ANNUAL PROGRESS REPORT

(2019-20)

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Department of Plant Pathology

College of Agriculture

Chaudhary Sarwan Kumar
Himachal Pradesh Krishi Vishvavidyalaya
PALAMPUR-176062 (HP)

ACKNOWLEDGEMENT

The 34th Annual Progress Report of the department has been brought out with the co-operation of the whole faculty deployed in the department, different Research Centers, Research Sub-stations 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 Arun Kumar Sud , Dr DK Banyal and Dr Amar Singh for compilation and editing 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 sinsere 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 copying and binding of the report.

05.10.2020

Head of the Department

CONTENTS

1. INTRODUCTION

The Department of Plant Pathology has the mandate of teaching, research and extension education pertaining to different streams of plant patholozy viz., Mycology, Virology, Bacteriology, Epidemiology, Plant Disease Management and Mushrooms. Scientists conduct research on different areas of specialization under different projects and the students admitted to M Sc and Ph D programmes are assigned research problems on different aspects of diseases of cereals, pulses, oilseeds, vegetable crops and mushrooms.

The research work on various ad-hoc projects & AICRPs 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 mainly 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 diseases blast, yellow rust, banded leaf & sheath blight, bacterial stalk rot, anthracnose, powdery mildews, downy mildews, bacterial wilt and canker, late blight, fusarial wilt, white rot, root rot /wilt complex, fruit rots and viral diseases receive special attention.

The department is also conducting research on different aspects of cultivation of mushrooms including their diseases. 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 various seminars/ symposia/ conferences organized by different scientific societies and workshops held by AICRPs and University 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, RKVY, 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.

2. STAFF POSITION

a. Faculty

The faculty strength of the discipline/ department borne on teaching, research and extension schemes has been given in the following Table.

Name	**Position/ Designation**	**E-mail**
Dr S K Rana	Professor & Head	skrana62@gmail.com
Dr A K Basandrai Dr P N Sharma Dr B R Thakur Dr A K Sud Dr D K Banyal Dr Amar Singh	Professor & Dean (Retired on 31.05.2020) Principal Scientist & Dean (01.06.20 to 28.07.20) Principal Scientist Principal Extension Specialist & Programme Director CMRT Principal Scientist Principal Scientist	bunchy@rediffmail.com pns1960@gmail.com drbrthakur@rediffmail.com arunsud7217@gmail.com dkbanyal@gmail.com singhamar008@gmail.com
Hill Agricultural Research & Extension Centre, Bajaura – 175125		
Dr R K Devlash Vacant	Scientist/ Principal Scientist Senior Scientist	devlashbajaura@rediffmail.com -
Hill Agricultural Research & Extension Centre, Dhaulakuan – 173031		
Dr V K Rathee Dr Akhilesh Singh	Scientist/ Principal Scientist & ADR Senior Scientist/ Principal Scientist	vkrrathee@gmail.com asingh1962@rediffmail.com
Hill Agricultural Research & Extension Centre, Kukumseri - 175142		
Vacant	Scientist	-
Mountain Agricultural Research & Extension Centre, Sangla – 172106		
Dr S K Sharma (Retired on 31.01.20)	Scientist & Scientist Incharge	surindersharma01@gmail.com
Shivalik Agricultural Research & Extension Centre, Kangra – 176001		
Vacant	Scientist	
Rice & Wheat Research Station, Malan – 176047		
Dr Sachin Upmanyu Vacant	Scientist Scientist	sachinupmanyu_mpp@rediffmail.com -
Research Sub-Station, Akrot – 177211		
Dr B K Sharma	Scientist/ Principal Scientist & Scientist Incharge	sharmabk63@yahoo.com
Research Sub-Station, Sunder Nagar - 175019		
Vacant	Scientist	-
Directorate of Extension Education, Palampur - 176062		
Dr Deepika Sood (From 13.09.19 AN)	Assistant Extension Specialist/ Subject Matter Specialist	deepika_agri@rediffmail.com
Krishi Vigyan Kendra, Dhaulakuan - 173031		
Dr Anand Singh	Assistant Extension Specialist/ Principal Extension Specialist & Programme Coordinator	singhanandisi@yahoo.com
Krishi Vigyan Kendra, Kukumseri – 175142		
Vacant	Subject Matter Specialist	-
Krishi Vigyan Kendra, Bara - 177044		

Dr Pardeep Kumar (Up to 12.09.19)	Subject Matter Specialist	pkdogra2007@rediffmail.com
Krishi Vigyan Kendra, Kangra - 176001		
Dr Deepika Sood (Up to 13.09.19 FN) Dr. Pardeep Kumar (From 13.09.19)	Subject Matter Specialist Subject Matter Specialist	deepika_agri@rediffmail.com pkdogra2007@rediffmail.com
Krishi Vigyan Kendra, Berthin - 174029		
Dr Suman Kumar	Subject Matter Specialist/ Principal Extension Specialist & Programme Coordinator	sumanhpkv@gmail.com
Krishi Vigyan Kendra, Una - 174303		
Vacant	Subject Matter Specialist	-

(b) Staff

The department is having a total strength of 9 staff members borne on various teaching and research schemes as given below.

Staff	**Name & Designation**
Ministerial Staff	
1	Smt Usha Rani, Section Officer
2	Sh Ravi Kumar, Senior Assistant
Technical Staff	
1	Sh Naresh Kumar, Field Assistant G-I)
2	Sh Himat Ram, Junior Technician
3	Sh Balwant Singh, Technical Assistant (G-II) Deputed at Salooni
Supporting Staff	
1	Sh Rattan Chand, Beldar (Retired on 31.12.19)
2	Sh Dalip Kumar, Beldar (Retired on 31.01.20)
3	Sh Subhash Chand, Beldar
4	Sh Desh Raj, Beldar

3. FINANCIAL OUTLAY AND STAFF POSITION IN DIFFERENT SCHEMES

The receipt of funds under plan and non plan schemes is as given under:

Name of the Scheme	**Expdt (Lac Rs.)**	**Staff**
Creation of facilities for Postgraduate Studies in the Department (APL-001-17)	41.92	Dr A K Basandrai, Dean COA (Retired on 31.05.20) Sh Harbans Lal, Sr Asstt (Biotech) Sh Shakti Chand, Jr Technician (COBS)
Facilities for teaching in the Department/ College of Agriculture (APL-010-17)	93.01	Dr S K Rana, Professor & Head Dr A K Sud, Principal Extension Specialist Sh Ravi Kumar, Senior Assistant Sh Vijay Kumar (Security Cell) Sh Balwant Singh, Tech Asstt G-II (RRS Salooni)
Strengthening of facilities for research in the Department (APL-021-17)	23.30	Sh Ramesh Kumar, Beldar (Seed Tech) Sh Dalip Kumar, Beldar (Retd) Sh Desh Raj, Beldar Sh Rattan Chand, Beldar (Retd)
Facilities for research in the Department (APL-059-17)	6.08	Sh Subhash Chand, Beldar
All India Coordinated Research Project on Seed Technology Research under NSP (ICAR-017-17 Pt-II)	32.38	Dr P N Sharma, Professor Sh Atul Kumar, Lab Attendant (Agri Biotech)
All India Coordinated Mushroom Improvement Project (ICAR-056-17)	2.50	-
Molecular mapping of anthracnose resistance gene in common bean land race KRC8 and identification of adult plant resistance components (DST- GOI-5042-17)	15.20	Ms Anila Badiyal, Research Associate
Fungicide testing (Ad Misc 626-17)	3.00	-
Evaluation of NBPGR wheat germplasm against powdery mildew under CRP on agro-biodiversity PGR management-component-II (Wheat) (Ad Misc 4079-17)	4.00	-
Bio-intensive disease management of soil borne diseases of vegetable crops under protected cultivation (Ad Misc 2195-17)	1.26	Mr Anudeep, Junior Research Fellow Mr Manish, Field Assistant
Evaluation of lentil and chickpea pre-breeding material and germplasm against rust and Asochyta blight (Ad Misc 4011-17)	2.00	
Up scaling Technical Support for Addressing Emerging Problems Vegetable crops under Protected Environment (Ad Misc 2239-17)	8.02	
Eco Friendly Management strategies for powedery mildew of wheat in HP (Ad Misc 2241-17)	6.00	
Protected Agriculture and Natural Farming (PANF) under NAHEP-CAAST Programme (NAHEP-ICAR-231-17)	7.00	
Research Activity on Screening Mungbean Germplasm (Ad Misc 776-17(i)	1.01	
Self Finance Scheme (SFS-001-17)	2.80	-
Revolving Fund (RF-A-46-036-17)	3.64	-
Revolving Fund Scheme under SFS (Experiential Learning) (RF-B-61-142-17)	0.78	-
CDA-004-17	1.00	
CDA-006-17	1.00	
CDA-011-17	0.20	
CDA-013-17	0.2 0	

4. TEACHING

a. Courses offered/ taught:

(i) UG courses

Course No.	Course Title	Cr Hr	Teacher(s)
Pl Path 352	Principles of Integrated Disease Management	2+1	Dr B R Thakur
Pl Path 353	Diseases of Field & Horticultural Crops and their Management-I	2+1	Dr A K Sud
Pl Path 111	Plant Pathogens & Principals of Plant Pathology (Old Syl)	3+1	Dr Amar Singh
Pl Path 121	Fundamentals of Plant Pathology	2+1	Dr Amar Singh
Pl Path 233	Diseases of Field Crops and their Management (Old Syl)	2+1	Dr B R Thakur
Pl Path 241	Crop Protection-1 (Plant Pathology)	0+1	Dr A K Sud
Pl Path 364	Diseases of Field & Horticultural Crops and their Management-II	2+1	Dr B R Thakur
Exp Learning	Mushroom Cultivation (Semester-I)	0+10	Dr A K Sud
Exp Learning	Mushroom Cultivation (Semester-II)	0+10	Dr A K Sud Dr Deepika Sud
(UG courses offered by other Departments)			
Bot 111	Biodiversity (Microbes, Algae, Fungi & Archegoniate)	4+2	Dr Arun Sud
Agron 3613	Agrochemicals	2+1	Dr D K Banyal
Soils 354	Biopesticides & Biofertilizers	2+1	Dr B R Thakur
Exp Learning	Nursery Management	0+1	Dr B R Thakur
Exp Learning	Protected Cultivation	0+1	Dr Amar Singh

(ii) PG courses

Pl Path 501	Mycology	2+1	Dr Amar Singh
Pl Path 502	Plant Virology	2+1	Dr P N Sharma Dr S Upmanyu
Pl Path 503	Plant Bacteriology	2+1	Dr S K Rana
Pl Path 504	Principles of Plant Pathology	3+0	Dr B R Thakur
Pl Path 505	Detection and Diagnosis of Plant Diseases	0+2	Dr P N Sharma Dr S K Rana Dr Amar Singh
Pl Path 506	Principles of Plant Disease Management	2+1	Dr B R Thakur
Pl Path 510	Seed Health Technology	2+1	Dr P N Sharma
Pl Path 511	Chemicals in Plant Disease Management	2+1	Dr D K Banyal
Pl Path 513	Disease Resistance in Plants	2+0	Dr D K Banyal Dr Amar Singh
Pl Path 518	Epidemiology and Forecasting of Plant Diseases	2+1	Dr D K Banyal
Pl Path 591	Master's Seminar	1+0	Dr B R Thakur
Pl Path 599	Master's Research	1-18	Major Advisors
Pl Path 601	Advanced Mycology	2+1	Dr Deepika Sud
Pl Path 602	Advanced Virology	2+1	Dr P N Sharma Dr S Upmanyu
Pl Path 603	Advanced Bacteriology	2+1	Dr S K Rana
Pl Path 604	Molecular Basis of Host Pathogen Interaction	2+1	Dr P N Sharma Dr D K Banyal
Pl Path 605	Principles and Procedures of Certification	1+0	Dr D K Banyal
Pl Path 606	Plant Bio-security and Bio-safety	2+0	Dr A K Basandrai
Pl Path 691/692	Doctoral Seminar-I/ II	1+0	Dr B R Thakur
Pl Path 699	Doctoral Research	1-18	Major Advisors

b. Students admitted:

S No	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Ms Ayushi Sharma (A-2019-30-067)	Dr B R Thakur	Biological control of pea root rot caused by *Fusarium solani* f. sp. *pisi*
2	Ms Kajal (A-2019-30-068)	Dr Rakesh Devlash	Epidemiology of Turcicum leaf blight in maize and identification of resistance sources
3	Ms Monika Rathi (A-2019-30-069)	Dr Sachin Upmanyu	Virulence analysis of *Rhizoctonia Solani* Kuhn and evaluation of resistance in rice
4	Ms Ridhima Gupta (A-2019-30-070)	Dr S K Rana	Biology of *Xanthomonas axonopodis* pv *glycines* causing bacterial pustule of soybean and identification of resistance sources
5	Ms Sakshi Sharma (A-2019-30-071)	Dr B K Sharma	Studies on epidemiodogy of lentil wilt and host resistance
6	Ms Tarushi (A-2019-30-072)	Dr Deepika Sud	Studies on synthetic log cultivation of Shitake mushroom *Lentinula edodes*
Ph D programme			
1	Ms Diksha Sinha (A-2019-40-024)	Dr D K Banyal	Biology and management of early blight of tomato caused by *Alternaria Solani*
2	Ms Khushwinder Kaur (A-2019-40-025)	Dr Amar Singh	Diversity analysis of *Pseudocercospora griseola* populations causing angular leaf spot of common bean and identification of resistant sources
3	Vakul Sood (A-2019-40-026)	Dr A K Sud	Studies on variability in pathogen(s) causing root rot of okra and its integrated disease management

c. Ongoing students:

S No	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Ms Aanchal Titaria (A-2018-30-061)	Dr S Upmanyu	Studies on sheath rot of rice caused by *Sarocladium oryzae*
2	Ms Ankita Chauhan (A-2018-30-062)	Dr Pardeep Kumar	Variability of *Ralstonia solanacearum* and eco-friendly management of bacterial wilt of tomato
3	Ms Divya Bhandari (A-2018-30-063)	Dr Amar Singh	Biology of *Phytophthora colocasiae* Raci. causing blight of colocasia and its eco-friendly management
4	Ms Nikita (A-2018-30-064)	Dr A K Sud	Management of wet bubble of white button mushroom caused by *Mycogone perniciosa* (Megnus)
5	Ms Pratibha Sharma (A-2018-30-065)	Dr P N Sharma	Analysis of virulence shift in *Colletotrichum lindemuthianum* causing bean anthracnose and its eco-friendly management
6	Mr Raghav alias Bantu (A-2018-30-066)	Dr Rakesh Devlash	Management of Turcicum leaf blight of maize in Himachal Pradesh
7	Ms Shiney Chatak (A-2018-30-067)	Dr D K Banyal	Integrated disease management of urdbean anthracnose caused by *Colletotrichum truncatum*
8	Ms Sunidhi	Dr B R Thakur	Epidemiology and management of Ascochyta

