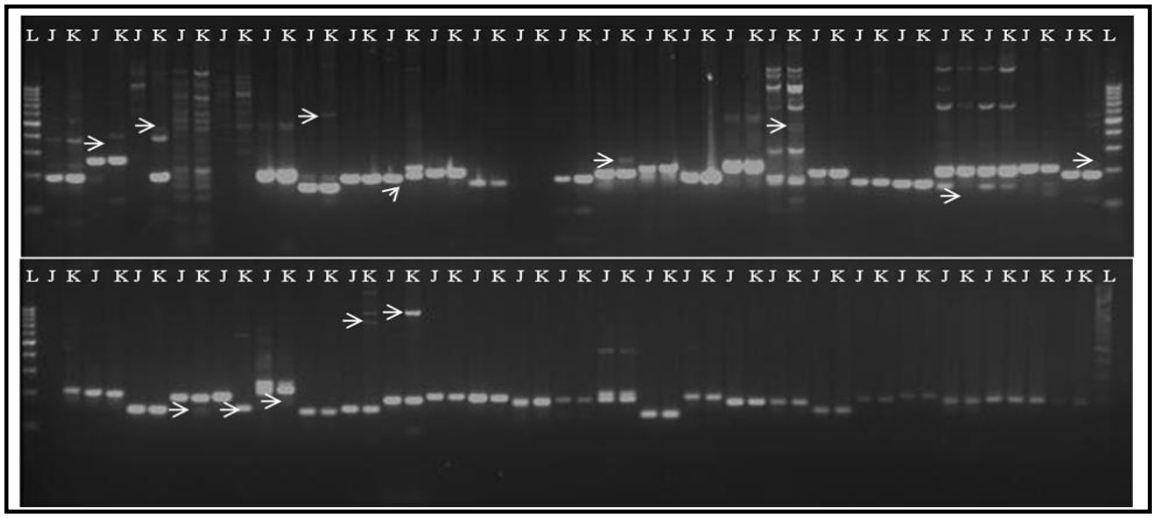


Fig 8. Screening of a panel of SSRs (Chr. 1, 5, 7) on Jawala (J) and KRC-5 (K) on 3% agarose gel. White arrows indicated polymorphic markers; L- 100 bp marker

Molecular Characterization of Pepper mild mottle virus (PMMoV) and its management through host resistance

i) Pathogenic variability of PMMoV on differential varieties

The pathogenic behavior of 16 isolates has been studied by inoculating each isolate on 5 differential varieties (Table 41) carrying different *L* alleles responsible for providing resistance in capsicum against tobamoviruses (Boukema 1980, 1982, 1984). All the isolates were able to infect and produce visible symptoms on 3 differential cultivars viz., *C. annuum* (Yolo wonder, L^1), *C. frutescense* (Tabasco, L^2) and *C. annuum* (Doux des Landes, L^+). However, on *C. annuum* (Yolo wonder, L^1) all isolates produced severe puckering, mottling of leaves followed by stunting of plants. The fruits developed by inoculated plants were mottled and deformed. On *C. frutescense* (Tabasco, L^2) and *C. annuum* (Doux des Landes, L^+) plants, prominent symptoms were mosaic, puckering, upward cupping of leaves, leaf banding and dwarfing of plants. In addition to these symptoms, 2 isolates viz., PMMoV-16.7 and 16.9 resulted in reduced leaf lamina in all the 3 differential varieties.

Table 41. Reaction of PMMoV isolates on differential cultivars vis-a-vis indexing through DAS-ELISA

Isolates	California wonder		Differential lines									
			101		102		103		104		105	
	A_{405}	Reaction	A_{405}	Reaction	A_{405}	Reaction	A_{405}	Reaction	A_{405}	Reaction	A_{405}	Reaction
PMMoV-16.1	1.407	+	0.806	+	0.894	+	0.715	+	0.253	-	0.236	-
PMMoV-16.2	1.532	+	0.830	+	0.763	+	0.692	+	0.321	-	0.201	-

PMMoV-16.3	1.152	+	0.901	+	0.920	+	0.923	+	0.245	-	0.219	-
PMMoV-16.4	1.135	+	0.890	+	0.808	+	0.735	+	0.262	-	0.207	-
PMMoV-16.5	1.067	+	0.889	+	0.730	+	0.692	+	0.222	-	0.205	-
PMMoV-16.6	1.072	+	0.903	+	0.718	+	0.788	+	0.227	-	0.232	-
PMMoV-16.7	1.840	+	1.026	+	0.976	+	0.666	+	0.358	-	0.203	-
PMMoV-16.8	1.280	+	1.295	+	0.730	+	1.082	+	0.190	-	0.194	-
									Positive		0.506	
									Negative		0.178	
PMMoV-16.9	1.567	+	1.296	+	0.864	+	0.915	+	0.138	-		-
PMMoV-16.10	1.267	+	1.147	+	1.564	+	1.059	+	0.207	-	0.149	-
PMMoV-16.11	1.216	+	0.738	+	1.163	+	1.004	+	0.196	-	0.136	-
PMMoV-16.12	1.076	+	0.716	+	0.677	+	0.713	+	0.318	-	0.131	-
PMMoV-16.14	1.201	+	1.198	+	1.029	+	0.902	+	0.179	-	0.165	-
PMMoV-17.1	1.264	+	0.936	+	0.757	+	0.733	+	0.165	-	0.242	-
PMMoV-17.2	1.478	+	0.998	+	0.765	+	0.794	+	0.291	-	0.278	-
PMMoV-17.3	1.143	+	0.923	+	0.779	+	0.727	+	0.216	-	0.201	-
									Positive		0.577	
									Negative		0.184	

+: Presence of symptoms; -: Absence of symptoms

However, none of the isolates produced symptoms on *C. chinense* (PI-159236, L^3) and *C. chacoense* (PI-260429, L^4) plants and were comparable to the uninoculated plants kept as control. The presence of PMMoV in inoculated plants of each differential cultivar was established by indexing with DAS-ELISA and the absorbance values for each cultivar is given in Table 42. The 3 cultivars viz., *C. annuum* (Yolo wonder, L^1), *C. frutescense* (Tabasco, L^2) and *C. annuum* (Doux des Landes, L^+) which were susceptible to present isolates exhibited very strong reaction in all the plants over negative control and the reaction was at par with that of susceptible cultivar "California wonder" (Table 42) whereas negative reaction was observed in resistant cultivars viz., *C. chinense* (PI-159236, L^3) and *C. chacoense* (PI-260429, L^4). Hence based on reaction on differential cultivars, all the isolates collected from capsicum growing areas of Himachal Pradesh were grouped in pathotype P_{12} only which can overcome L^+, L^1 and L^2 alleles.