	(A-2018-30-068)		blight of chickpea (*Cicer arietinum*)
Ph D Programme			
1	Ms Shabnam (A-2015-40-020)	Dr S K Rana	High resolution mapping of *Co-Ind* gene from common bean landrace KRC-5 possessing resistance to *Colletotrichum lindemuthianum* races
2	Ms Shiwali Dhiman (A-2015-40-021)	Dr P N Sharma	Molecular mapping of anthracnose resistance gene in common bean landrace KRC-8 and identification of adult plant resistance components
3	Mr Anudeep B M (A-2016-40-017)	Dr D K Banyal	Studies on virulence and host resistance in oat-*Blumeria graminis* f *sp avenae* pathosystem
4	Ms Ashima Thakur (A-2017-40-019)	Dr D K Banyal	Epidemiology and management of Stemphylium blight of onion
5	Ms Dimple Rana (A-2017-40-020)	Dr B R Thakur	Studies on variability and management of Fusarium wilt of chickpea
6	Ms Priya Bhargava (A-2017-40-021)	Dr S K Rana	Epidemiology and management of flag smut (*Urocystis agropyri* (Preuss) Schroet) of wheat
7	Ms Abhilasha Sharma (A-2018-40-023)	Dr Amar Singh	Characterization of variability in *Cercospora sojina* Hara causing frogeye leaf spot and identification of resistant sources in soybean
8	Ms Gurpreet Kaur (A-2018-40-024)	Dr S K Rana	Epidemiology and management of Fusarium head blight of wheat

d. Students completed M Sc / Ph D programme:

Name of student	Major advisor	Title of thesis
M Sc programme		
Ms Divyanshi Bhatti (A-2017-30-066)	Dr Suman Kumar	Biology and management of bacterial canker of tomato
Ms Harneet kaur (A-2017-30-067)	Dr A K Basandrai	Eco-friendly management of wheat powdery mildew caused by *Blumeria graminis tritici*
Ms Himani Gupta (A-2017-30-068)	Dr P N Sharma	Impact of head blight on seed health of wheat and its management
Ms Khushwinder Kaur (A-2017-30-069)	Dr B R Thakur	Eco-friendly management of pea root rot caused by *Fusarium solani* f sp *pisi*
Ms Jaina V Patel (A-2017-30-070)	Dr Amar Singh	Biological management of damping off of okra (*Abelmoschus esculentus*)
Ms Priyanka B Patel (A-2017-30-071)	Dr P N Sharma	Investigation on seed borne nature of pepper mild mottle virus and assessment of yield losses in capsicum
Ms Pooja Kapoor (A-2017-30-072)	Dr S K Rana	Integrated management of sheath blight (*Rhizoctonia solani* kuhn) of Rice
Ms Prerna Thakur (A-2017-30-073)	Dr A K Sud	Studies on cultivation of Golden Oyster Mushroom (*Pleurotus citrinopileatus Singer*)
Mr Siddharth Anand (A-2017-30-074)	Dr D K Banyal	Etiology and Epidemiology of collar rot complex of cowpea
Ph D programme		
Mr Narinder Pal (A-2014-40-017)	Dr Ashok Kumar	Variability, epidemiology and management of *Fusarium oxysporum* f sp *lini*

e. Students' placement

Name of Student & Admission No.	Name of Major Advisor	Nature of Placement along with Details
Ms Himani Gupta A-2017-30-068	Dr P N Sharma	Agriculture Officer, JICA, Bilaspur, HP
Ms Pooja Kapoor A-2017-30-072	Dr S K Rana	AEO, Deptt of Agriculture, Bhedu Mahadev, HP
Ms Prerna Thakur A-2017-30-073	Dr Arun Sud	Agriculture Officer, JICA, Mandi, HP
Mr Narender Pal A-2014-40-017	Dr Ashok Kumar	Lecturer, Private Univ, Bathinda, Punjab

f. Theses Abstracts:

(i) M Sc

Name of the student: Ms Diyanshi Bhatti

Major advisor: **Dr Suman Kumar**

Title of thesis: Studies on *Clavibacter michiganensis* and its management

Abstract: Tomato (*Solanum lycopersicum* L.) is one of the most important widely cultivated vegetable crops in open as well as polyhouse conditions in the world. Its cultivation in the state is beset with many production constraints especially bacterial canker which have emerged as major bottleneck in the economic production of crop. The highest incidence of the disease was recorded under polyhouse conditions from Kangra and Solan districts. Climatic condition with high temperature and relative humidity makes the crop vulnerable to the disease. The bacterium manifested to develop cracks to form cankers. Based on morphological, physiological, biochemical and molecular characters and pathogenicity test the pathogen was identified to be *Clavibacter michiganensis* subsp. *michiganensis* (Smith) Davis *et al.* Medium aged plants exposed to any injury and temperature of 30^0C is most congenial for the initiation of the disease. The bacterium was found to be seed borne in nature. Considerable onset in expression of the disease symptoms under controlled conditions was observed with temperature above 28^0C in medium aged plants when inoculated with 15-30 days old culture. Slurry treatment of seed with streptocycline @1g/kg provides protection to tomato against *Clavibacter michiganensis.*

Name of the student: Ms Harneet Kaur

Major advisor: Dr A K Basandrai

Title of thesis: Eco-friendly management of wheat powdery mildew caused by *Blumeria graminis tritici*

Abstract: The present investigation entitled "Eco-friendly management of wheat powdery mildew caused by *Blumeria graminis tritici"* was undertaken to identify resistant sources, study pathogenic variation and the disease management using plant extracts and organic formulations. Out of 2023 genotypes, seventeen genotypes were free from disease at seedling and adult plant stage at Palampur and Malan during 2017-18 and 2018-19. Pathogenic variation was studied in 20 ascosporic isolates collected from Dalang Maidan (Lahaul & Spiti) during September – October, 2018, on a differential set comprising of 36 known *Pm* genes. Based on the differential reaction, the isolates were grouped into 20 pathotypes. The most virulent pathotype was 20 attacking 22 resistant genes whereas, pathotype 2 was the least virulent as it showed susceptible reaction on 12 genes i.e. Sonora *(Pm3c),* Aristide (*Pm3g*), Hope (*Pm5a*), Siete Cerros (*Pm5b*), Transec (*Pm7*), Kavkaz (*Pm8*), Norin (*Pm10*), Wembley (*Pm12*), *Lr* 34 (*Pm38*), TD114 (*Pm2+6*), Talent (*Pm5+?*) and Chancellor. Powery mildew differential lines with resistance genes WHMN (*Pm 1c),* near isogenic line (*Pm2*), Chul (*Pm3b*) and Maris Dove (*Pm2, Mld),* were resistant to all the isolates of *B. graminis* f.sp. *tritici*. Among plant extracts and organic formulations, *Azadirachta indica* (20%) under *in vitro* conditions and foliar spray under polyhouse conditions and *Calotropis gigantia* (15%) under field conditions were found to be the most effective and may be harnessed as a potential alternate to fungicides.

Name of the student: Ms Himani Gupta

Major advisor: Dr P N Sharma

Title of thesis: Impact of head blight on seed health of wheat and its management

Abstract: In the present study, fifty nine processed wheat seed samples procured from different seed multiplication farms of University divided into two seed lots (sterilized and unsterilized) were assessed for the prevalence of seed mycoflora and *Fusarium* spp. associated with head blight disease and their impact on seed health. Attempts were also made to find suitable fungicide and bioagents to control the seed borne infection of head blight pathogen *Fusarium graminearum* and associated seed mycoflora. The associated seed mycoflora detected from two seed categories (sterilized and unsterilized) revealed the presence of 9 fungi (*Alternaria alternata, Aspergillus niger, A. flavus, A. clavatus, Fusarium graminearum, Fusarium poae, Penicillium* spp., *Trichoderma* spp., and a non-sporulating fungus). Among the two assay methods, agar plate method was found more suitable than the blotter method in terms of mycoflora expression. *A. alternata* and *F. graminearum* were the most predominant fungi in most of the samples along with high frequency. *Fusarium graminearum* and *F. poae* were found to be associated with FHB disease in different wheat varieties being multiplied in different agro-climatic zones of the state. The seed health parameters *viz.*, seed germination, seed and seedling health were adversely affected in artificially inoculated seed samples than apparently healthy samples, where seed germination was higher along with least seed and seedling rot. The seed germination reduced significantly by 71.86 per cent in *F. graminearum* inoculated seeds to that of 89.56 per cent in uninoculated apparently healthy seed lots. The seedling vigour index was also affected by *F. graminearum* inoculations with a seed vigor index of 1542.85 as compared to the uninoculated seeds (2069.87). Two seed dressing fungicides Vitavax Power and Bavistin were most effective in controlling the *F. graminearum* and other seed mycoflora, whereas among the bio-agents, *Trichoderma harzianum* (TH-5) found to most effective. In rolled paper towel bioassay seed treatment with Vitavax Power resulted in maximum mycoflora control including *F. graminearum* followed by *T. harzianum*. The seed vigour also increased in Vitavax Power treated seeds as gradual decrease in seed vigour and other seed health parameters were noticed over the period of storage.

Name of the student: Ms Khushwinder Kaur

Major advisor: Dr B R Thakur

Title of thesis: Eco-friendly management of pea root rot caused by *Fusarium solani* f. sp. *pisi*

Abstract: The present investigation entitled "Eco-friendly management of pea root rot caused by *Fusarium solani* f. sp. *pisi*" had been undertaken in the Department of Plant Pathology, College of Agriculture, CSK HPKV, Palampur during 2017-2019. Pea root rot had been observed as an alarming problem in pea growing regions of Himachal Pradesh and poses major constraints in pea cultivations. At Bir, the highest disease incidence of 75.2 per cent was recorded. *Fusarium solani* f. sp. *pisi* was found to be associated with pea root rot in the state. The pathogen produced characteristic symptoms in pathogenicity tests as blackening and maceration of pea roots resulted in yellowing of leaves from basal leaf to upward. Different disease management components *viz*., composts, botanicals, bioagents, PGPR and organic inputs were evaluated for their efficacy against *F. solani* f. sp. *pisi in vitro* conditions. In the composts, Vermicompost showed the maximum mycelial inhibition of 36.7 per cent against *F. solani* f. sp. *pisi* followed by Sheep goat manure with 33.0 per cent at 25 per cent test concentration. In the bioagents and PGPR, a strain SMA-5 of *Trichoderma harzianum* showed maximum mycelial inhibition of 76.0 per cent against *F. solani* f. sp. *pisi*. Among botanicals, *Eupatorium adenophorum* yielded maximum mycelial inhibition of 77.4 per cent in alcoholic extracts whereas, 38.9 per cent in aqueous extracts against *F. solani* f. sp. *pisi* at 25 per cent test concentration. In the organic inputs , Jeevamrit showed cent per cent mycelial inhibition even at 8 per cent test concentration followed by Panchgavya with 62.7 per cent mycelial inhibition at 10 per cent test concentration against *F. solani* f. sp. *pisi*. For eco-friendly management module, soil amendment with Vermicompost @ 10 tonnes/ ha + chopped *Eupatorium adenophorum* leaves @ 20 tonnes/ ha and further seed treatment with Jeevamrit @ 5ml/ kg seed + *Pseudomonas fluorescens* @ 5ml/ kg seed + *Trichoderma harzianum* (SMA-5) @ 5g/ kg was found best against pea root rot pathogen to yield 60.87 per cent disease control.

Name of the student: Ms Jaina Vinodchandra Patel

Major advisor: Dr Amar Singh

Title of thesis: Biological control of damping off of okra (*Abelmoschusesculentus* L.)

Abstract: The investigation on the biological control of damping off of okra (*Abelmoschus esculentus* L.) was undertaken during 2017-19 in the Department of Plant Pathology, CSK HPKV, Palampur. Damping off pathogen (*Rhizoctonia solani*) was isolated from the disease samples collected from different okra growing areas and pathogenicity proved. Twenty isolates of *Trichoderma* spp. were isolated from different rhizosphere soil and five standard isolates of *Trichoderma* spp. were evaluated for their antagonistic activity *in vitro* against *R. solani*. The bioagent strains obtained from the department were statistically less effective than *Trichoderma* strains isolated from okra rhizosphere soil such as isolate 2,6,9,11. *Trichoderma* sp.-2 was the best performing strain among the bioagents tested in dual culture as well as its volatile compounds activity in inhibiting maximum mycelial growth 67.8 and 42.4 per cent, respectively. However, non-volatile compounds produced by *Trichoderma* sp.-6 in autoclaved sterilized and filter sterilized culture filtrates inhibited mycelial growth upto 11.1 and 62.2 per cent at 2:1 ratio, respectively. In morpho-cultural identification of four potential *Trichoderma* isolates, *Trichoderma* sp.-6 and *Trichoderma* sp.-9 were identified as *T.harzianum* and *T. viride*, respectively. In mycoparasitic interaction, bioagents hyphae coiled around *R. solani* and after penetration lysed the pathogen hyphae. Among the eleven different solid media evaluated for the linear mycelial growth and spore production of potential bioagents, *Trichoderma* sp.-2 showed highest mycelial growth (171.0 mm) and population (2.6×10^{8}spore/g) in sorghum grains. Agro-by products *viz*., paddy straw, cow dung and FYM supplemented with different carbohydrates *viz*., glucose, sucrose and jaggery (at the rate 1.0% and 5.0%) enhanced the growth of bioagents. *Trichoderma* sp.-2 showed highest linear mycelial growth on paddy straw (170.7 mm) when amended with 5.0 per cent sucrose.Under net house conditions, seed biopriming was found superior application method of bioagents for management of damping off of okra than soil application, seed treatment and drenching while *Trichoderma* sp. -2 was found most superior to other bioagents. Among Four fungicides tested *in vitro* carbendazim was most effective against *R.solani* but incompatible with bioagents while copper oxychloride was found compatible with bioagents.

Name of the student: Ms Priyanka B Patel

Major advisor: Dr P N Sharma

Title of thesis: Investigation on seed borne nature of pepper mild mottle virus and assessment of yield losses in capsicum

Abstract: Capsicum (*Capsicum annuum* L. var *grossum* Sendt), a member of family *Solanaceae* commonly known as bell pepper or sweet pepper, is highly popular and economic crop grown throughout India under both open and polyhouse conditions since the 15th century. The crop is being attacked by numbers of fungal, bacterial and viral pathogens. Among viral pathogens *Pepper mild mottle virus* (PMMoV), a member of family *Virgaviridae* and genus *Tobamovirus* is extremely destructive due to its highly contagious and seed borne nature. The present investigations on PMMoV were undertaken to study the transmission of PMMoV through seeds, detect PMMoV from seeds through ELISA and RT-PCR and assess yield losses in capsicum due to PMMoV. The typical virus symptoms produced on infected plants were upward cupping of the leaves, mild mosaic, reduction in leaf lamina, mild mottling on the newly emerging leaves and leaf deformation. The infected plants remained stunted and had less number of fruits which showed mottling, deformation, and reduction in their size as compared to healthy plants. DAS-ELISA and coat protein gene amplification confirmed the identity of the virus as PMMoV. For seed transmission study of PMMoV, Grow Out Test (GOT) and RT-PCR using coat protein gene-specific primers were performed in three capsicum cultivars *viz.*, *Capsicum annum* (California Wonder), *Capsicum annum* (Yolo Wonder) and *Capsicum annum* (Doux des Landes) under greenhouse conditions. Seed transmission was highest in cultivar California Wonder (63.04 %) followed by Yolo Wonder (33.80 %) and Doux des Landes (33.30 %) on the basis of visual symptom observation in Grow Out Test, however, indexing of randomly selected symptomatic plants from Grow Out Test through DAS-ELISA and RT-PCR confirmed the seed transmission behavior of the three test varieties, though the percentage transmission was lower than the GOT. The RT-PCR based assay of seed transmission showed 60.32, 36.94 and 33.13 percent transmission of the PMMoV in cv. California Wonder, Yolo Wonder, and Doux des Landes. This suggests that RT-PCR and DAS-ELISA as more reliable techniques over GOT. 20 mg (~3-4 seeds) and ~8-10 mg (1 seed) infected seeds of cv. California Wonder is sufficient to detect PMMoV by DAS-ELISA and RT-PCR assay, respectively. The DAS ELISA values and band intensity in RT-PCR suggested uneven distribution and concentration of the virus in a given sample. The yield loss assessment in capsicum hybrid Indira under polyhouse and greenhouse conditions revealed a

significant reduction in fresh fruit yield and market quality trait. The yield attributing factors affected by virus infection included average plant height, average leaf size, number of leaves per plant and number of branches per plant, number of marketable fruits, average fruit weight, PMMoV infection at early growth stages causes severe infection and pronounced yield losses than later stages infection. However, seed-borne infection of PMMoV causes even higher yield losses than artificially inoculated plants.

Name of the student: Ms Pooja Kapoor

Major advisor: Dr S K Rana

Title of thesis: Integrated Management of Sheath Blight (*Rhizoctonia solani*) of Rice

Abstract: The investigation on "Integrated management of sheath blight (*Rhizoctonia solani* Kuhn) of rice" was undertaken during 2017-19 in the Department of Plant Pathology, CSK HPKV, Palampur. Sheath blight pathogen was isolated from infected rice plants and pathogenicity was proved. Among six organic amendments, Jeevamrit and Neem Cake gave cent per cent mycelial growth inhibition of the *Rhizoctonia solani* at ≥ 15 and 30 per cent concentration, respectively by poisoned food technique. *In vivo* Neem Cake gave maximum disease control with 55.17, 52.94 and 50.00 percent reduction in disease incidence and 40.49, 38.85 and 35.33 per cent reduction in disease severity at maximum tillering, booting and panicle formation stages, respectively followed by Jeevamrit. *In vitro*, Bavistin 50 WP (at ≥ 25 ppm), Nativo 75 WG (≥ 50 ppm), Vitavax 75 WP (≥ 100 ppm) and Raxil 250 EC at 250 ppm concentration gave cent per cent inhibition of *R. solani*. Bavistin 50 WP (0.1 %) was found to be most effective both as seedling root dip treatment with 64.52 and 51.27 per cent reduction in disease incidence and severity and foliar sprays with 70.59 and 85.93 per cent reduction in incidence and severity of ShB, respectively at maximum tillering stage and similar pattern of effectivity was observed at booting and panicle formation stages. Among 50 genotypes of rice screened under artificial infection conditions 14 genotypes were found to be resistant while 16 genotypes were moderately resistant. In compatibility studies *T. harzianum* (TH-4) showed complete compatibility with Raxil 250 EC at 1 ppm and moderate compatibility up to 7 ppm while all the bioagents viz., *T. koningii* (DMA-8), *T. harzianum* (TH-4), *T. viride*, *T. harzianum* (TH-11), *T. harzinum* (Isolate-7) and *T. harzianum* (Isolate-8) showed complete incompatibility with Bavistin 50 WP at all the concentrations (1-20 ppm). The integrated treatment T_9 (soil amendment with Neem Cake + seedling root dip treatment with Bavistin 50 WP + foliar application of *T. harzianum* (TH-4) + foliar application of Raxil 250 EC) was found to be most effective in reducing disease incidence (64.56, 63.76 and 59.45 %) and severity (69.24, 66.27 and 66.31 %) at three crop stages (maximum tillering, booting and panicle formation), respectively.

Name of the student: Ms Prerna Thakur

Major advisor: **Dr Arun Kumar Sud**

Title of thesis: Studies on cultivation of Golden Oyster Mushroom (*Pleurotus citrinopileatus*)

Abstract: The present investigations entitled "Studies on cultivation of golden oyster mushroom (*Pleurotus citrinopileatus* Singer) was undertaken to evaluate various cultural requirements, grain substrate for spawn production and different agro-based substrates used for sporophore production of the test fungus. Out of seven solid media tested, Potato Dextrose Agar was found to be the best for mycelial growth of the test fungus and also took minimum days to full the Petri plate. Out of nine spawn substrates, the maximum mycelial growth rate was observed on sorghum grains (1.12cm/day) and minimum on pigeonpea (0.65cm/day). The minimum (27.33 days) time for spawn run was observed on sorghum grains spawn and maximum yield was observed in wheat grain spawn i.e. 893.33g/kg dry substrate. The minimum cost of production was observed on wheat grain spawn (Rs. 63.25) with maximum profit of Rs. 86.75. Out of nineteen agro-based substrates, minimum time for spawn run and primordia formation was taken by wheat straw i.e. 29 days and 34.67 days, respectively and maximum 5.00 number of fruit bodies was observed on soybean straw substrate. The soybean+maize combination took minimum days for spawn run (28.67 days) and primordia formation (34.67 days) and maximum number of primordia (4.33). So far as morphological characters of *P.citrinopileatus* in different substrates was concerned, largest pileus size (7.22x6.39cm) was observed on oat straw with highest average sporophore weight (11g). Among different agro-based substrate combinations, soybean+maize+oat produced largest pileus size (9.00x7.24cm) and maximum sporophore weight (12.33g). Maximum yield of 893.33g/kg dry substrate was observed on

wheat straw substrate with maximum number of flushes (3) followed by soybean i.e. 860g/kg. Biological efficiency of different substrates, ranged between 16.67 to 89.33 per cent, with highest on wheat straw (89.33%). In different agro-based substrate combinations, soybean+maize+wheat performed quite well with biological efficiency of 87.33 per cent which is at par with the wheat straw.

Name of the student: Mr Siddharth Anand
Major advisor: Dr D K Banyal
Title of thesis: Etiology and epidemiology of collar rot complex of cowpea

Abstract: The present investigation entitled "Etiology and epidemiology of collar rot complex of cowpea" was undertaken to identify the associated pathogen(s), factors affecting the pathogen & disease development and effect of weather variables on the diseases development. Collar rot of cowpea is known to be caused by number of pathogens and is one of the most destructive disease in Himachal Pradesh. Isolation was taken from the diseased samples and three fungal pathogen were isolated among which pathogenecity was established only with *Sclerotium* sp. On the basis of symptological and morpho-cultural characteristics of test pathogen, the pathogen was ascertained as *Sclerotium rolfsii*. Maximum mycelial growth and sclerotial production was observed on potato dextrose agar and oat meal agar at 30°C to 25°C, respectively. Incubation and latent period of *S. rolfsii* was observed to be 7 and 13 days respectively. Inoculum load of pathogen was tested between 1g-5g/kg of soil and 2g/kg of soil was found optimum, which gave 86.66 percent disease incidence. Young and early generation of cultures gave maximum disease incidence of collar rot. Significant decrease in the disease incidence was observed with increase in age and sub-culturing of pathogen. The disease incidence was observed maximum at low soil moisture and disease incidence was decreased with increase in soil moisture. Sandy clay loam soil gave the maximum per cent incidence of disease and minimum was observed with silty clay loam. The disease incidence was observed minimum in early sown crop as compared to normal and late sown crop. The minimum disease incidence was also observed at wider spacing (60 cm), as compared to normal (45 cm) and closer (30 cm) spacings. Maximum disease incidence 76.53 per cent was observed on late sown and narrow spaced crop (30 cm) as compared to timely and normal sowing and wider spacing. Disease incidence was highly positively correlated with temperature (minimum, maximum and average) and relative humidity (minimum, maximum and average) on all the dates and sowing. The coefficient of determination revealed that the temperature and relative humidity contributed 97.8, 90.06 and 97.1 per cent towards incidence of collar rot on crop sown at 7th June, 22nd June and 8th July, respectively. AUDPC and infection rate (r) followed the similar trend of disease incidence with respect to 7th June, 22nd June and 8th July date of sowing.

(ii) PhD
Name of the student: Mr Narinder Pal
Major advisor: Dr Ashok Kumar
Title of thesis: Variability, epidemiology and management of *Fusarium oxysporum* f. sp. *lini*

Abstract: The investigation entitled, "Variability, epidemiology and management of *Fusarium oxysporum* f. sp. *lini*" was conducted at Department of Plant Pathology, CSKHPKV, Palampur and Shivalik Agricultural Research and Extension Centre, Kangra during 2015-2018. 35 isolates of *F. oxysporum* f. sp. *lini* were obtained from the diseased samples collected from Kangra and Mandi districts of Himachal Pradesh and other parts of India. Three isolates were categorized as weakly pathogenic, 7 as moderately pathogenic and 25 as highly pathogenic during pathogenicity test. All the isolates showed variability in morphological and cultural characteristics. To identify the wilt resistant sources, 176 linseed genotypes were evaluated under field conditions. Among these 5 genotypes *viz.*, KL-215, KL-261, EC541213, H-18 and TL-50 showed highly resistant, 7 genotypes showed resistant and 21 genotypes showed moderately resistant disease reactions. A set of 17 genotypes i.e. TL-9, R-552, H-34, Janaki, Himalini, Polf-24, TL-22, EC541213, KL-187, POLF-16, EC-541212, H-18, EC541211, POLF-22, Kangra local, Baner and Chambal was standardized as different hosts. Pathogenic variability among 25 isolates was determined on differential set and 5 pathotypes were recorded and designated as Pathotype-1 to 5. 32 promising genetypes of linseed were evaluated against the 5 pathotypes and 13 genotypes *viz.*, EC-541199, H-18, H-36, Him Alsi-1, Jeevan Janaki, KL-215, KL-227, KL-265, Nagarkot, Natazo, POLF-19 and Surbhi showed resistant disease reaction against all the 5 pathotypes. Maximum *in vitro* growth of *F. oxysporum* f. sp. *lini* on PDA was

observed at 24^{o}C and pH 5.5 with highest growth rate and sporulation. Lowest wilt incidence was recorded in clay loam soil compared to sandy, sandy clay loam and loam soils. Disease incidence during the crop season 2015-16 and 2016-17 showed positive correlation with minimum temperature and soil temperature at 10 cm and negative correlation with relative humidity at evening time. Delay in date of sowing from 16 October to 26 November resulted decrease in wilt incidence in varieties Chambal and Janaki. *Trichoderma viride* (Strain Tr-3) & Carbendazim 50 WP were found most effective for mycelia growth inhibition of the *F. oxysportum* f. sp. *lini* during *in vitro* studies and Tr-3 (*Trichoderma viride)* showed highest compatibility with fungicides among three tested bioagents. In pot studies, the highest seedling emergence and lowest linseed wilt incidence was observed with Tr-4(*Trichoderma* harzianum) (seed treatment+soil application), Thiram 75WP seed treatment and Thriam 75 WP + Tr-4(Trichoderma harzianum)(seed treatment+soil application). In field studies, Carbendazim (50%) +Tr-4 (T. harzianum)(seed treatment+soil application) showed highest disease reduction and yield increase over control.

g. Experiential learning on mushroom cultivation:

Under experiential learning programme/ course on mushroom cultivation, 27 students of B. Sc. Agriculture final year were enrolled. Of these, a batch of 14 students undertook ELP from June to November, 2019 while 13 students from November, 2019 to May 2020. They were given the training on all the aspects of mushroom cultivation i.e. on isolation, master culture preparation of dhingri and white button mushrooms, commercial spawn production , long and short methods of composting, preparation of casing material, dhingri cultivation, update with machinery and equipments, mushroom production technology, harvesting packing and sale of button mushroom and dhingri, sale of spawn etc.

The economic activity is as given under:

S No	**Activity**	**Production cost (Rs)**	**Gross income (Rs)**	**Net profit (Rs)**	**Profit share of students (75 %)**	**Profit share of Department (25 %)**
1	Spawn production	14774.00	31290.00	**16516.00**	12387.00	4129.00
2	Mushroom production	11695.00	23150.00	**11455.00**	8591.00	2864.00
3	Dhingri production	2269.000	9150.00	**6881.00**	5161.00	1720.00
4	Compost production	7184.00	15000.00	**7816.00**	5862.00	1954.00
	Total	**35922.00**	**78590.00**	**42668.00**	32001.00	10667.00

5. RESEARCH

A. Survey and surveillance

I. Rice:

Survey in major rice growing districts of Himachal Pradesh namely, Kangra, Mandi, Una, Solan and Sirmour districts was conducted under Production Oriented Survey (POS) programme of AICRIP during *kharif* 2019 (Table 1).

Kangra: Thirty three villages from eight blocks of district Kangra *viz.*, Nagrota Bagwan, Kangra, Baijnath, Rait, Bhawarna, Panchrukhi, Dharamshala and Fatehpur were surveyed during *kharif* 2019 at different crop stages. Diseases such as leaf blast, neck blast and false smut were observed as moderate while sheath rot and grain discolouration were low to moderate whereas brown spot, sheath blight and narrow brown leaf spot were recorded as low. However, incidence of sheath rot in certain parts was higher.

Mandi: Survey was mainly conducted in Harabagh and Balh valley. Diseases like neck blast, sheath rot, grain discolouration and false smut appeared as low to moderate while leaf blast, sheath blight and brown spot appeared as low.

Una: Survey was conducted in lower hills of Una district comprising Jankor, Takarla, Thathal, Basal, Santokhgarh and Nangalkalan (Tahliwal) areas. Diseases like false smut, narrow brown leaf spot, neck blast, brown spot and sheath rot were low to moderate while leaf blast, grain discolouration and sheath blight were recorded as low.

Solan: The survey was conducted in Nalagarh area of Solan district at crop maturity stage. The predominant variety was Arize 6444. Diseases like false smut and brown spot were moderate while leaf blast, neck blast, grain discolouration, sheath blight and sheath rot were low to moderate.

Sirmour: The survey was conducted at maturity stage of the crop. Diseases such as leaf blast, neck blast, brown spot, false smut, sheath blight and sheath rot were low to moderate while grain discolouration, narrow brown leaf spot and bacterial leaf blight were recorded as low. However, false smut appeared in moderate to severe form in some varieties like Mahindra 3030 etc.

Table 1: Prevalence of diseases of rice in Himachal Pradesh during *kharif* 2019

District	Diseases									
	LBL	**NBL**	**BS**	**GD**	**FS**	**LS**	**NBLS**	**SHBL**	**SHR**	**BLB**
Kangra	M	M	L	L-M	L-M	L	L	L	L-M	-
Mandi	L-M	L-M	L	L-M	L-M	L	L	L	L-M	-
Una	L	L-M	L-M	L	L-M	L	L-M	L	L-M	-
Solan	L	L-M	M	L-M	M	L	L	L-M	L-M	-
Sirmour	L-M	L-M	L-M	L	M	L	L	L-M	L-M	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%.

II. Maize:

Surveys of maize growing areas of Sirmour district was also done during the season. The maize diseases like Erwinia stalk rot, Maydis leaf blight and banded leaf and sheath blight were prevalent in the low hill sub mountainous areas whereas, Turcicum leaf blight, banded leaf and sheath blight and maydis leaf blight in mid hill areas. The incidence of various maize diseases varies from place to place and variety to variety (Table 2). The diseases of maize in Kullu district are given in Table 3.