Characterization of PMMoV pathotypes using molecular markers

The Cp gene amino acid sequences of all the test isolates were analyzed to characterize the virus isolates into pathotypes.

i) Amplification, cloning and sequencing of CP gene of present isolates

The CP gene of all the test isolates amplified using CP gene specific primers generated an amplicon of ~743 bp in all the isolates (Fig. 9). The amplified products corresponding to CP gene of each present isolate were eluted from agarose gel (Fig 10), ligated into pGEMT Easy vector and *E. coli DH5α* strain was successfully transformed with each isolate (**Fig. 11**).

Positive recombinant colonies produced an amplification product of ~743 bp in colony PCR with insert specific primers (**Fig. 12**), however, non-recombinant colonies did not produce any amplification of expected size. Then plasmid from recombinant colonies with CP gene insert of PMMoV test isolates was isolated, lypholized and custom sequenced from Agrigenome Pvt. ltd Labs.

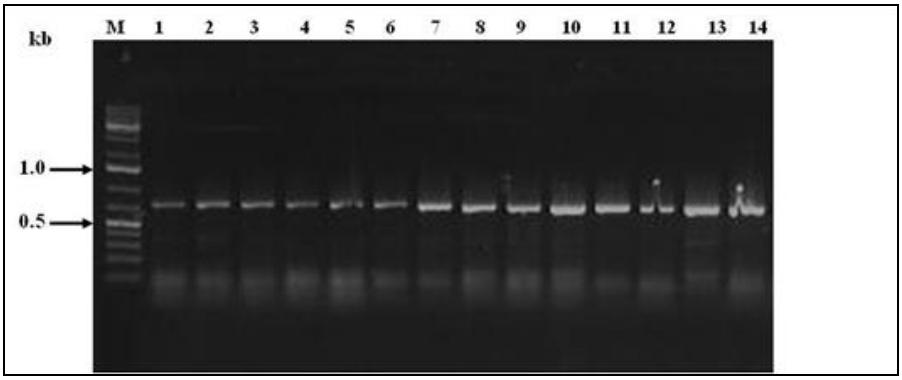
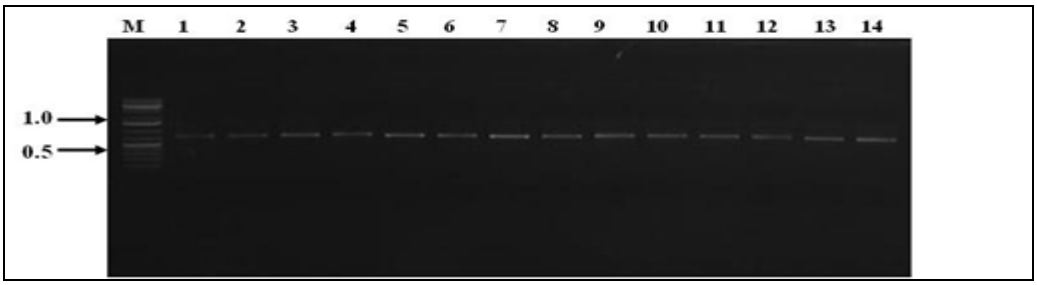


Fig. 9. Coat Protein gene amplification of PMMoV isolates using CP specific primers. M: 1 kb plus ladder, Lane 1-14: PMMoV isolates



,Fig 10. Agarose gel presenting the elution of amplified CP gene of PMMoV isolates. M: 1 kb plus ladder, Lane 1-14: PMMoV isolates

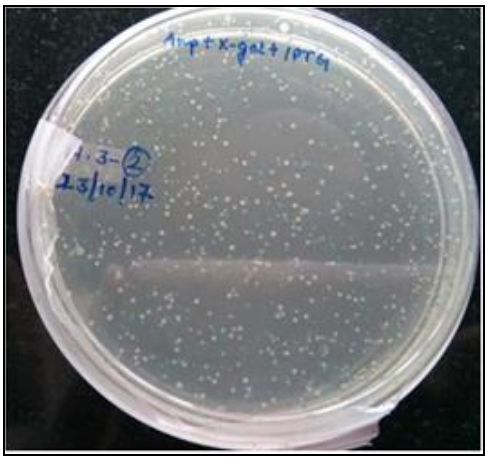


Fig 11. Recombinant *E. coli* colonies transformed with pGEMT- PMMoVCP.

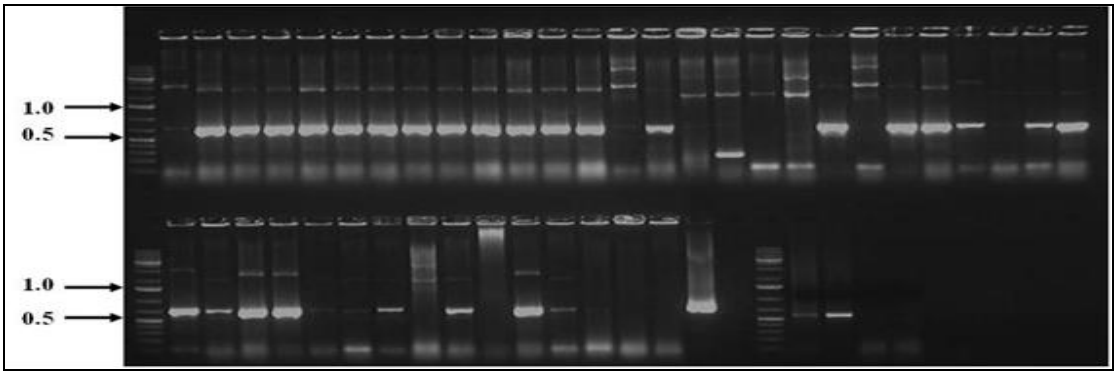


Fig 12. Confirmation of presence of insert in transformed colonies through colony PCR using insert specific primers.

ii) Nucleotide sequence assembly and analysis

The sequences of each isolate obtained after custom sequencing were edited with vecscreen programme (http://www.ncbi.nih.gov/vecscreen) to remove the vector sequences and subjected to BLAST analysis to make confirmation of the sequence as CP gene of PMMoV. The forward and reverse sequences were assembled manually. The obtained sequences corresponded to PMMoV region ranging from 5512 nt to 6258 nt containing 474 nts long (5685-6158 nt) CP gene of test PMMoV isolates. The CP gene sequences of all the present isolates aligned through ClustalW showed more than 98 per cent identity to each other with no significant variability at nt level. The nt sequence of isolates viz., PMMoV-16.6, 16.7, 16.9, 17.3, 16.11, 16.14 and 17.2, showed substitution of T to C, A to T, T to C and A to G at 24^{th}, 57^{th}, 198^{th} and 342^{th} nt position, respectively. In addition to these 4 nt substitutions, further substitutions of T to C, A to G and G to A at 203^{th}, 228^{th} and 313^{th} nt position, respectively was also noticed in case of isolate PMMoV-16.6. Substitution of A to T was found at 168^{th} position in case of PMMoV-16.6, 16.7, 16.9, 17.3, 16.11 and 16.14. In case of isolate PMMoV-16.10, 2 nt substitutions viz., A to G and G to A at 272^{th} and 464^{th} position was observed. There was a substitution of G to A at 100^{th} nt position of PMMoV-17.1. Isolates named PMMoV-16.1, 16.2, 16.3, 16.4, 16.5, 16.8 and 16.12 were 100 per cent identical whereas isolates 16.7, 16.9, 16.11 and 17.3 were 100 per cent identical.