Table 2: Disease survey & surveillance in maize growing areas of Sirmour district

S. NO.	VILLAGE	BLSB*	CLS	BS	BSR	TLB	MLB
1.	Rampur	M-H	L	T	L-M	T	L
2.	Khambanagar	M-H	T	T	L-M	-	M
3.	Parduni	H	L	-	L-M	-	M
4.	Kotli	L	L	-	L	-	L
5.	Kolar	M-H	T	T	L-M	-	M
6.	Johro	M	L	L	L	-	M
7.	Fatehpur	L	L	-	L	-	-
8.	Sainwala	H	L	L	H	-	H
9.	MatakMajri	M	M	L	M	-	M

***Disease intensity: T - Traces; L - Low; M - Medium; H – High*

Table 3: Disease survey, surveillance in different maize growing areas of Kullu district

Crop	Disease	Disease Intensity	Area Surveyed
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,

III. Wheat:

Stripe Rust: Severe outbreak (80-100S) of yellow rust in wheat was observed in Agojar area of Panchrukhi block, Haler (Jaisinghpur) and Bhallundar area of Lambagaon block, Mahakaal and Langhu area of Baijnath block, Dhaloon, Serathana, Sarotri and Erla areas of NagrotaBagwan block, Gujrehra village of Bhawarna block, Paniarkhar and Chaniara area of Dehra block and Chanour and Shamnagar areas of Pragpur block of district Kangra between tillering to heading/ flowering stage. In rest of the places covered under survey the crop was either free from yellow rust or had moderate (Up to 20S) severity (Table 2).

Powdery Mildew: Moderate severity (score = 5) of powdery mildew was observed in the crop under shade in Riyali area of Indora block of district Kangra. However, powdery mildew exhibited very low proportions that too in relatively few instances (Table 4). The diseases of wheat and barley in Kullu district are given in Table 5.

Table 4: Occurrence of different diseases of wheat in Sirmour district at farmers' fields

S. No.	Name of the village	Incidence/ Severity/ Score	
		Yellow rust score	Powdery mildew score
1	Gorkhuwala	20S	2
2	Sainwala	10S	3
3	Phoolpur	10S	2
4	Bhagani	10S	2
5	Puruwala	10S	3
6	KhodriMajri	20S	2
7	Khandowala	10S	2
8	Mehruwala	10S	2
9	Guruwala	Tr	2
10	Kishncot	10S	0
11	Nihalgarh	Tr	0
12	Muglawala	Tr	3
13	kartarpur	10S	0
14	Ajoli	20S	2
15	Majra	10S	3

16	Fatehpur	Tr	2
17	Rajban	Tr	0
18	Satiwala	10S	0
19	Behrewala	10S	2
20	Jamniwala	10S	5
21	Misserwala	10S	0
22	Amarkot	20S	0
23	Shivpur	10S	2
24	Rampur Bharapur	20S	2
25	Kolar	10S	2
26	Baliwala	10S	0

Table 5: Disease survey, surveillance in of wheat and barley in Kullu district

Crop	Disease	Disease Intensity	Area Surveyed
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	

IV. Vegetables and pulses

Systematic surveys were conducted in the command area of Hill Agricultural Research and Extension Centre Bajaura. The diseases observed in different crops are given in Table 6. Incidence of various diseases varies from locality to locality.

Table 6: Survey and Surveillance of vegetable diseases

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	Low	
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	
	Bulb rot	Low	
Onion	Purple blotch, downy mildew	Moderate	-
	Bulb rot	Low	
Urd Bean	cercospora leaf spot,	Low - Moderate	-
	Leaf crinkle virus	Low	

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V. Oilseeds/ Soybean

Surveys were conducted in main soybean growing areas of Himachal Pradesh during September 2019 to record data on the occurrence of different diseases. 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 in areas of Kangra and Mandi districts (Table 7). 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. Low incidence (5-15%) of collar rot caused by *Sclerotium rolfsii* was also observed at seedling stage. Incidence of YMV disease was also prevalent at low to moderate intensity only in warmer climate around Kangra area.

Table 7: Occurrence of soybean diseases in major soybean areas in HP

District/village	Variety grown	Percent disease index			
		Frogeye leaf spot	Pod blight	YMV	Bacterial pustule
Kangra district					
Mahakal	Hara Soya	55.55	11.11	0.0	11.11
Sungal	Hara Soya	33.33	21.11	0.0	0.0
Pantehar	Hara Soya	55.55	33.33	0.0	0.0
Nagri	Hara Soya	55.55	33.33	0.0	11.11
Kachyari	Hara Soya	11.11	11.11	11.1	0.0
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	11.11
	Bragg	55.55	55.55	0.0	0.0
	Shivalik	77.77	33.33	0.0	0.0
	Him Soya	77.77	33.33	0.0	0.0
Mandi district					
Karsog	Hara Soya	33.33	0.0	0.0	0.0
Jogindernagar	Hara soya	33.3	11.11	0.0	0.0
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	33.3	0.0	11.11
	Him soya	77.77	11.11	0.0	0.0
Sunder Nagar	Hara Soya	11.11	11.11	0.0	0.0

VI. Fodder crops

During *kharif* 2019 wilt/root rot, leaf spot and blights of cowpea, blight and BLSB of maize, zonate leaf spot sorghum and blast of bajra were observed the main diseases. In the *Rabi* 2019-20 season oat powdery mildew and leaf blights of oats, root rot and powdery mildew of clovers was observed the important diseases (Table 8).

Table 8: Diseases and Insect-pests of different Kharif & Rabi fodder crops

Crop	Diseases and insect pest	Incidence/Severity (%)
Cowpea	Wilt/root rot (*Fusarium, Rhizoctonia*)	66
	Leaf spot and blight (*Phytophthora, Ascochyta, Phyllosticta*)	25
Maize	Blight (*Helminthosprium maydis* and *H. Tercicum*)	10
	Banded leaf & sheath blight (*Rhizoctonia*)	6
Sorghum	Zonate leaf spot (*Gloeocercospora sorghi)*	40
Bajra	leaf blight *(Helminthosporium*)	20
	Blast (*Pyricularia grisea*)	25
Oats	Powdery mildew	45
	Leaf blights	25
	Loose smut	1
Berseem	Root rot	4
	Leaf spot	10
Lucerne	Leaf spot	9

B. Cereals

I. Rice

Resistrance sources:
i. Screening for leaf and neck blast resistance: Rice germplasm consisting of 1403 entries from various screening nurseries viz. National Screening Nursery-1 (353), National Screening Nursery-2 (672), National Screening Nursery-Hills (120), National Hybrid Screening Nursery (108) and Donor Screening Nursery (150) were screened under natural epiphytotic conditions at RWRC, Malan. Out of these nurseries, 157 entries from NSN-1, 262 from NSN-2, 79 from NSN-H, 44 from NHSN and 40 entries from DSN were found promising against leaf blast while 46 entries from NSN-H and 28 entries from NHSN were found promising against neck blast under field conditions.
ii. 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 including Malan. The observations revealed that Usen, Dular, Kanto 51, Shia tia Tsao, HR 12 and Co-39 showed susceptible reaction while rest of the differentials were found resistant 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 throughout India was grouped into six major groups in which reaction pattern of Malan was included in group four.
iii. Disease Observation Nursery: To observe the time of occurrence and intensity of leaf blast a trial was conducted during *kharif* 2019 at RWRC, Malan. A susceptible variety, HPU 2216 was selected and the crop was sown on 21.05.19 (early), 05.06.19 (normal) and 20.06.19 (late). The early sown crop was found to be relatively disease free (2.6 to 5.05% PDI) when compared to the normal (14.45 to 28.9% PDI) and late sown (6.96 to 34.2% PDI) crop. More availability of moisture during the early stages of the crops under the late sown conditions led to the more incidence of the disease. In the case of early sown conditions, initial stage of the crop was relatively dry and the crop matured when the humidity starts building up during late stages of the crop.

Disease Management:
i. Evaluation of new fungicides against location specific diseases: A field trial was conducted during *kharif* 2019 in randomized block design to evaluate the efficacy of some new fungicides viz.,prochloraz 23.5% w/w + tricyclazole 20% w/w SE, prochloraz 45% EC, tricyclazole 75% WP, azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC, difenoconazole 25% EC, hexaconazole 5% EC, propiconazole 25% EC formulations against neck blast in susceptible variety 'HPU 2216'. Two sprays were applied with first on September 9, 2019 and second on September 24, 2019 at booting and flowering stages, respectively. A perusal of the data (Table 9) revealed that all the fungicides significantly reduced the neck blast incidence as compared to control and combination fungicide, prochloraz 23.5% w/w +tricyclazole 20.0% w/w SE proved to be the best in containing the disease incidence (15.2%) which was statistically at par with tricyclazole 75% WP (18.4%) and combination of azoxystrobin 18.2 % w/w + difenoconazole 11.4% W/W SC (18.5%) resulting in 75.4, 70.3 and 70.3 per cent reduction in disease incidence over control, respectively.

Table 9: Evaluation of fungicides for the management of rice blast during *kharif* 2019

Fungicide	Dose/ L)	Neck blast incidence (%)	Reduction in neck blast (%)	Grain yield (q/ha)	Increase over control (%)

T1- Prochloraz 23.5% w/w + tricyclazole 20.0% w/w SE	2 ml	15.2 (22.8)	75.4	47.6	204.7
T2- Prochloraz 45% EC	2 ml	32.4 (34.6)	47.7	34.0	118.0
T3- Tricyclazole 75% WP	0.6 g	18.4 (25.3)	70.3	42.5	172.1
T4- Azoxystrobin 18.2 % w/w + difenoconazole 11.4% W/W SC	1 ml	18.5 (25.4)	70.1	35.2	125.6
T5- Difenoconazole 25 EC	1ml	52.2 (46.2)	15.7	28.0	79.1
T6- Hexaconazole 5% EC	2 ml	56.3 (48.6)	9.0	25.1	60.5
T7- Propiconazole 25% EC	1 ml	44.1 (41.6)	28.8	26.5	69.8
T8 - Control	-	61.9 (51.9)	-	15.6	-
CD (*P = 0.05*)		4.8		7.3	

Figures in parentheses are arcsine transformed values

ii. Integrated disease management of rice blast: A field trial was laid out in RBD design to evaluate the Integrated Disease Management practices against rice blast. A highly susceptible variety, HPU 2216 with five treatments of IDM as enlisted in the table were applied. The perusal of data (Table 10) revealed that among different treatments, T3 proved to be highly effective in reducing leaf blast severity to 20.2 % with 34.8 % reduction over control and was at par with T5, T2 and T4 resulting in 26.1, 25.8 and 22.6 per cent reduction in disease over control, respectively. However, neck blast incidence was best contained (4.4%) by the treatment T5 with 79 per cent reduction in neck blast incidence over control.

T1	Seed treatment with bio-control agent (10g/ kg seed)
T2	Seed treatment with bio-control agent (10g/ kg seed) + One application of bio-control agent at 15-20 DAT (10g/ litre)
T3	Seed treatment with bio-control agent (10g/ kg seed) + One application of propiconazole (1g/ litre) at booting stage
T4	Seed treatment with bio-control agent (10g/ kg seed) + One application of bio-control agent at 15-20 DAT (10g/ litre) + One blanket application of propiconazole (1g/ litre) at booting stage
T5	Seed treatment with carbendazim (2g/ kg seed) + One blanket application of combination fungicide (trifloxystrobin 25% + tebuconazole 50%) @ 0.4g/ litre) at booting stage
T6	Control (No seed treatment, no spraying of bio-control agent or any fungicide)

Table 10: Integrated management of leaf and neck blast of rice

Treatment	**Leaf blast severity (%)**	**Per cent reduction in LB**	**Neck blast incidence (%)**	**Per cent reduction in neck blast**	**Grain* yield (q/ ha)**	**Per cent increase over control**
T1	25.5 (30.3)	17.7	18.5 (25.3)	11.9	7.3	7.5
T2	23.0 (28.6)	25.8	17.6 (24.8)	16.2	8.1	19.6
T3	20.2 (26.7)	34.8	14.5 (22.2)	31.0	8.3	21.5
T4	24.0 (29.2)	22.6	18.0 (25.0)	14.3	8.2	20.0
T5	22.9 (28.6)	26.1	4.4 (12.0)	79.0	8.4	24.0
T6 (Control)	31.0 (33.8)	-	21.0 (27.2)	-	6.8	-
CD (*P = 0.05*)	3.3	-	5.2	-	NS	-

Figures in parentheses are arcsine transformed values

iii. Effect of some essential oils on rice blast: A field trial was conducted to evaluate the efficacy of seven essential oils namely; citronella oil, eucalyptus oil, cedar wood oil, nirgundi oil, lemon grass oil, clove oil and neem essential oil besides an emulsifier some essential oils on rice blast using a susceptible variety 'HPU 2216'. Two sprays were applied first on September 9 and second spray was applied on September 16, 2019 at booting and panicle emergence stages, respectively. The perusal of data (Table 11) revealed that there was no statistical difference among all the treatments except carbendazim (0.6g/ litre) which was superior to all and caused maximum (35.5%) reduction in neck blast incidence over control.

Table 11: Effect of different essential oils on rice blast

Fungicide	Dose / Litre	Neck blast Incidence (%)	Reduction in neck blast Incidence (%)	Yield (kg/ha)	Increase over control (%)
T1 = Citronella Oil	2.0 ml/l	46.1	10.1	24.0	66.7
T2 = Eucalyptus Oil	2.0 ml/l	44.0	14.2	22.3	54.8
T3 = Cedar Wood Oil	2.0 ml/l	47.2	8.0	20.2	40.5
T4 = Nirgundi Oil	2.0 ml/l	48.0	6.4	20.6	42.9
T5 = Lemon Grass Oil	2.0 ml/l	44.3	13.7	26.7	85.8
T6 = Clove Oil	2.0 ml/l	44.3	13.7	23.0	59.6
T7 = Neem Essential Oil	2.0 ml/l	43.5	15.2	25.4	76.3
T8 = Emulsifier	2.0 ml/l	47.7	7.0	20.2	40.5
T9 = Carbendazim 50 WP	0.6g/l	33.1	35.5	30.5	111.9
T10 = Control	-	51.3	-	14.4	-
CD *(P= 0.05)*	-	9.1	-	5.7	-

II. Maize

Resistance sources:

i. Screening of germplasm against important diseases: At Dhaulakuan, one hundred thirty four entries/genotypes of maize hybrids and composites received from IIMR, Ludhiana were evaluated against bacterial stalk rot (BSR) and banded leaf and sheath blight (BLSB) under artificial epiphytotic conditions. None of the Maize entries were found free from Erwinia stalk rot and banded leaf and sheath blight. Only 24and 7entries gave resistant reaction and 53and 43 entries gave moderately resistant reaction to BSR and BLSB, respectively (Table 12).