iii) Amino acid sequence analysis

The amino acid sequence of each test isolates was determined using Expasy Translate tool. The amino acid sequences of all the present isolates along with P_{12}, P_{123} and P_{1234} pathotypes were aligned by ClustalW programme to elucidate amino acid mutations to designate various isolates. Most of the nt substitutions mentioned in previous section were silent and did not cause any change in the amino acid of the test isolates. The substitutions at 313^{th} position of isolate PMMoV-16.6 and at 100^{th} position of PMMoV-17.1 led to the substitution of Threonine to Alanine at 105^{th} position of PMMoV-16.6 and Asparatic acid to Asparagine at 34^{th} position of PMMoV-17.1. In case of PMMoV-16.10, 2 nt substitutions at position 272 and 464 resulted in substitution of Lysine to Arginine at 91^{th} position and Alanine to Threonine at 156^{th} position, respectively. Phylogenetic tree was constructed using the amino acid sequences of the present isolates as well as P_{12}, P_{123} and P_{1234} pathotypes of PMMoV through MEGA7 software (Figure 13) All the present isolates were clustered along with the P_{12} PMMoV isolates in one clade except PMMoV-16.10 that was placed on another clade of same cluster. However when amino acid sequence of PMMoV (P_{12}) were compared with present isolates, all isolates except 16.6, 16.10 and 17.1 were found to be 100 per cent similar to P_{12} pathotype. Five CP gene sequences of P_{123} were obtained from NCBI database and compared with the present isolates. Two mutations viz., Threonine to Serine at 6^{th} position and Valine to Alanine at 148^{th} position were common in all the P_{123} sequences (P_{123} from Turkey: HE96026.1, HE96027.1,

HE96028.1 (Caglar et al. 2012), PMMoV-Is: EF432637.1 (Antignus et al. 2008), PMMoV-Ia: AJ308228.1 (Velasco et al. 2010). Other than these, 3, 5 and 10 mutation were found in case of HE96026.1, HE96027.1, HE96028.1 while 4 and 5 mutations were observed in caes of PMMoV-Is and PMMoV-Ia. Two CP gene amino acid sequences of P_{1234} pathotype are available at NCBI database. PMMoV-Is (P_{1234}) (Antignus et al. 2008) had 4 amino acid mutations viz., Threonine to Serine, Glycine to Alanine, Asparagine to Methionine and Valine to Alanine at 6th, 87th, 139th and 148th positions, respectively. However, PMMoV-L4BV (P_{1234}) (Genda et al. 2007), only 2 mutations viz., Arginine to Glutamine at 47th position and Lysine to Glycine at 86th position were found.

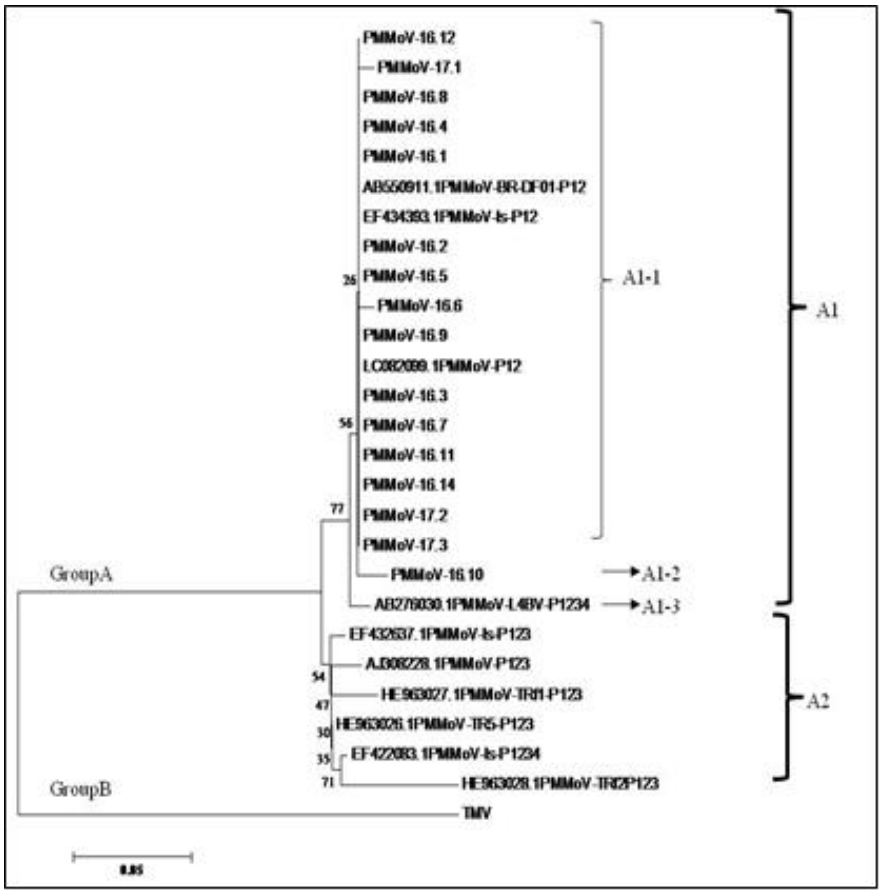


Fig 13. Phylogenetic tree constructed using the predicted amino acid sequences of PMMoV pathotypes through MEGA7 software

Development of Low cost virus indexing/Detection kits

In the present study the CP gene was selected for antigen preparation using recombinant DNA technology as it is the more relevant viral protein for immune-detection purposes. The target CP gene was first cloned in a non-expression vector, pGEM-T easy vector, followed by sub-cloning in an expression vector, pET-28a to prevent the instability of plasmid due to the production of proteins potentially toxic to the host cell (Rosano and Ceccarelli 2014).