Table 12: Screening of maize germplasm against important diseases

Sr. No.	Name of the trial	Entries	BSR (%)		BLSB (1-9)	
			R	MR	R	MR
1	Screening of NIVT(medium maturity)	24	9	12	0	12
2	Screening of NIVT(early maturity)	30	6	6	-	20
3	Screening of AVT I II (medium maturity) maize	10	3	6	1	5
4	Screening of AVT I II (early maturity)	9	1	5	-	-
5	Screening of QPM I II III	18	3	5	2	7
6	Screening of baby corn I II III	10	1	2	1	1
7	Screening of pop corn I II III hybrids	10	-	1	1	4
8	Screening of sweet corn I II III	9	-	3	-	2
9	Screening of maize OPVs	14	-	3	2	2
	Total	134	23	43	7	53

At Bajura a total of 87 maize and 47 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*, 2019. 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 as under:

Maturity groups	Total genotypes	Resistant maize genotypes
NIVT medium maturity	24	AH1625, AH1634, AH8245R, DH323, DKC8205, HKH372, JKMH1481, LMH4219 and KMH1871
NIVT early and extra early maturity	30	AH1608, AH4045, AH8178,AH8323, AH8622, DH322, FH3900, H118, HKH371 and LMH 1946
AVT Medium Maturity	10	DKC9190, JKMH15303 and LMH1417.
AVT Early Maturity	9	FH3875 and KMH17-89.

QPM	18	APH1 (Pro vit A), APQH1 (QPM + Pro A), FQH165, LQPMH 219, LQPMH 319, LQPMH118 and SQPMH2
Sweet Corn	9	FSCH 128 and Nuzi205
Pop Corn	10	APCH3, Bajaura Popcorn, LPCH119 and LPCH219
Baby Corn	10	TLB, AH 5021
OPV(Open pollinated variety)	14	KDM25 and L315

ii. Screening of maize hybrids of public and private sector: Twenty four maize hybrids of public and private sectors were screened against Turcicum leaf blight (TLB) and Maydis leaf blight (MLB) under artificial epiphytotic conditions during *kharif* 2019.All the maize hybrids were found resistant/ moderately resistant against both the diseases. Maize hybrids SMS-137, B-52 Gold, VNR 4343, PSC-3322 Gold, MM 9333, P 3378, B-52 Super, GX888, NMH 1277, Vyaas Gold and Super-9396were found promising (Table 13).

Table 13: Evaluation of maize hybrids against important diseases

Hybrids	**TLB Score (1.9 Scale)**	**Reaction Type**	**MLB Score**	**Reaction Type**	**Yield (q/ha)**
DKC-7074 (C)	3.5	MR	2.5	R	89.5
SMS-137	2.5	R	2.5	R	127.5
B-52 Gold	2.5	R	2.5	R	122.1
Vyaas Gold	2.5	R	3.0	R	89.2
GX888	2.0	R	2.0	R	99.5
Super-9396	2.0	R	2.0	R	87.9
P.S.M.-2 (C)	3.5	MR	2.5	R	128.8
PSC-3322 Gold	3.5	MR	2.0	R	115.1
B-52 Super	3.5	MR	2.5	R	109.5
MM 9333	4.0	MR	3.0	R	118.5
Vyaas Super	2.5	R	2.5	R	98.3
VNR 4343	2.5	R	2.0	R	116.4
VNR-Y 3099	2.0	R	2.5	R	104.0
Bio-9544 (C)	2.0	R	3.0	R	124.4
DKC 8181	3.5	MR	2.0	R	84.0
Fauiji-313	3.0	R	2.5	R	116.6
NMH 1277	3.5	MR	2.0	R	92.5
MM 9344	4.5	MR	3.5	MR	93.1
Samba Gold	3.5	MR	2.0	R	81.8
Indam 1118	3.0	R	2.0	R	110.1
P 3378	2.5	R	2.5	R	102.2
MM 9366	2.0	R	3.0	R	93.2
PSC 4455	3.0	R	2.0	R	110.5
P 3302	2.5	R	3.5	MR	70.3

Assessment of avoidable yield losses due to TLB of maize: A field trial was conducted to determine avoidable losses due to turcicum leaf blight (TLB) of maize using variety Early Composite during *kharif*, 2019. Trial comprises of two treatments viz. protected and unprotected with 12 replications. The crop was inoculated once with TLBat 30 DAS. In protected plot, Dithane M-45 @ 0.25% was sprayed two times at 3 DAI and 15 DAI. In non-protected plot, plain water was sprayed after inoculation of the plants with pathogen. Avoidable losses to the tune of 20 % were recorded (Table 14).

Table 14: Assessment of avoidable yield losses due to Turcicum Leaf Blight

Replication	Treatment	Disease Score/ Incidence	PDI (%)	Yield q/ha)	Yield Loss (%)
R1	Protected	3.3	36.7	53.6	2.9
	Unprotected	7.1	78.9	52.1	-
R2	Protected	2.9	32.2	63.1	29.0
	Unprotected	7.0	77.8	48.9	-
R3	Protected	3.1	34.4	61.2	30.7
	Unprotected	6.8	75.6	46.8	-
R4	Protected	2.9	32.2	58.1	33.9
	Unprotected	6.9	76.7	43.4	-
R5	Protected	3.2	35.6	63.7	31.0
	Unprotected	7.2	80.0	48.6	-
R6	Protected	3.0	33.3	56.4	36.4
	Unprotected	7.1	78.9	41.4	-
R7	Protected	2.8	31.1	41.5	2.4
	Unprotected	6.9	76.7	40.5	-
R8	Protected	3.1	34.4	50.8	0.2
	Unprotected	7.2	80.0	50.7	-
R9	Protected	3.2	35.6	55.3	38.7
	Unprotected	6.8	75.6	39.8	-
R10	Protected	3.0	33.3	53.8	21.1
	Unprotected	6.9	76.7	44.5	-
R11	Protected	2.8	31.1	57.5	13.3
	Unprotected	7.1	78.9	50.8	-
R12	Protected	3.1	34.4	36.4	2.9
	Unprotected	6.8	75.6	35.4	-
Mean	Protected	3.0	33.7	54.3	20.0
	Unprotected	7.0	77.6	45.2	-
	Avoidable Loss (%)	20.0	-	-	-
CD (5%)		0.1	0.9	4.2	-
CV (%)		2.9	2.2	9.4	-

Disease management:

i. Efficacy of fungicides in control of Turcicum leaf blight (TLB): A field trial consisting of eight treatments was conducted for the management of Turcicum leaf blight (TLB) of maize with variety Early Composite in RBD having 3 replications during *kharif*, 2019. Plot size was 2.5 x 2.4 m**.** Two sprays at 15 days interval were given. First spray was given 3 days after inoculation with the pathogen. All the treatments were found superior over the control treatment. Two sprays of Azoxystrobin 7.5% +Propiconazole 12.5% SE @ 0.2 % or Kresoxim methyl 44.3%SC @ 0.1 % or Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.1 % at were found most effective in controlling TLB giving 75 to 77 per cent disease control with 32 to 45 per cent increase in yield (Table 15).

Table 15: Efficacy of fungicides in control of Turcicum leaf blight (TLB)

Treatments	Dose (%)	Percent Disease Index	Average Disease Score	Disease Control (%)	Yield (q/ha)	Increase in Yield (%)
T1: Kresoxim methyl	0.10	20.0 (26.5)	1.8	75.9	62.9	33.3

44.3%SC						
T2: Zineb75% WP	0.20	40.4 (39.4)	3.6	51.4	54.5	15.4
T3: Thiram 75% WS (seed treatment)	0.20	65.9 (54.3)	5.9	20.6	52.2	10.7
T4: Azoxystrobin 18.2 +Difenoconozole11.4% w/w SC	0.10	22.6 (28.3)	2	72.8	58.8	24.6
T5: Tebuconazole 50% + Trifloxystrobin 25% WG	0.10	20.4 (26.8)	1.8	75.5	68.4	45.0
T6: Azoxystrobin 7.5% +Propiconazole 12.5% SE	0.20	18.9 (25.7)	1.7	77.2	62.7	32.8
T7: Protected check (Mancozeb 75%WP	0.20	42.2 (40.5)	3.8	49.1	52.6	11.5
T8: Control	-	82.9 (65.6)	7.5	-	47.2	-
CD (0.05)		2.2	0.3	-	4.3	-

ii. Evaluation of Panchgavya for the management of Turcicum leaf blight of Maize: A field trial was conducted to evaluate different doses of Panchgavya for the management of Turcicum leaf blight (TLB) of maize with variety Early Composite in RBD having 3 replications during *kharif*, 2019. Plot size was 2.5 x 2.4 m**.** Two sprays at 10 days interval were given. First spray was given with the appearance of disease. All the treatments were found superior over the control treatment. However, two sprays of mancozeb were found significantly better in managing turcicum leaf blight. All doses (2.0 -8.0 per cent) of panchgavya gave 30.3 to 38.3 per cent disease control with 12.1 to 32.9 per cent increase in yield as compare to control treatment (water spray only) (Table 16).

Table 16: Evaluation of Panchgavya for the management of Turcicum leaf blight

Treatment	Dose (%)	Percent Disease Index	Disease Score	Disease Control (%)	Yield (q/ha)	Increase Yield (%)
T1: Panchgavya	2.0	48.5 (44.1)	4.4	30.3	48.2	12.1
T2 : Panchgavya	4.0	45.6 (42.4)	4.1	34.5	52.6	22.5
T3 : Panchgavya	6.0	45.2 (42.2)	4.1	35.1	54.3	26.6
T4 : Panchgavya	8.0	43.0 (40.9)	3.9	38.3	57.0	32.9
T5 : Mancozeb	0.25	30.4 (33.4)	2.7	56.4	60.8	42.1
T6 : Control		69.6 (56.5)	6.3	-	43.1	-
CD (0.05)		2.6	0.4	-	3.7	-

III. Wheat

Resistance sources:

i. Evaluation of advanced breeding material against yellow rust and powdery mildew: At Malan, 1813 entries comprising Plant Pathological Screening Nursery (NIVT= 260), Elite Plant Pathological Screening Nursery (58), Initial Plant Pathological Screening Nursery (1324), AVT 1st Year (137) and Multiple Disease Screening Nursery (34) were evaluated against yellow rust at RWRC, Malan and 170 entries from Powdery Mildew Screening Nursery (PMSN) were screened against powdery mildew. The results are given in Table 17. It was observed that out of 1813 entries from various screening nurseries, 237 entries were free from yellow rust in which172 entries were found highly resistant (DS ≤ 5S). Hence, on the basis of disease reaction, 22 entries from EPPSN, 292 entries from IPPSN, 60 entries from PPSN (NIVT), 25 entries from AVT 1st Year and 10 entries from MDSN were found promising against yellow rust during 2019-20. However, out of 170 entries from PMSN, 89 entries were found promising against powdery mildew. On the basis of location-wise overall performance, the most promising entries (ACI ≤ 15) developed by CSKHPKV, Palampur were selected for leaf and yellow rust resistance which are listed below:

Table 17: Leaf rust and yellow rust resistant sources in wheat

Nursery	Leaf Rust	Yellow Rust
IPPSN	PW 1901, PW 1902, PW 1903, PW 1905, PW 1906, PW 1908, PW 1909, PW 1911, PW 1912, PW 1914, PW 1915, BW 275, BW 276, BW 278, BW 279, DW 261, DW 262, DW 263, DW 264, DW 267, DW 268, DW 269, DW 270	PW 1903, BW 276, BW 278, DW 264
PPSN (AVT 1st Year)	HPW 349 (C), HPW 473, HPW 474	HPW 349 (C)
PPSN (NIVT)	HPW 469, HPW 470, HPW 471, HPW 472	HPW 470, HPW 472

At Dhaulakuan, 2226 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 All India Coordinated Wheat and Barley Improvement Project and 38,3, 43 and 13 were found free from Karnal bunt, yellow rust and powdery mildew, respectively (Table 18).

Table 18: Number of wheat stocks free to Karnal bunt, yellow rust, Head scab and powdery mildew in various plant pathological nurseries

Sr. no	Name of nursery	Total entries	No. of free entries			
			Yellow rust	Powdery mildew	Karnal bunt	Head scab
1	IPPSN	1324	343	-	-	-
2	PPSN	137	40	-	-	-
3	NIVT	260	67	-	-	-
4	MDSN	34	11	1	12	8
5	PMSN	170	13			-
7	KBSN	164			38	-
8	Head Scab SN	137	-	-	-	-
9	SAARC	20	5	-	-	-
10	TPN	20	5	-	-	-

At Bajura a total of 397 Wheat lines/ genotypes received from ICAR-IIWBR under PPSN AVT and PPSN NIVT/ Special trials were screened against yellow rust during Rabi 2019-20 and 102 genotypes were found free from Stripe rust.

Disease management:

i. Fungicide management of stripe rust of wheat: A field experiment consisting of five treatments was conducted for the management of yellow rust of wheat (variety PBW 343) with fungicides in RBD with 3 replications during *Rabi*, 2019-20. The data on yellow rust were recorded on 15 plants in each replication of all the treatments. All the treatments were found superior over the control treatment. Two sprays of propiconazole @ 0.1% at 15 days interval was found most effective in controlling yellow rust which gave 93.2 % yellow rust control. Two sprays of Propiconazole 13.9% +Difenoconazole 11.7% SC @ 0.1 % and Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.06 % were also found effective gave 92.6 and 91.4 per cent yellow rust control, respectively. Similar trends were also observed in yield (Table 19).

Table 19: Management of yellow rust of wheat with fungicides

Treatment	Doses (%)	Yellow rust severity (%)	Disease Control (%)	Grain yield (q/ha)	Yield increase (%)
T_1: Propiconazole 13.9% +Difenoconazole 11.7% SC,	0.10%	6.2 (14.4)	92.6	22.09	89.8

T_2:Azoxystrobin 18.2% w/w + Difenconazole 11.4% w/w SC	0.10%	14.3 (22.2)	82.8	18.95	62.8
T_3:Tebuconazole 50% + Trifloxystrobin 25% WG	0.06%	7.2 (15.5)	91.4	23.11	98.5
T_4:Propiconezole	0.10%	5.7 (13.8)	93.2	27.86	139.3
T_5: Control		83.3 (65.9)		11.64	
CD *(P = 0.05)*		0.6		0.59	

ii. Evaluation of Pydiflumetofen 15.0 % +Propiconazole 12.5 % w/w SE (275 SE) against wheat diseases: At Dhauakuan**,** Pydiflumetofen 15.0 % +Propiconazole 12.5 % w/w SE (275 SE)was tested as foliar spray @ 1.0 ml/lt, @1.2mlg/lt, @1.4ml/lt, and 2.8ml/lt and Pydiflumetofen 20 % SC@ 1.1 ml/lt , Propiconazole 25 EC@ 1.0 ml/lt along with Tebuconazole 50 + Trifloxystrobin 25WG@ 0.6 g/lt and Pyraclostrobin 133 g/lt +Epoxiconazole 50 g/l SE@ 1.5 ml/lt water for bio-efficacy against rust and powdery mildew.All the treatments were significantly effective in controlling leaf and stripe rust / powdery mildew of wheat when compared to control. Two sprays of Pydiflumetofen 15.0 % +Propiconazole 12.5 % w/w SE (275 SE) @1.4ml/lt, and 2.8ml/ltat fortnightly interval starting at first appearance of disease were most effective in the management of wheat diseases and increasing in yield over check.