Cloning and sequencing of CPgene

For raising the polyclonal antiserum against PMMoV, the CP region of isolate 3 (PMMoV-HP1) was amplified using virus specific primers (F: 5'-ACGAGAATTCATGGCTTACACAGTTTCCA-3', R: 5'-ATCGGTCGACGGAG CGGAGTTGTAGCCCAGGTGA-3') with built in restriction sites for *EcoR1* and *Sal1*. An amplification product of 500 bp corresponding to PMMoV-CP gene was observed (Fig. 14).

The amplified product was eluted from agarose gel and ligated in to pGEMT-Easy vector. *DH5α* strain of *E. coli* was successfully transformed with the ligated product. Colony PCR was performed using both vector specific (SP6 and T7) and insert specific primers to identify the transformed recombinant colonies (Fig. 15). Amplification produced from insert specific primers was 500 bp in size, however vector specific primers produced amplification product of ~700 bp because the primers amplified the region between SP6 and T7 promotor including the insert cloned in between of the vector (Fig. 16).

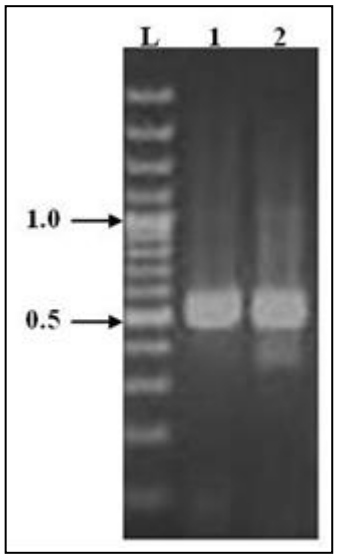


Fig 14. Amplification of CP gene of PMMoV using primers with built in restriction sites for *EcoR1* and *Sal1*, L: 1 kb plus ladder, Lane 1 and 2: PMMoV infected sample

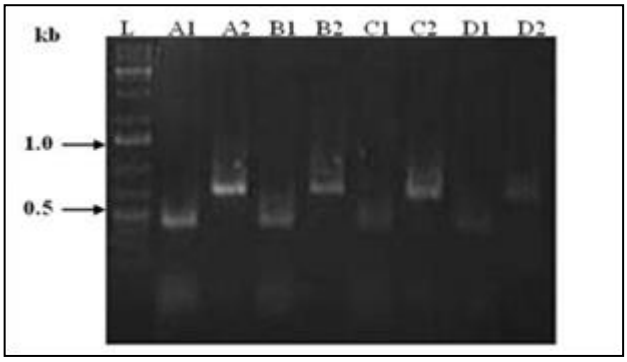


Fig 15. Colony PCR of *E. coli DH5α* recombinant colonies using gene specific (1) and vector specific (2) primers. L: 1 Kb plus ladder, A, B, C, D: Recombinant colonies.

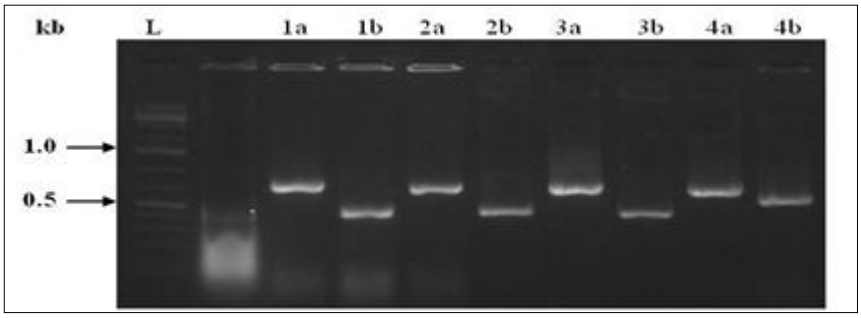


Fig 16. Colony PCR of *E. coli BL-21 (DE3)* recombinant colonies using vector specific (a) and insert specific primers (b). L: 1 Kb plus ladder, 1-4: Recombinant colonies

The plasmid from recombinant colonies was successfully isolated and digested with *EcoR1* and *Sal1* (13). The digested plasmid was ligated into expression vector pET-28a predigested with same restriction enzymes (Fig. 17).. Transformation of BL21 (DE3) strain of *E. coli* using pET-28a-PMMoV-CP was performed followed by colony PCR using vector (T7 promoter and T7 terminator) and insert specific primers (14) to confirm the presence of insert. In all the picked colonies amplification of desired size (500 bp) was obtained with insert specific primers, however vector specific primers yielded an amplication product of more than 700 bp. Plasmid from a positive colony was isolated and custom sequenced using T7 promoter and T7 terminator primers. The obtained sequence comprised of 787 nucleotides containing 486 nucleotides corresponding to PMMoV-genome ranging from nucleotide position 5685- 6154th. The BLASTn analysis confirmed the identity of sequence as PMMoV-CP with 100 per cent similarity to the PMMoV-HP1 (KJ631123.1) (Rialch et al. 2015). The obtained sequence (pET-28a-PMMoVCP) translated by ExPassy Translate Tool and compared with the aa sequence of CP gene of PMMoV-HP1 isolate (KJ631123.1) showed 100% similarity (Fig. 18) with PMMoV-HP1 isolate of the virus. Thus these results confirmed the successful insertion of full length PMMoV-CP gene in pET-28a expression vector inframe without any frameshift (Figure 19).

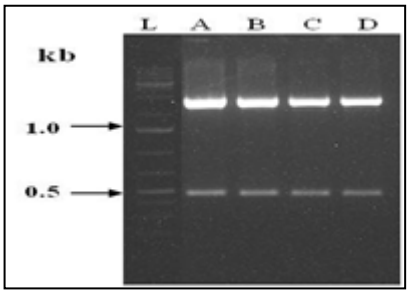


Fig 17. Restriction digestion analysis of (pGEM-T Easy Vector) recombinant plasmid containing desire DNA insert. L: 1 Kb plus ladder, A, B, C, D: Recombinant colonies.

```
pET-28a+CP      MAYTVSSANQLVYLGSVWADPLELQNLCTSALGNQFQTQQARTTVQQQFSDVWKTIPTAT
HP-1            MAYTVSSANQLVYLGSVWADPLELQNLCTSALGNQFQTQQARTTVQQQFSDVWKTIPTAT
                ************************************************************
pET-28a+CP      VRFPATGFKVFRYNAVLDSLVSALLGAFDTRNRIIEVENPQNPTTAETLDATRRVDDATV
HP-1            VRFPATGFKVFRYNAVLDSLVSALLGAFDTRNRIIEVENPQNPTTAETLDATRRVDDATV
                ************************************************************
pET-28a+CP      AIRASISNLMNELVRGTGMYNQALFESASGLTWATTP
HP-1            AIRASISNLMNELVRGTGMYNQALFESASGLTWATTP
```

Fig 18. Alignment of amino acid sequence of pET-28a+CP with that of PMMoV-HP1 generated through multiple alignment tool clustalW

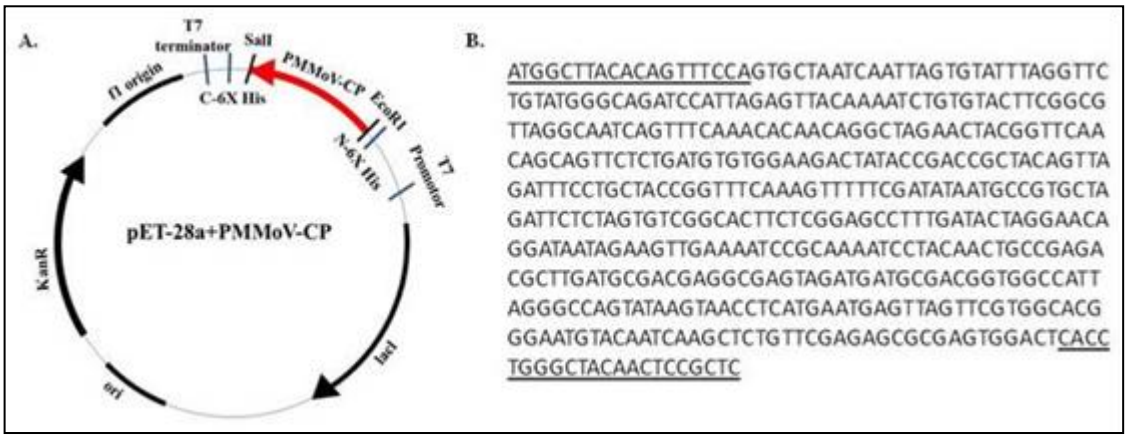


Figure 19. A diagram showing PMMoV-CP cloned in expression vector, pET-28a; 4.6B: Nucleotide sequence of coat protein region of PMMoV cloned in pET-28a

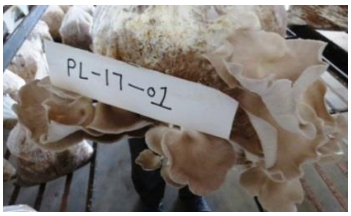
I. Mushroom Cultivation

During the period under report eight cultures of Oyster Mushroom and seven accessions of white button mushroom were received from DMR for conducting evaluation trials.

Initial varietal trial on button mushroom (*Agaricus bisporus*):
The experiment was conducted with 7 white accessions of *Agaricus bisporus* viz., IVT-17-01 to 07 in 4 replications each with 6 bags of 10.0 kg compost in RBD. IVT-17-04 gave the maximum yield of 11.4 kg/ 100kg compost with 1165 number of fruitbodies having average fruitbody weighing 9.8 grams. The average pileus size was 9.2cm having stipe size of 3.4 x 1.3 cm.

Advance varietal trial-1 on oyster mushroom (*Pleurotus* spp):
The experiment was conducted with four high yielding varieties/ strains of oyster mushroom viz., PL-16-01 to PL-16-04 with 6 replications in RBD with 8 bags in each replication. PL-16-02 gave the maximum yield of 33.9 kg/ 100 kg dry weight of wheat straw with total number of fruit bodies being 5148.4. The average weight per fruit body was 6.6 grams. Average pileus size was 8.9 x 6.9 cm and stipe of 2.4 x 0.6 cm.

Advance varietal trial-2 on oyster mushroom (*Pleurotus* spp):
Four high yielding varieties/ strains of *Pleurotus* spp viz., PL-17-01 to PL-17-04 were evaluated for their performance in RBD having 6 replications each with 8 bags of 1 kg dry weight wheat straw. The spawn rate was 1% for dry substrate. PL-17-01 recorded the highest yield of 42.6 kg/ 100 kg dry weight of wheat straw with total number of fruitbodies being 3590. The average weight per fruitbody was 11.9 grams. The pileus size was 7.4 x 6.7 cm with stipe of 2.9 x 0.6 cm and gills had average width of 0.4 cm.



Experiential Learning Programme: Twelve students joined the Experiential Learning Module on Mushrom Cultivation during July to December 2017 (II) semester and Nine students during January to May 2018 (I) semester. They were imparted training on Mushroom Cultivation through both theoretical lectures and practical demonstrations performed by the students themselves as per the course contents.

EXTENSION EDUCATION

Various activities performed by the scientists of this department posted at head quarter, research stations and KVK's are as under:

Extension Publications	25 Nos.
Advisory	Advisory and consultancy services to farmers and visitors regarding diagnostic and management of diseases of wheat, rice, pulses, ginger, vegetables and other field crops , was provided to more than 1400 persons.
Liaison/ collaboration with National/ International bodies/ agencies	Liaison was established with various agencies like ICARDA, AVRDC, ICRISAT, NBPGR, MYMV, RKVY,ATMA etc.
Trainings conducted	175 various training programmes were conducted at head quarter and out side the stations/ KVK's and 5250 farmers were trained
Participation in Extension Training Programmes	267 numbers of lectures were delivered to farmers in various training programmes conducted at head quarter and out side the stations/ KVK's and 10640 farmers were trained
Front Line Demonstrations	14 numbers of FLDs were conducted
Radio/ TV talks delivered	6 Radio and TV talks were given by various scientists on different topics
On farm trials	16 numbers of on Farm trials were conducted
Field demonstrations	84 numbers of Field demonstrations were conducted
Adaptive trials	9 numbers of Adaptive trials were conducted
Kisan melas/ divas	46 numbers of kisan melas/divas were organized
Workshops organized/ attended	21 numbers of workshops organized/attended
Pamphlets	12 pamphlets were prepared and published
Mushroom Cultivation	• Two five days trainings • Three one days trainings cum demonstrations • 29 lectures to 1075 farmers • 30 qtl. of spawn production • 10 tons of compost production • 4.5 qtl. of fresh mushroom production • Advisory services to mushroom growers • Visit to mushroom farms for survey of diseases and disorders

Success Story

Manoj Gupta, B. Pal, S.S. Paliyal, Sangeeta Attri, Akhilesh Singh and Pragya Bhadauria (2017). Small –Scale Dairy Farming: Pathway of Prosperity in Western Himalya. In Vignettes of Farming Excellenge, ICAR-ATARI Ludhiana Punjab PP-107-110 Published by Rajbir Singh, Arvind Kumar, V.P Chahal and A.K Singh.

Awards: Sirmour Shree Samman Puraskar 2017 by Himotkarsh was awarded to KVK, Sirmour.

PUBLICATIONS

1. Research publications (published/ accepted) in the referred journals

Acharya, M.K. and Kumar, A. 2017. Antifungal activity of alkaloids from *Murraya koenigii* (Linn.) Spreng against *Alternaria brassicae* (Berk.) Sacc. *Indian Journal of Agricultural Biochemistry* 30:115-120.