At bajura, new fungicide Pydiflumetofen15.0% + Propiconazole 12.5% w/v SE was tested for its bioefficacy for the control of stripe rust of wheat. Fungicide was tested by laying out trial in RBD with three replications with susceptible wheat variety PBW343 during *Rabi* 2019-20. The test fungicide was found very effective for the management of yellow rust at 1400 ml/ha giving 97.0 per cent control followed by doses 700 ml/ha, 600 ml/ha and 500 ml/ha which gave 95.4, 94.8 and 92.8 per cent yellow rust control, respectively. An increase in yield was also observed with all doses of test fungicides as compared to control. The doses of test fungicide (600 ml/ha and 700 ml/ha) were found statistically at par in controlling stripe rust of wheat. No phyto-toxic symptoms could be observed on different parameters viz. leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing, wilting & rosetting on 0, 1, 3, 5 , 7 & 10 days after spray at all doses of test fungicide

IV. Barley

Resistance sources:

i. Screening of Barley Germplasm against Stripe Rust: A total of 577 barley lines/ genotypes received from ICAR-IIWBR under IBDSN, NBDSN and EBDSN were screened against yellow rust during *rabi* 2019-20. A total of 226 genotypes were found resistant to Stripe rust.

Disease management

i. Management of stripe rust of Barley: A field trial consisting of five treatments was conducted for the management of yellow rust of barley (Var. Jyoti) with fungicides in RBD with 3 replications during *Rabi*, 2019-20. The data on yellow rust were recorded on 15 plants in each replication of all the treatments. Two sprays of test fungicides were given at 15 days interval started with the appearance of disease. All the treatments were found superior over the control treatment. Two sprays of propiconazole @ 0.1% at 15 days interval was found most effective in controlling yellow rust in barley which gave 92.6 % disease control with 109.7 % increase in yield as compare to control treatment. Two sprays of Propiconazole 13.9% +Difenoconazole 11.7% SC @ 0.1 % and Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.06 % were also found effective gave 91.8 and 91.2 per cent yellow rust control, respectively. Similar trends were also observed in yield (Table 20).

Table 20: Management of yellow rust of barley with fungicides

Treatment	Doses (%)	Yellow rust severity (%)	Disease Control (%)	Grain yield (q/ha)	Yield increase (%)
T_1:Propiconazole 13.9% +Difenoconazole 11.7% SC	0.1%	7.0 (15.3)	91.8	24.2	104.7
T_2: Azoxystropbin 18.2% w/w + Difenoconazole 11.4% SC	0.1%	15.5 (23.2)	81.8	19.8	67.8
T_3: Tebuconazole 50% + Trifloxystrobin 25% WG	0.06%	7.5 (15.9)	91.2	20.8	75.9
T_4:Propiconezole	0.1%	6.3(14.6)	92.6	24.7	109.7
T_5: Control		85.3 (67.5)		11.8	-
CD *(P = 0.05)*		0.9		0.3	-

C. Pulses

Common bean/ Rajmash

Non chemical management of seed borne infection of common bean: The field trial on evaluation of non-chemical methods for the management of bean anthracnose using bioagents (*Trichoderma harzianum*), organic inputs (Panchgavy and Jeevamrit) and fungicide Nativo was conducted at MAREC, Sangla, Kinnaur. The data recorded on disease severity (Table 21) revealed that the level of disease was very low in different treatments and ranged between 0.00 to 2.33 whereas, it was 4.33 in untreated control. All the treatments have almost same impact on disease management and crop yield. Althogh under *in vitro* evaluation both jeevamrit and beejamrit have resulted in 100% growth inhibition of the fungus at 4% and above concentrations.

Table 21: Effect of various biogents and organic inputs on seed germination of common bean in *C. lindemuthianum* infected seeds during storage

Treatment		Dose	Disease severity*	Seed Yield (kg)
T1	Seed treatment with Bavistin	2.5g/kg seed	1.33	311.667 (17.630)
T2	Seed treatment with *Trichoderma harzianum*	10g/kg seed	0.66	318.333 (17.858)
T3	Foliar spray with Nativo	0.01%	1.33	336.667 (18.182)
T4	Foliar spray with *Trichoderma harzianum*	10g/litre	0.66	265.000 (16.179)
T5	T1+ T3		2.33	375.000 (19.289)
T6	T2+T3		0.66	235.000 (15.335)
T7	T1+T4		1.33	335.000 (18.268)
T8	T2+T4		0.00	410.000 (20.266)
T9	T3+T4		2.33	261.667 (16.200)
T10	Seed treatment with Panchgavya	1:7 dilution	0.00	253.333 (15.839)
T11	T10+T3		1.33	341.667 (18.346)
T12	T10+T4		2.00	313.333 (17.637)
T13	Seed treatment with Jeevamrit	5 %	2.00	341.667 (18.483)
T14	Control		4.30	227.333 (15.061)
	C.D.			NS

D. Oilseeds

Resistance sources:

i. Evaluation of breeding materials for resistant donor(s): Forty five entries including checks in Initial Varietal Trial (IVT), eighteen entries of AVT-I and 20 entries of AVT-II of AICRP on soybean for 2019 were evaluated for disease resistance under natural hot spot conditions. The trial was planted on 24.06.2019 alongwith two susceptible checks i.e JS 335 and Shivalik after every five entries. The data on disease was recorded on 0-9 scale at terminal condition. The lines were categorized into different resistance categories (Table 22).

ii. Performance of the previous year's resistant entries against Frogeye leaf spot and Pod blight (Ct): Seventeen lines found resistant in IVT, AVT, AVT-II, and germplasm evaluation during 2018, *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 replications on 23.06.2019. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS) and anthracnose (pod blight) and the each entry was categorized into different disease reaction as presented in Table 23. Eight lines maintained their high resistance status against frogeye leaf spot. Eleven lines maintained their high resistance status against pod blight. Eight lines have shown high to absolute resistance against both the diseases.

Table 22: Resistant sources for important diseases of soybean

Trial	Resistant entries		
	Frogeye leaf spot	**Pod blight**	**Brown spot**
IVT	VLS 99, NRC 154, NRC 163, TS 46, AMS 20-19, DSb 37, ASb 51, AUKS 218, SKF 6029, NRC 167, Asb 50	VLS 99, SL 1213, PS 1641, MACS 1655, DS 1318, TS 46, PS 1642, DSb , ASb 51 37, NRC 149, DS 1326, Himso 1690, BAUS 103, TS 107, MACS 1639, DS 1320, KDS 1099, AMS 353, NRC 167, Asb 50	NRC 154, AMS 20-19, BAUS 103, MACS 1639
AVT-I	MACS 1566, NRC 146	DS 3110, Himso 1689, JS 21-71	NRC 146
AVT-II	NRC 147	DS 3108, MACS 1493, NRC 128, NRC 132, NRC 136, NRC 137	NRC 147
	PS 1613	PS 1613, SKF SP-11	

Table 23: Disease reaction of previous resistant entries of soybean against important diseases

No	Entry	Year of testing	Frogeye leaf spot		Pod blight	
			Score	**Reaction**	**Score**	**Reaction**
1	AMS MB 5-18	1st year	1	HR	1	HR
2	DSb 32	1st year	3	MR	1	HR
3	EC 309537	1st year	0	AR	1	HR
4	PS 1092	1st year	0	AR	5	MS
5	TS 53	1st year	3	MR	3	MR
6	RSC 10-52	1st year	1	HR	0	AR
7	SL 1123	1st year	1	HR	0	AR
8	CAT 407	2nd year	3	MR	0	AR
10	CAT 473B	2nd year	1	HR	0	AR
12	KDS 992	2nd year	3	AR	3	AR
13	SQL 89	2st year	3	MR	1	HR
14	Himso 1685	3nd year	0	AR	1	HR
15	JS 20-116	3nd year	0	AR	3	MR
16	NRC 126	3nd year	1	HR	0	AR
17	PS 1572	3nd year	1	HR	1	HR

	JS 335 Check		5	MR	7	S
	Shivalik Check		9	S	3	MR

AR: Absolute resistant, HR: Highl resistant, MR: Moderately Resistant, MS: Moderately susceptible, S: Susceptible, HS: Highly susceptible

iii. Evaluation of germplasm for identification of multiple disease resistant sources: Fifty soybean germplasm lines received from ICAR IISR, Indore were sown on 24.06.2019. Two rows of 3 meter length of each line were sown in augmented design. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS), anthracnose (pod blight) and brown spot (BS). The germplasm lines; EC 1619, EC 241771, DSb 21, EC 114573, CAT 195(BR4) VP 1164, JS 20-75 and EC 241778 were observed having multiple disease resistance against frogeye leaf spot (*Cercospor asojina*), pod blight (*Colletotrichum truncatum*) and brown spot (*Septoria glycines*).

Disease management:

Integrated management of the root rot complex and stem borers of soybean: An experiment comprising of nine seed treatments with chemical fungicides or bioagents alone and integrated with insecticide seed treatment was conducted with three replications in RBD. Experiment was planted on 24.06.2019. Data on percent field stand, percent root rot incidence, percent girdling incidence, plant growth parameters and yield attributes were taken and presented in Table 24. Seed treatment with carboxin + thiram 3.0g/kg resulted in minimum root rot incidence.

Table 24: Integrated management of the root rot complex and stem borers of soybean

Treatment	**% field stand**	**% root rot incidence**	**% Girdling**	**Plant height (cm)**	**No. of pods/Pt**	**100g seed wt.(g)**	**Seed yield (q/ha)**
T1= SST with Carboxin +thiram (3g/kg)	73.3	0.83	4.3	46.0	37.1	12.80	12.360
T2= ST with Trifloxystrobin (1g/kg)	67.6	5.67	3.7	46.4	35.7	12.87	11.686
T3= ST with Thiophanate methyl (2g/kg)	75.7	2.33	4.3	47.9	33.5	12.70	12.303
T4= ST with *Trichoderma harzianum* (10g/kg)	70.4	5.00	3.7	45.6	36.0	12.87	10.676
T5= ST with Thiomethoxam (2g/kg)	63.9	13.33	3.7	47.1	35.3	12.45	9.070
T6= T1 +T5	72.3	0.83	2.3	46.5	37.8	12.40	12.280
T7= T2 +T5	71.5	4.33	4.3	46.4	36.2	12.43	11.310
T8= T3 +T5	72.5	2.67	3.7	47.5	36.7	12.80	11.860
T9=T4 +T5	72.5	5.67	3.0	43.7	38.9	12.83	10.590
T10= Untreated control	62.8	14.00	16.7		30.2	11.80	8.143
CD (P= 0.05)	5.829	2.567	2.713	2.156	NS	NS	1.288

ST = Seed treatment

Two spray with chlorantroniprole @ 0.2ml/L at 15 and 35 DAS in treatment no. T1 to T9

Two sprays with Propiconazole @ 1ml/L at 35 and 45 DAS in treatment no. T1 to T9

E. Vegetables

a. Ginger

Studies on the rhizome rot of ginger: Rhizome rot caused by *Fusarium oxysporum* f.sp. *zingiberi, Pythium* spp and bacteria *Ralstonia solanacearum* is the major factor for the reduction in area and production of ginger in the state in general and district Sirmour in particular. The result on percent plant stand, rhizome rot incidence and its yield are summarized in Table 25. All the treatments resulted in significantly less plant rot as compared with check. Rhizome rot followed the same trend and all the treatments resulted in statistically less rhizome rot incidence as compared with control (50.3%). The highest yield (88.2qtl/ha) was recorded in soil application of neem cake at the time of sowing @ 2kg/6sqm followed by seed treatment with hot water at 51^0C for 10 minutes, after that seed treatment with mancozeb (2.5g/L of water)+carbendazim(1g/L of water) for 30 minutes and drying in shade showed minimum disease incidence of rhizome rot (20.18%)followed by seed treatment with hot water at 51^0C for 10 minutes, after that seed treatment with mancozeb (2.5g/L of water)+carbendazim(1g/L of water) for 30 minutes and drying in shade with disease intensity (25.55%) and rhizome yield (80.6q/ha)

Table 25: Management of Rhizome rot of ginger through fungicides and bio agent

Treatment	Dose	Plant stand (%)	% Rhizome rot	% Control over check	Rhizome yield(q/ha)
T1	Control	44.3(41.73*)	59.2(50.3*)	-	40.2
T2	Seed treatment with mancozeb(0.25%)+ Carbendazim(0.1%)	63.9(53.07)	29.1(32.65)	50.84	71.4
T3	Seed treatment with hot water at 51^0C for 30 minutes	59.4(50.42)	35.7(36.69)	39.7	64.6
T4	T3+T2	73.9(59.28)	18.6(25.55)	68.6	80.6
T5	Seed treatment with Trichoderma harzianum(10g/kg seed)	58.6(49.95)	41.3(39.99)	30.24	58.3
T6	Soil application of neem cake @2kg/6sqm)	57.3(49.2)	43.1(41.03)	27.2	56.9
T7	T6+T2	70.7(57.23)	25.6(30.4)	56.76	74.9
T8	T6+T4	78.4(62.31)	11.9(20.18)	79.9	88.2
-	CD at 5%	3.91	4.92		4.41

*Figures in parentheses are arc sine transformed values

b. Onion:

Management of onion diseases: A field experiment was conducted during Rabi 2019-20 to study the efficacy of different fungicides and bio-agent for minimize the yield losses of onion caused by purple blotch (*Alternaria porri*) and Stemphylium blight (*S. vesicarium)* diseases. Maximum disease control (86.1 %) was recorded in foliar application of Ridomil Gold followed by propiconazole, Mancozeb and Copper oxychloride resulting 82.3, 77.6 and 71.3 per cent disease control, respectively. The lowest (42.9%) disease control was noted in *Trichoderma harzianum* treatment. Similar trend was observed in case of *Stemphylium* blight. Maximum bulb yield of 286.1 q/ha was recorded in Ridomil Gold sprayed plot followed by propiconazole (284.6q/ha), Mancozeb (274.3q/ha) and copper oxychloride (255.2q/ha) in case of purple blotch (Table 26).

Table 26: Management of onion diseases through fungicides and bioagent

Treatment	Conc. (%)	Purple blotch		Stemphylium blight		Bulb yield (q/ha)
		Disease severity (%)	% control over check	Disease severity (%)	% control over check	
Mancozeb	0.25	13.2(21.3*)	77.6	14.7(22.55*)	76.9	274.3
Carbendazim	0.1	19.8(26.42)	66.3	18.5(25.48)	70.95	251.8
Propiconazole	0.1	10.4(18.81)	82.3	11.8(20.04)	81.47	284.6
Copper oxychloride	0.3	16.9(24.27)	71.3	14.9(22.71)	76.6	255.2
Ridomil Gold	0.25	8.2(16.64)	86.1	10.71(19.09)	83.2	286.1
Trichoderma harzianum	0.5	33.6(35.43)	42.9	35.9(36.81)	43.6	213.3
Control		58.8(50.07)		63.7(52.95)		149.2
C.D. at 5%		2.51		2.12		6.53

*Figures in parentheses are arc sine transformed values.

c. Garlic

During Rabi 2019-20, conducted trial on screening of garlic germplasm against *Stemphylium* blight of garlic and out of 19 germplasm only three(G3, G14 & GHC-1)were found resistant.

d.Tomato

Evaluation of Fungicide Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) against foliar diseases of Tomato: Bio efficacy of Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) fungicide was evaluated against early blight, late blight and powdery mildew of tomato during *Kharif*season 2018-19 and 2019-20. All the treatments were significantly effective in controlling early blight, late blight and powdery mildew in tomato when compared with control. The test chemical i.e. Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) at all the three concentrations and Azoxystrobin 23SC were very effective in controlling all three diseases (Table 27). During 2018-19, the test chemical provided 79.06 per cent control against early blight and 81.05 per cent control against late blight with 26.05 per cent increase (207.33 q/ha) in yield at 900 ml/ha dose as compare to control (153.33q/ha)and 23.97 per cent (201.67q/ha) increase in yield at 800 ml/ha dose.
During 2019-20all the treatments were also significantly effective in controlling early blight, late blight and powdery mildew in tomato when compared with control. The test chemical provided 80.28 per cent control against early blight, 79.71 per cent control against late blight and 78.36 per cent against powdery mildew with 23.20 per cent increase (208.33 q/ha) in yield at 900 ml/h dose as compare to control (160.00 q/ha) and 21.31 per cent increase (203.33 q/ha) in yield at 800 ml/h dose. The Famoxadone 16.6% + Cymoxanil 22.1% SC was found to be effective in controlling late blight at par with the tested chemical, however the per cent control of early blight and powdery mildew was less as compared to Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) at all concentrations.