Arushi, Malannavar, A.B. and Banyal, D.K.2017.Effect of spacing and planting dates on the development of powdery mildew of tomato. *Pl. Dis. Res.*32: 226-227

Basandrai, A.K., Basandrai, Daizy and Sharma, B.K. 2016. Fungicidal management of Web. Blight of Urdbean caused by *Rhizoctonia solani .Legume Research*. 39:1038-42.

Gangawr, O.P., Kumar, Subodh, Bhardwaj, S.C. Parsad, P., Khan, Hanif and Sharma, S.K. (2017). Detection of New Yr1-Virulences in *Puccinia strifirmis* f.sp.*tritici* population and its sources of resistance in advance wheat lines and released cultivar. *Indian Phytopathology*. 70 (3):307-314.

Garg, Tosh ; Mallikarjuna, B.P. ; Thudi, Mahendar ; Samineni, S., Singh, S., Sandhu, Singh, Kaur, J.S. L., Inderjit, S., Asmita, Basandrai, A.K., Basandrai, D., Varshney, R.K. ; Gaur, P.M. 2017. Identification of QTLs for resistance to Fusarium wilt and Ascochyta blight in a recombinant inbred population of chickpea (*Cicer arietinum* L.) Euphytica: Vol. 214: **DOI:** 10.1007/s10681-018-2125-3.

Katna , G., Kumari ,V., Dev, J., Singh, Amar and Bala, A. 2017. Stability analysis for seed yield and related traits in soybean (*Glycine max* L. Merrill). *Agric. Res .J.* 54: 165-169

Katoch, A, Sharma, Prachi, Padder, B.A. and Sharma, P.N. 2017. Population Structure of *Colletotrichum truncatum* in Himachal Pradesh and Identification of Broad-Spectrum Resistant Sources in Capsicum. *Agricultural Research*. DOI10.1007/s40003-017-0261-y

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Katoch, A., Sharma, Prachi and Sharma, P.N. 2017. Identification of Colletotrichum spp. associated with fruit rot of *Capsicum annuum* in North Western Himalayan region of India using fungal DNA barcode markers. *J. Plant Biochem. Biotechnol.* 26:216–223.

Katoch, R., Thripati T., Kumar, N., Sood, V.K. and Banyal, D.K. 2018. Revisiting prospects in red clover: A potential temperate fodder legume. National group meet – *Kharif* 2018 held at TNAU Coimbatore on 6th -7th April, 2018. *Souvenir* 55-61.

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Katoch, Shabnam and Kumar, Suman (2017). Perpetuation of Stemphylium blight of garlic under mid hill conditions of Himachal Pradesh.*Indian Phytopath.* 70 (3):294-296.

Kumar, Pardeep. 2017. Effect of different agricultural substrates on yield of *Pleurotus sajor-caju. Journal of Krishi Vigyan* 6(1): 61-64.

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Singh, S., Vikram, P. Sehgal, D., Burgueño, J., Sharma, A., Singh, S.K., Sansaloni, C.P., Joynson, R., Brabbs, T., Ortiz, C., Moya, E.S., Govindan, V., Gupta, N., Sidhu, HS.,Basandrai, A.K., Basandrai, D., Ledesma-Ramires, L., Suaste-Franco, M.P., GuillermoFuentes-Dávila, Moreno, J.I., Sonder, K., Singh, V.K., Singh, S., Shokat, S., Arif, M.A.R., Laghari, K.A., Srivastava, P., Bhavani, S., Kumar, S., Walia, D., Jaiswal, J.P., Kumar, U., Chaudhary, H.K., Crossa, J., Payne, T., Imtiaz, M., Sohu, V.S., Singh, G.P., Bains, N.S. Hall, A. and Pixley, K.V. 2018. Rare haplotypes from germplasm bank accessions contribute to drought and heat tolerance and disease resistance of elite wheat lines**.** *Scientific Report Nature* 8: 12527.

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Thakur, B.R., Kumari, N. and Singh, A. 2017. Occurrence of pea root rot/wilt complex disease in Himachal Pradesh. *Himachal Journal of Agricultural Research*. 42: 187-191

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2. Papers Presented in Workshop / Symposia

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Kumar, D. Dogra,V., Sharma, S., Sharma, P.K., Sud, D., Sharma. N. 2018. *Azolla*: A Model Food for Dairy Cattle and Wonderful Bio-fertilizer for Himachal Pradesh. In. "Doubling the Farmers' Income: Challenges and Strategies", CSKHP Krishi Vishvavidyalaya, Palampur w.e.f. April 23-24. (*Abstract, CD75*)

Kumar, Pardeep 2017. Management of seabuchkthorn (*Hippophae* sp.) diseases with organic fungicides in Lahaul valley- A cold desert area of Himachal Pradesh. Abstract in "National Conference on seabuckthorn" held at Defence Institute of High Altitude Research, LehLadakhw.e.f. 22-24 September, 2017.

Kumar, Pardeep, Upadhayay, Sanjiv; Chauhan, C. L., Thakur, Anjana and Dogra, Rekha (2018). Mushroom Cultivation- A significant intervention for doubling farmers income. Abstract in the conference on "Doubling farmers' Income: Challenge and Strategies" at CSKHPKV, Palampurw.e.f 23-24 April, 2018.

Sharma, Neetu, Dogra,Vishal, Sud, Deepika, Sharma, Sanjay, Kumar, Deep and Sharma,P.K. 2018. Adding value to agricultural produce: a key to raise farm Incomes. In. "Doubling the Farmers' Income: Challenges and Strategies", CSKHP Krishi Vishvavidyalaya, Palampur w.e.f. April 23-24. (Abstract, CD79)

Sharma, Parveen Kr. Dogra, Vishal, Sharma, Sanjay, Kumar,Deep, Sharma, Neetu, Sud, Deepika & Thakur, Rakesh. 2018. Agricultural tools / implements in sub mountainous region of Himachal Himalayas –at the verge of extinction. In. "Doubling the Farmers' Income:

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Sud, Deepika, Dogra, Vishal and Sharma , Neetu. 2017 . Management of Potato Blights and Tuber Moth under Saviour Window for Soundness of Technology (SWST) in Kangra District of Himachal Pradesh. in the National Seminar `Crop Protection: Current trend and future perspective` Medziphema Campus, Nagaland University w.e.f. 16-18, November 2017, (Oral Presentation, Abstract)

Sud, Deepika, Dogra, Vishal , Sharma, Neetu , Sharma, Sanjay, Kumar ,Deep, Sharma P.K. 2018. Popularization of Oyster Mushroom Cultivation – A Vital Component for Doubling Farm Income of hill farmers. In."Doubling the Farmers' Income: Challenges and Strategies", CSKHP Krishi Vishvavidyalaya, Palampur w.e.f. April 23-24. (*Abstract,* NF18)

Thakur, Anjana, Chauhan, C. L., Kumar, Pardeep, Upadhayay, Sanjiv and Dogra, Rekha 2018. Impact of frontline demonstrations on vegetables in enhancing income of small and marginal farmers of low hills of Himachal Pradesh. Abstract in the conference on "Doubling farmers' Income: Challenge and Strategies" at CSKHPKV, Palampurw.e.f 23-24 April, 2018

Books

Thakur, D. R., Guleria, S.K., Sharma, S. D. and Devlash, Rakesh . 2018. Maize – Golden crop for Himachal Pradesh. CSK Himachal Pradesh KrishiVishvavidyalaya, Hill Agricultural Research & Extension Centre, Bajaura-175 125, Distt. Kullu (H P). pp 51.