Table 27: Bio-efficacy of Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) against foliar diseases of Tomato

Treatments		Dose		Early blight 2019		Late blight 2019		Powdery Mildew 2019		Yield 2019	
		a.i. (g/ha)	Form (ml or g /ha)	% severity	% control	% severity	% control	% severity	% control	q/ha	% increase
T_1	Control	-		52.59	-	25.56	-	8.52	-	160.00	-
T_2	Oxathiopiprolin 15+	119	700	20.00	61.97	7.41	71.02	2.96	65.26	190.00	15.79

	Azoxystrobin 155 w/v (170 SC)	(10.5+ 108.5)									
T_3	Oxathiopiprolin 15+ Azoxystrobin 155 w/v (170 SC)	136 (12+ 124)	800	12.59	76.06	6.29	75.38	2.59	69.60	203.33	21.31
T_4	Oxathiopiprolin 15+ Azoxystrobin 155 w/v (170 SC)	153 (13.5+ 139.5)	900	10.37	80.28	5.19	79.71	1.84	78.36	208.33	23.20
T_6	Oxathiapiprolin 10 OD	13.5	135	26.67	49.29	9.81	61.63	4.07	52.19	191.67	16.52
T_7	Azoxystrobin 23 SC	125	500	25.93	50.70	8.52	66.67	5.55	34.82	198.33	19.33
T_8	Famoxadone 16.6% + Cymoxanil 22.1% SC	210	500	34.81	33.80	12.73	50.18	6.67	21.71	183.33	12.73
T_9	Captan 50WP	1250	2500	37.04	29.57	13.03	49.01	7.04	17.37	188.33	15.04
	CD			**2.26**		**2.48**		**2.07**			**0.15**

F. Fodder crops

Evaluation of breeding material: During *Kharif*, 20 entries of IVTM were evaluated against leaf blight and all the entries found moderately resistant except IVTM-9 and 19, which found moderately susceptible. During *Rabi*, 52 entries were evaluated and 24 entries i.e. IVTO (SC)-1, 4, 6, 11, 12 & 13, IVTO(MC)-1, 4 & 6, AVTO(SC-1)-1, 2, 4, 6, 10, 11 &12, AVTO-2 (SC) -1, 2, 4 & 5 and AVTO(SC)-2(S)-1, 2, 5 & 7 were found moderately resistant, under different experiments of oats against powdery mildew (Table 28).

Table 28: Field screening of *Kharif* & *Rabi* breeding material

Crop and disease	Name of the trial	Entries	Resistant/ Moderate Resistant entries
Maize (Leaf blights)	IVTM	19	All except IVTM-9 and 19
	AVTM	15	All except AVTM-2, 4 and 10
Cowpea (Root rots)	IVTC	9	-
	AVTC-2	4	-
	AVTC-2 (seed)	4	-
Oats (Powdery mildew)	IVTO (SC)	14	IVTO (SC)-1, 4, 6, 11, 12 & 13
	IVTO (MC)	9	IVTO(MC)-1, 4 & 6
	AVTO (SC) -1	13	AVTO(SC-1)-1, 2, 4, 6, 10, 11 &12
	AVTO-2 (SC)	8	AVTO-2 (SC) -1, 2, 4 & 5
	AVTO-2 (SC) Seed	8	AVTO(SC)-2(S)-1, 2, 5 & 7
Beseem (Root rot)	IVTB	6	IVTB-1, 2, 3, 4, 5&7
	AVTB1	7	AVTB-1, 2, 3, 4, 5, 6 & 7
White clover (Powdery mildew)	VT-WC	6	-
Red clover (Powdery mildew)	VT-RC	7	-

Pathogenic variability in *Blumeria graminis* f. sp. *avenae* on oat : Pure culture of 24 isolates of *Blumeria graminis* f. sp. *avenae*, collected from six districts of Himachal Pradesh during 2016-19 were maintained under controlled conditions (Green House). The reaction of these isolates with oat genotypes under greenhouse condition using seedling method was studied to find out the pathogenic variability. The reaction genotypes for these isolates will be recorded on as infection types i.e. 0-4 under stereo zoom microscope. The above infection types were employed for studying the pathogenic variability.

i. Refinement of Differential set: For development of differential set, 142 lines from field screened set of 303 lines were selected these lines were evaluated with 5 isolates, 44 lines which exhibited varied reaction to specific isolate were selected and further screened against 9 pure culture isolates of powdery mildew. After recording data on infection types, it was found that 20 lines were exhibiting differential reaction to the isolates and now these 20 lines will be evaluated with 24 isolates and lines (about 10 lies) showing differential reaction the isolates will be selected from the panel of these 20 lines and final differential et will be selected.

ii. Study of inheritance of Powdery mildew in oat: To study the inheritance of powdery mildew resistance, three resistant lines (OL-1847, OG-77 and OL-1689) were selected and crossed with HJ-8 (Susceptible check) at Palampur and Kukumseri (Lahul and Spiti) in field and F1 seeds were harvested. The F1 seeds were sown in polyhouse and seeds were harvested.. The F_2 seeds of these crosses will be evaluated under field conditions or in green house with different isolates of powdery mildew for inheritance of resistance.

iii. Studies on components of slow mildewing: Susceptible genotypes were selected and studied for components of slow mildewing i.e. incubation period, latent period, number of conidiophores bearing conidia and size of mildew colonies under greenhouse and laboratory conditions. Three oat lines, KRR-AK-06, IG-03-203 and JPO-20 showing moderately susceptible reaction to single colony purified powdery mildew inoculum along with susceptible check HJ-8 were selected to carry out experiment on study of slow mildewing components. Among all the lines, the incubation period varied between 3-4 days and the latent period between 4-5 days. Maximum incubation period of 4 days was observed in IG-03-203, JPO-20 and KRR-AK-06 and minimum 3 days in HJ-8. Similarly, higher latent period of 5 days was also observed in these lines as compared to 4 days in susceptible check (HJ-8). After 5 days of inoculation with *B. graminis* f. sp. *avenae* inoculum, minimum conidiophores bearing conidia i.e. 8 were observed in IG-03-203 followed by 16 and 14 in JPO-20 and KRR-AK-06 respectively, whereas conidiophores bearing conidia per colony was maximum (22) in HJ-8. After 6 days of inoculation, conidiophores bearing conidia ranged from 14-35 in selected lines with least *i.e.* 14 in IG-03-203 followed by 26 in JPO-20, 24 in KRR-AK-06 and being maximum of 35 in HJ-8. On 8th day after inoculation, number of conidiophores bearing conidia were found to be 30 (IG-03-203), 40 (JPO-20), 35 (KRR-AK-06) and 50 (HJ-8). After 10 days of incubation, except HJ-8 all the lines had countable number of conidia i.e. 49 (IG-03-203), 60 (JPO-20), 55 (KRR-AK-06) and HJ-8 had a greater number of conidia that were unable to count and was designated as countless (C). After 11 days, countless conidiophores bearing conidia were produced on all the selected lines except in IG-03-203 whereas, being very high numbers in susceptible check (HJ-8). The size of powdery mildew colony was recorded after 11 days of inoculation and the data were presented in Table 2. Maximum colony size *i.e.* 3.87 mm was observed in HJ-8 followed by 2.87, 3.37 and 3.30 mm in IG-03-203, JPO-20 and KRR-AK-06, respectively (Table 29).

Table 29: Slow mildewing components on selected oat genotypes

S. No.	Genotypes	Slow mildewing components							
		Incubation Period (Days)	Latent Period (Days)	Number of Conidiophores bearing Conidia					Colony Size (mm)
				5th day	6th day	8th day	10th day	11th day	
1	IG-03-203	4	5	8	14	30	49	60	2.87
2	JPO-20	4	5	16	26	40	60	C	3.37
3	KRR-AK-06	4	5	14	24	35	55	C	3.30
4	HJ-8	3	4	22	35	50	C^{+}	C^{++}	3.87
	CD (p=0.05)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.20**

- = No conidia
C = Countless: too many to be counted; more than (>) 75, but give individual appearance
C^{+} = Countless: conidiophores and conidial density very high.
C^{++} = Countless: conidiophores and conidial density very high and look like cluster overlapping each other

Assessment of avoidable crop losses due to diseases and insect-pests in forage Cowpea: The experiment was conducted to assess the crop losses due to diseases and insect-pests in forage cowpea with two treatments i.e. protected and unprotected. In the protected treatment the cowpea was protected from all the prevalent diseases and insect pests by seed treatment with tebuconazole 2DS @ 1g/kg seed + NSKP (50 g/kg seed) followed by foliar spray of propiconazole @ 1ml/l at 15 days interval) for diseases management. For insect management foliar application of *B. bassiana* @ 5g/L ($1x10^{7}$ cfu/ml) and two sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval followed by two sprays of *Verticillium lecani* @ 5 g/L at 10 days interval were given. In protected treatment 68.7, 69.2, 68.8, and 62.5 per cent control of root rot, foliar diseases, YMV and defoliators respectively was found with 38.3 percent increase over unprotected treatment. Hence by using theses protective measures 38.3 per cent losses of GFY can be avoided in cowpea at Palampur (Table 30).

Table 30: Assessment of losses due to diseases and insect-pests in forage Cowpea

Treatments	Root rot		Foliar diseases		YMV		Defoliators		Green Fodder yield	
	Incidence (%)	Control (%)	Severity (%)	Control (%)	Incidence (%)	Control (%)	Incidence (%)	Control (%)	(q/ha)	(%) increase
T_1 =Protected	15.9 (23.3)	68.7	11.0 (19.2)	69.2	1.3	68.8	5.6	62.5	155.7	38.3
T_2 = Unprotected	50.7 (45.4)	-	35.7 (36.6)	-	4.1	-	14.9	-	96.1	-
CD (P=0.05)	7.44	-	4.80	-	0.83	-	3.69	-	19.14	-

*Figures in parentheses are arc sine transformed values

Protected = Seed treatment with tebuconazole 2DS @ 1g/kg seed + NSKP (50 g/kg seed) followed by foliar spray of propiconazole @ 1ml/l at 15 days interval). Foliar application of *B. bassiana* @ 5g/L (1x10^7 cfu/ml). Two sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval followed by two sprays of *Verticillium lecani* @ 5 g/L at 10 days interval.

Management of diseases

i. Evaluation of Integrated disease management components against leaf blast of forage pearl millet: The experiment was conducted with 11 treatments having 3 replication in RBD at Palampur for the management of leaf blast of forage pearl millet using chemicals & non chemical methods. Among all the treatments the seed treatment with tebuconazole + trifloxystrobin @ 1 g/kg seed followed by two sprays of same fungicide @ 0.4g/l was found most effective which gave 71.2 % disease control with 18.9 % increase in the green fodder yield over check. This treatment was followed by seed treatment with tricyclazole @ 0.6 g/kg seed and two sprays of same fungicide @ 0.3g/l which gave 62.9% disease control with 17.0% increase in the yield over check. Among the non-chemical methods seed treatment with chitosan @ 0.05% followed by the foliar spray of chitosan @ 0.05% was found effective with 52.4 % disease control with 15.8 % increase in the yield over check. The values of r/day and AUDPC were also observed minimum i.e. 0.28 and 44.2 respectively, in seed treatment with tebuconazole + trifloxystrobin followed by two sprays of same fungicide) followed by seed treatment with tricyclazole and two sprays of same fungicide (0.36 and 55.5 respectively. The value of r and AUDPC were 0.40 and 60 with seed treatment and foliar sprays of Chitosan. In control the disease severity was observed 56.7 per cent with maximum r (0.76) per day and AUDPV (116.9) and minimum GFY (328.3 q/ha) (Table-31).

Table 31: Evaluation of IDM components against leaf blast of forage pearl millet

Treatment	Blast				GFY	
	Severity (%)	Control (%)	r (per day)	AUDPC	(q/h)	Increase over check (%)
T1	45.3(42.3)	20.0	0.69	92.2	343.3	4.4
T2	46.7(43.1)	17.7	0.61	90.9	343.3	4.4
T3	47.7(43.6)	15.9	0.66	98.9	345.0	4.8
T4	50.3(45.2)	11.2	0.74	102.7	340.0	3.4
T5	46.3(42.9)	18.2	0.71	94.2	350.3	6.3
T6	22.7(28.4)	60.0	0.34	54.9	393.3	16.5
T7	16.3(23.8)	71.2	0.28	44.2	404.7	18.9
T8	27.0(31.2)	52.4	0.40	60.0	390.0	15.8
T9	44.3(41.7)	21.8	0.63	84.2	341.7	3.9
T10	21.0(27.3)	62.9	0.36	55.5	395.7	17.0
T11	56.7(48.8)	-	0.76	116.9	328.3	-
CD (5%)	3.17	-			12.64	-

*Figures in parentheses are arc sine transformed values

Treatments:

T1: Seed treatment with carbendazim @ 2.0g/kg seed

T2: Seed treatment with tebuconazole + trifloxystrobin

T7: T2+ foliar spray of tebuconazole + trifloxystrobin @ 0.4g/L

@ 1 g/kg seed
T3: Seed treatment with chitosan @ 0.05%
T4: Seed treatment with neem seed extract @ 5%
T5: Seed treatment with tricyclazole @ 0.6 g/kg seed
T6: T1+ foliar spray of carbendazim @ 0.5 g/L
T8: T3+ foliar spray of chitosan @ 0.05%
T9: T4+ foliar spray of neem seed extract @ 5%
T10: T5+ foliar spray of tricyclazole @ 0.3 g/L
T11: Control

ii: Validation of best treatments of trial entitled "Integrated Management of Banded leaf and sheath blight of forage Maize (Modified)"

The experiment was conducted to validate the management technology for Banded leaf and sheath blight of forage Maize. The most effective two treatments i.e. seed treatment with carbendazim@ 2 g/kg seed + two foliar sprays with (Tryfloxystrobin + Tebuconazole) @ 1g/l at 10 days interval and. seed treatment with carbendazim @ 2 g/kg seed + two foliar spray of carbendazim @1g/l at 10 days interval were evaluated at large plot. It was observed that the seed treatment with carbendazim+ two foliar sprays with (Tryfloxystrobin + Tebuconazole) provided 74.5 per cent control of BLSB (2.4 % disease severity) over check (9.5 % disease severity) with 7.2 per cent increase in green fodder yield (394.7q/ha) as compared to control (366.3 q/ha). The second treatment i.e. seed treatment with carbendazim + two foliar spray of carbendazim also found equally effective provided 69.9 per cent disease control with 6.3 per cent increase in yield with high B:C ratio i.e.4.37 as compared to seed treatment with carbendazim+ two foliar sprays with (Tryfloxystrobin + Tebuconazole) which gave 1.27 ratio only (Table 32).