Extension Publications

a) Training manuals

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Sharma, K. C., Singh, A., Sharma, V., Rana, R., and Singh, J. 2017.Himachal Pradesh me Dalhani Faslon ki Kheti. *CSKHPKV, Palampur*.(56 pages).

Sharma, K. C., Singh, A., Sharma, V., Thakur, D. R. and Sharma, A. 2017. Pahari khetro mein sabjion ki vaigyanik kheti. *CSKHPKV, Palampur*.(56 pages).

Singh, A., 2017. Aushdhiya guno se bharpur laldhan wa mote anaj ki kheti ki takneek. *CSKHPKV, Palampur.(56 pages).*

Singh, A., and Sharma,J. K. 2017 . Cultivation practices of pulses for higher productivity. *CSKHPKV, Palampur*.(56 pages).

Singh, A., and Sharma,J. K. 2017.Cultivation practices of cereals for higher productivity. *CSKHPKV, Palampur*.(56 pages).

Singh, Anita, Singh, Anand and Chauhan, Shivani 2018. Practical manual of Botany. *CSKHPKV, Palampur*.(74 pages).

b) Popular articles

Kumar, Pardeep and Kumar ,Gulshan. 2017. Azolla- Pashuon ke liye Sastaa va adarsh aahar. *Parvatya Khetibari*. 37(3-4):23-24.

Kumar, Pardeep. 2018. Bangan ki vimarian va unka pravandhan. *Giriraj Saptahiki* (Communicated).

Mahajan, Girish., Kumar, Deep and Sud, Deepika**.** 2017**.** Sunishchit hua kisano ka arthik uthaan. *Giriraj* ***Saptahik,*** 39(31):5**.**

Rathee, V.K. , Manchanda , A.K., Singh, Dhirendra, Sharma, Jitender and Singh ,Akhilesh 2018 *GAHUN KA PILA RATUA* 4 pages

Sharma, Neetu., Sud, Deepika, Dogra, Vishal., and Kumar, Deep . **2017.** Haldi ka prasanskaran evm mulyavardhan**..** *Parvatiya Khetibari* **37(2):13-14.**

Singh, Amar and Banyal, D.K. 2017. Polyhouse main ugaijanewali sabjiaon ke permukh rog abum unki roktham (Hindi). *Parvatia Khatibari*. 37 (1): 20-22

Singh, P.K., Chopra, P., Paul, S. and Kumar A. 2018. Double purpose linseed: a viable option for doubling farmers' income in the north western Himalayan region. *Indian Farming* (In press)

Singh, Dhirendra, Manchanda, A.K., Rathee, V.K., Sharma, Jitender and Singh, Akhilesh 2018 *GAHUN KA BEEJ UTPADAN* 4 pages

Singh,R.P ,Singh ,A.P and Singh,Akhilesh 2017. Khumb Utpadan Se Ahar –Postikata evam Arthik Sampanta. *Phal Phool*, March –April 28 (2):29-33

Sud, Deepika and Sharma, Neetu. 2017. Methi ki kheti mein fasal sanrakshan. *Giriraj Saptahik*. 40(6):5.

Sud, Deepika., 2018. Khumb mein fasal Prabandhan. *Giriraj Saptahik*.40 (15):5.

Thakur, Anjana, Chauhan ,C.L., Kumar, Pardeep and Arya ,Kalpna. 2018. Piaj main rog va keet pravandhan. *Giriraj Saptahiki*. 2 March, 2018 (5)

Upmanyu, S., Basandrai, D., Mankotia, B. S., Pandey, D. P., Srivastava, A., Rana, V. and Manuja, S. 2017. Lal Dhan – Himachal ke lalmoti. CSK HPKV Rice and Wheat Research centre, Malan. Pp. 1-8.

c) Folders

Arya, Kalpna, Kumar, Pardeep, Sharma, Parveen and Dogra Rekha 2017. Mushroom ka mulya parivardhan vibhin khadiya padarthon ke roop main. 2017:9.

Kumar, Pardeep, Upadhayay, Sanjiv, Arya, Kalpna, Chauhan, Chaman Lal and Thakur, Anjana 2018. Bangan main ekikrit rog pravandhan. 2018:1

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Thakur Anjana, Kumar, Gulshan, Kumar, Pardeep, Chauhan, C.L. and Dogra, Rekha 2018. Jalvayu parivartan se keeton par prabhav, samashayan avam samadhan. 2018: 3.

Thakur Anjana, Upadhaya, Sanjeev, Kumar, Pardeep, Arya, Kalpna and Chauhan C.L. 2018 Jalvayu Parivartan ka Krishi par prabhav. 2018:2.

d) Booklets

Arya, Kalpna , Kumar, Pardeep and Chauhan,C.L. 2017. National Nutritional Week. No. 12:35p.

Arya, Kalpna , Upadhaya, Sanjeev, Kumar, Pardeep, Thakur, Anjana, Chauhan,C.L. Singh, Dhanbir, Sharma, Parveen and Dogra, Rekha 2017. Rashtriya Poshaahar Saptaha. No. 11: 23p.

Kumar,**Pardeep ,** Thakur, Anjana, Chauhan,C.L., Upadhaya, Sanjeev. 2018. Khumb ke rog va keet avam unaka pravandhan. (In press).

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Manchanda, A.K. Singh, Dhirendra, Rathee,V.K., Sharma ,Jitender and Singh, Akhilesh 2018. *GAHUN KI VAGYANIC DHANG SE KHETI*. March 18 pages-8

Sharma, S.K., **Sharma, B.K.,** Sharma, Yogita and Sinha, B.N**.** 2018.Adarak ki unnat kheti ammulyabhardhak utpad. (26 pp).*In press.*

Singh, Akhilesh, Sharma, P.C., Mittal, P. and Gupta, M. 2016. Ginger (in Hindi) pp8

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Singh, Akhilesh, Sharma, P.C., Mittal, P. and Gupta, M. 2016. Zero budget khaad pp8

Thakur,Anjana, Kumar,Gulshan, Deepika, Sharma, Upadhaya, Sanjeev, Chauhan,C.L., Sharma, P.K., Kumar, Pardeep, Singh , Dhanbir, Arya, Kalpna, Dogra, Rekha and Thakur, Rakesh. 2018. Impact of technology demonstrations for climate resilient agriculture. No.2: 35 pp.

Participation in summer schools/ Meetings/ workshops/ seminars etc.

Scientists of the Department posted at main campus and out stations attended various programmes:

1. Annual Group Meeting of Safflower and Linseed from 17-19 August, 2017 at PJTSAU, Hyderabad
2. Attended National group meeting – *Rabi* 2017 of All India Co-ordinated Research Project on Forage Crops at GKVK, Bengaluru, Karnataka-560065 on 4-5th September, 2017 and Acted as Repporteurs in one session.
3. National Conference on enhancing productivity of oilseeds in changing climate scenario at Directorate of Groundnut Research, Junagarh from April 7-9, 2018.
4. Attended State Level Agriculture officer's workshop on *Rabi* crops (21.10. 2017) and .*Kharif* crops at CSK HPKV Palampur on 9th May 2018
5. Attended National group meeting – *Kharif* 2018 of All India Co-ordinated Research Project on Forage Crops at TNAU Coimbatore on 6th -7th April, 2018and Acted as Repporteurs in one session.
6. Attended National Seminar on "Environmental concerns and sustainable development at DDM Sai College of education Kallar (Nadaun) on 17.4.2018.

SUMMARY

- Seed treatment with Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) at 3.0 ml/ Kg of seed, gave maximum control of loose smut (97.8 %) of wheat and increase in the grain yield (24.7%) and was closely followed by Sedaxane 2.5% w/v + Fludioxonil 2.5 % w/v (50FS) at 1.5 ml/ Kg of seed.
- Fungicides tebuconazole, hexaconazole, propiconazole and nativo were effective in reducing severity of wheat powdery mildew and increasing the yield.
- **S**eed treatment with carbendazim followed by two sprays with tryfloxystrobin + tebuconazole was found highly effective against BLSB of fodder maize with 86.9% disease control and 17.2% increase in yield over check followed by seed treatment with - carbendazim and its two foliar sprays.
- The new coordinated molecule (Pydiflumetofen 7.5% + Difenoconazole 12.5%) was found very effective in controlling early blight of potato at different concentrations providing 70.8 and 73.8 per cent control with 13.7 and 10.9 % increase in yield as compare to control at 500 & 600 ml/h.
- Dr SK Rana was associated with the development and evaluation of Wheat variety Him Palam Gehun 3 (HPW 373) recommended in *Rabi* Workshop on 21.10.2017 for release by SVRC.
- Karnal bunt incidence in the state varied between 0.1 to 2.8 percent (30.43% samples) with a maximum incidence of 2.8% in Bhalana area of district Hamirpur. However, ~71 percent of the samples showed infection above certification level, though much less over previous years. The hybrid rice grown in Bheora area of Mandi showed very high incidence (62.5%) of neck blast.
- Soybean seed treatment with fungicide carboxin + thiram (Vitavax power) @ 2g/kg seed and two foliar sprays with thiophanate methyl @ 0.1% at 55 and 75 days after sowing effectively manage the pod blight and resulted higher seed yield (15.4q/ha) as comparisons to control (10.1 q/ha).
- The seed treatment with bioagents, organic inputs like panchgabya, Jeevamrit and bijamrit over the period of storage had significant effect on seed germination though it was maximum in treatment *Trichoderma viride* + *Pseudomonas fluorescence* and bijamrit. Bijamrit followed by Bavistin (as Check) and Pachgavya + P. fluorescence were found to be effective against seed borne infection of bean anthracnose and seedling rot.
- The pathogenic and molecular variability studies on *Pepper mild mottle virus* have revealed the prevalence of pathotype P_{12} different districts of the state.
- Standardized the protocol of the over-expression of PMMoV coat protein gene in *E. coli* using IPTG at 1mM final concentration with overnight incubation in shaking incubator at 16^{o}C resulting in the induction of target recombinant protein with molecular weight ~26kDa for production of polyclonal antiserum.
- Established the association of Fusarium *solani* f. sp. *pisi* with pea root rot/wilt and *Fusarium oxysporum* f. sp. *pisi* peas wilt.
- Chickpea genotype ICWA 1640, 1642, 1644 and ICWA 05529 were resistant whereas, ICWA 133, 1643 and 1648 were moderately resistant to Ascochyta blight.
- **S**eed treatment with carbendazim followed by two sprays of propiconazole was found highly effective against foliar diseases of forage sorghum which gave 86.4% disease control with 20.9% increase in the yield over check.

- In a field trial on screening of brassica germplasm against major diseases, two genotypes viz., RH-1573 and RAUDT-10-33 out of 43 entries were found resistant to white rust. None of the entry showed resistance to Alternaria blight.
- In UDN, six rapeseed-mustard genotypes namely YSB-9, PDZ-2, PDZ-3, PDZ-5, PDZ-7, DRMR-1-5 were observed resistant to white rust disease among 40 genotypes screened.
- In national disease nursery trial on white rust genotypes DRMRIJ 12-26, DRMRIJ 12-28, DRMRIJ 12-37, DRMRIJ 12-39, DRMRIJ 12-40 and DRMRIJ 12-41 were observed resistant to white rust disease out of 44 genotypes screened.
- In uniform disease nursery trial on linseed, two entries coded RLC-164 and RLC-92 were observed resistant to wilt.
- Scientists published 47 Nos. of Extension publications in the form of Books, Popular articles, Pamphlets , Booklets and Folders .
- Advisory and consultancy services to farmers and visitors regarding diagnostic and management of diseases of wheat, rice, pulses, ginger, vegetables and other field crops , was provided to more than **1400** persons.
- 175 various training programmes were conducted at head quarter and outside the stations/ KVK's and **5250** farmers were trained
- **267** numbers of lectures were delivered to farmers in various training programmes conducted at head quarter and outside the stations/ KVK's and **10640** farmers were trained
- 6 Radio and TV talks were given by various scientists on different topics
- In addition 14 nos. Of FLD's, 16 numbers of on Farm trials , 84 numbers of Field demonstrations, 9 numbers of Adaptive trials and 46 numbers of kisan melas/divas 21 numbers of workshops organized/attended were also conducted.
- **Sirmour Shree Samman Puraskar 2017** by Himotkarsh was also awarded to KVK, Sirmour.