Table 32: Validation of best treatments of trial entitled "Integrated Management of Banded leaf and sheath blight of forage Maize (Modified)"

Treatment	BLSB		Green Fodder yield		B:C
	Disease Incidence (%)	Disease control (%)	(q/ha)	(%) increase	
T_1 = Seed treatment with carbendazim @ 2 g/kg seed + two foliar sprays with (Tryfloxystrobin + Tebuconazole) @ 1g/l at 10 days interval	2.4	74.5	394.7	7.2	1.27
T_2 = Seed treatment with carbendazim @ 2 g/kg seed + two foliar spray of carbendazim @1g/l at 10 days interval	2.9	69.9	391.0	6.3	4.37
T_3 = Control	9.5	-	366.3	-	
CD (P=0.05)	0.53	-	7.60	-	

iii: Validation of best treatments of trial entitled "Integrated Management of foliar diseases of forage Sorghum": The experiment was conducted to validate the management technology for zonate leaf spot disease of sorghum. The most effective two treatments i.e. seed treatment with carbendazim @ 2 g/kg seed + two foliar sprays with propiconazole @ 1g/l and. seed treatment with *T. viride* @ 5g/kg + two foliar sprays with propiconazole @ 1g/l were evaluated at large plot. It was observed that the seed treatment with carbendazim + two foliar sprays with propiconazole provided 74.1 per cent control of zonate leaf spot (17.7 % disease severity) over check (68.4 % disease severity) with 8.2 per cent increase in green fodder yield (378.3 q/ha) as compared to control (347.4 q/ha). The second treatment i.e.seed treatment with *T. viride* + two foliar sprays with propiconazole also found equally effective provided 69.7 per cent disease control with 7.2 per cent increase in yield. Seed treatment with carbendazim + two foliar sprays with propiconazole also gave high B:C ratio i.e.6.37 as compared to seed treatment with *T. viride* + two foliar sprays with propiconazole which gave 5.96 ratio only (Table 33).

Table 33: Validation of best treatments of trial entitled "Integrated Management of foliar diseases of forage Sorghum"

Treatment	Zonate leaf spot		Green Fodder yield		B:C
	Disease Severity (%)	Disease control (%)	(q/ha)	(%) increase	
T_1 = Seed treatment with carbendazim @ 2 g/kg seed + two foliar sprays with propiconazole @ 1g/l	17.7(24.8)	74.1	378.3	8.2	6.37
T_2 = Seed treatment with *T. viride* @ 5g/kg + two foliar sprays with propiconazole @ 1g/l	20.7(27.0)	69.7	374.3	7.2	5.96
T_3 = Control	68.4(55.8)	-	347.4	-	
CD (P=0.05)	2.89	-	11.19	-	

*Figures in parentheses are arc sine transformed values

iv. Biological management of powdery mildew of oats caused by *Blumeria graminis* f. sp. *avenae*: The experiment was conducted to manage the powdery mildew through biological management in oat crop. It was observed that chemical check i.e Three foliar spray of hexaconazole @ 0.1% gave best control of powdery mildew (5.7 % disease severity and 83.0% disease control) with maximum increase (8.9 %) 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 51.0 and 50.0 % powdery mildew control with 5.14 and 3.7 % increase in the seed yield respectively over check (Table 34).

Table 34: Biological management of powdery mildew of oats caused by *Blumeria graminis* f. sp. *avenae*

Treatment	Powdery mildew		Yield	
	% Severity	% control	(q/ha)	% increase
T1: Three foliar spray of *Trichoderma viride* @ 0.5%	16.7 (24.0)	51.0	17.0	5.1
T2: Three foliar spray of *Trichoderma harzianum* @ 0.5%	19.0 (25.8)	50.0	16.8	3.7
T3: Three foliar spray of *Psuedomonas flourescens* @ 0.5%	28.3 (32.1)	14.9	16.4	1.4
T4: Three foliar spray of extract of *Eupatorium adenophorum* @ 10%	17.7 (24.8)	47.0	16.7	3.3
T5: Three foliar spray of Azadirachtin 3000 ppm @ 0.3%	23.0 (28.6)	30.9	16.3	0.4
T6: Three foliar spray of NSE 5%	25.3 (30.2)	23.9	16.6	2.3
T7: Three foliar spray of Eucalyptus @ 10%	18.0 (25.)	46.0	16.2	0.2
T8: Three foliar spray of Vitex @ 0.1%	16.3 (23.8)	43.0	16.5	1.7
T9: Three foliar spray of hexaconazole @0.1% (Chemical control)	5.7 (13.7)	83.0	17.6	8.9
T10: Control	33.3 (35.2)	-	16.2	-
CD (5%)	2.57		0.74	

v: Validation of best treatment of trial entitled "Management of soil borne and powdery mildew diseases in red clover seed crop": The experiment was conducted to manage the powdery mildew and soil borne diseases in the seed crop of red clover. 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 6.0 per cent disease severity and 85.7 per cent disease control of powdery mildew and 3.3 % disease incidence with 66.7 % disease control of soil borne disease with 21.7 per cent increase in yield over control. The non-chemical treatment i.e. *Trichoderma* @ 5g/kg seed +

Three foliar spray of *Trichoderma* @ 0.5% also gave 25.6 per cent disease severity with 55.6 per cent disease control of powdery mildew and 6.3 per cent disease incidence and 36.7 % disease control of soil borne disease with 5.8 per cent increase in yield over control (Table 35).

Table 35: Validation of best treatment of trial entitled "management of soil borne and powdery mildew diseases in red clover seed crop

Treatment	% severity / incidence				Seed yield		B:C
	Powdery mildew	% Control	Soil borne	% Control	Q/ ha	% Increase	
T_1= Seed treatment with *Trichoderma* @ 5g/kg seed + 3 foliar spray of *Trichoderma* @ 0.5%	18.67 (25.6)	55.6	6.3 (14.6)	36.7	1.41	7.60	1: 4.7
T_2 = Seed treatment with carbendazim@ 2 g/kg seed+ 3 foliar spray of hexaconazole @ 0.1 %	6.00 (14.1)	85.7	3.3 (10.5)	66.7	1.53	12.90	1: 11
T_3 =Control	42.00(40.4)	-	10.0 (18.4)	-	1.36	-	
CD (5%)	3.07	-	1.74	-	0.04		

vi: Integrated disease management in berseem: The seed treatment with carbendazim @ 0.02 % followed by foliar spray of carbendazim @ 0.01 % was proved best with 81.1 and 72.0 per cent control of root rot and leaf blight with maximum increase (5.2 %) in the GFY over the check, which was followed with non-significant difference by ST with carbendazim @ 0.02 % followed by foliar spray of Chitosan @ 0.05 % with 74.8 and 68.9 % control of root rot and leaf blight with 4.3 per cent increase in the GFY over the check. Minimum disease control and increase in the yield was provided by Seed treatment with *Trichoderma* @ 0.05 % (Table 36).

Table 36: Integrated disease management in berseem

TREATMENT	Root rot		Leaf blight		Yield (GFY)	
	% Incidence	% control	% Severity	% control	(q/ha)	% increase
T1: Seed treatment with Chitosan @ 0.05 %	2.3 (8.7)	56.0	8.3 (16.8)	22.1	354.3	1.4
T2: Seed treatment with *Trichoderma* @ 0.05 %	4.3 (12.0)	18.2	9.3 (17.8)	12.8	352.7	0.7
T3: Seed treatment with carbendazim @ 0.02 %	1.3 (6.5)	74.8	7.3 (15.7)	31.5	362.0	3.3
T4: Seed treatment with Chitosan @ 0.05 % + *Trichoderma* @ 0.05%	2.3 (8.7)	56.0	8.0 (16.4)	25.2	358.3	2.3
T5: Seed treatment with Chitosan @ 0.05 % + carbendazim @ 0.01%	1.3 (6.5)	74.8	7.0 (15.3)	34.6	366.7	4.7
T6: T1 + foliar spray of Chitosan @ 0.05%	2.3 (8.7)	56.0	4.0 (11.5)	62.6	359.7	2.7
T7: T2+ foliar spray of Chitosan @ 0.05 %	3.3 (10.5)	37.1	5.0 (12.9)	53.3	361.7	3.4
T8: T3 +foliar spray of Chitosan @ 0.05 %	1.3 (6.5)	74.8	3.3 (10.5)	68.9	365.3	4.3
T9: T3 + foliar spray of carbendazim @ 0.01 %	1.0 (5.7)	81.1	3.0 (10.0)	72.0	368.7	5.2
T10: Control	5.3 (13.3)	-	10.7 (19.0)	-	350.3	-
CD (5%)	0.72		1.06		5.18	

G. Protected Cultivation

Identification of biological control agents (BCAs) against plant pathogens under protected cultivation: Twenty isolates of antagonists were isolated from soil sample/s using serial dilution method. Out of which seven isolates were evaluated for their bio efficacy along with the identified potential strains of *Trichoderma* (*T. harzianum* isolates TH-4, TH-11 and T-5; *T. viride* isolates TV-1; *T. koningii* isolates DMA-8 and JMA-11) available in the Department of Plant Pathology, CSK HPKV, Palampur. These isolates have been screened *in vitro* against *Pythium ultimum* and *Rhizoctonia solani* causing damping off in nursery. Evaluation of these isolates against *Rhizoctonia solani* and *Pythium ultimum* indicated that the isolates inhibited mycelium of the pathogen from 45.55 – 59.26 and 36.30 – 61.85 per cent. Isolate T5 (59.26 %) and TV-1 (57.41 %) were found highly effective against *Rhizoctonia solani* (Table 5) however, TI-20 (50.00 %), TI-12 (48.15 %) and TI-10 (48.89%). Isolate TV-1 (61.85%) and DMA-8 (60.74 %) were found highly effective against *Pythium* sp. however; TI-20 (57.04 %), TI-12 (53.33 %) and TI-10 (54.07 %) were effective at par with the known isolates of *Trichoderma* (Table 37). These isolates of antagonists isolated so far will be evaluated against major pathogens of polyhouse crops.

Table 37: Bio efficacy of *Trichoderma* isolates against *Rhizoctonia solani* and *Pythium ultimum*

Isolate	**% Mycelial inhibition**	
	Rhizoctonia solani	***Pythium ultimum***
DMA-8	54.45 (47.567)	60.74 (51.202)
TH-4	52.85 (47.792)	59.26 (50.344)
JMA-11	50.00 (45.000)	57.41 (49.268)
T-5	59.26 (50.344)	60.37 (50.986)
TV-1	57.41 (49.268)	61.85 (51.856)
TH-11	51.85 (46.064)	57.41 (49.266)
TI-4	45.55 (42.448)	36.30 (37.023)
TI-9	47.04 (43.300)	45.92 (42.658)
TI-12	48.15 (43.940)	53.33 (46.913)
TI-20	50.00 (45.000)	57.04 (49.049)
TI-10	48.89 (44.364)	54.07 (47.337)
TI-17	46.30 (42.878)	47.41 (43.514)
TI-15	47.04 (43.299)	39.63 (38.999)
CD (0.05)	**3.963**	**2.527**

*Values in the brackets indicate arcsin transformed values.

H. Zero Budget Natural Farming

Status of diseases & their management:
During ***kharif*** **2019**, the diseases appearing on different crops in various demonstrations/ trials laid under ZBNF, Organic and control were recorded periodically. Likewise the effect of natural preparations (Table 38) on disease control was evaluated under ZBNF and Organic Farming in comparison to control. In addition to the preparations like Beejamrit, Jeevamrit, Ghanjeevamrit etc. used in routine, different ZBNF preparations were applied for the management of diseases and insect pests.The ZBNF preparations were applied at the concentration of 10% in the form of a spray schedule as given in Table 38. These preparations were sprayed at the interval of 7-10 days.

Table 38: ZBNF preparations used for the management of diseases and insect pests

S. No.	ZBNF	Organic
1	Darek Astra	Neem oil
2	Darek Astra	Neem oil
3	Eupatorium extract	Eupatorium extract
4	Eupatorium extract	Eupatorium extract
5	Agneyastra	Lantana extract
6	Agneyastra	Lantana extract
7	Lantana extract	Agneyastra
8	Lantana extract	Agneyastra
9	Khatti Lassi	Khatti Lassi
10	Khatti Lassi	Khatti Lassi
11	Brahmastra	Brahmastra
12	Brahmastra	Brahmastra
13	Dashparni	Dashparni
14	Dashparni	Dashparni

As far as diseases are concerned their incidence and severity are given in Table 39.

Table 39: Incidence/ severity of different diseases on various crops under ZBNF during *kharif* 2019

Crop	Disease	Incidence/ Severity (%)			Disease control (%) under ZBNF
		ZBNF	Organic	Control	
Chilli	Bacterial wilt	0.0	3.3	2.2	100.0 (may be an escape)
	Phytophthora blight	6.5	7.0	7.0	7.1
Mash	Anthracnose	35.0	37.5	37.5	6.7
	Cercospora leaf spot	20.0	20.0	22.5	11.1
	Ascochyta leaf spot	5.0	5.0	5.0	Nil
	Powdery mildew	20.0	20.0	20.0	Nil
Ramtori	Downey mildew	40.0	40.0	40.0	Nil
Pumpkin	Downey mildew	30.0	30.0	30.0	Nil
Maize	Maydis blight	30.0	30.0	35.0	14.3
Soybean	Cercospora leaf spot	15.0	15.0	15.0	Nil
Rice (GP)	Brown spot	10.0	0.0	0.0	Nil
Cowpea (GP)	Septoria/ Brown spot	35.0	0.0	0.0	Nil

It is evident from the data that the ZBNF preparations were not much effective in the management of diseases. However, disease control ranging from 6.7 to 14.3% was observed/ obtained by their applications in case of foliar diseases of vegetable and field crops. As far as bacterial wilt of chilli is concerned a cent percent control is reflected by the data. However, it is not due to the effect of ZBNF preparations but actually due to the fact that a few seedlings carried infection from the nursery and majority were disease free. Moreover, for the management of seed and soil borne diseases causing complete mortality of the plants need seed treatment and soil drenching for their management which was not given. Sprays of Khatti Lassi alone did not give effective control of powdery mildew however, sprays of Khatti Lassi fortified with Hing were found effective in controlling the disease. In one of the student' trial on Mash, Ghanjeevamrit and Jeevamrit applications were found effective in curtailing the foliar diseases Cercospora leaf spot and Anthracnose) of Mash.

In ***rabi*** **2019-20,** different demonstrations/ trials conducted under ZBNF were monitored from January to March (before lockdown) for the appearance of diseases during the *rabi* season. The data recorded on diseases did not reflect much difference between ZBNF, organic and control demonstrations on different crops. The terminal disease incidence/ severity which actually reflect the effect of preparations applied could not be recorded due to the imposition of lock down w.e.f. 23.03.2020. However, the data recorded by research staff during lockdown on important diseases was considered and authenticated with the observations taken till March. In demonstrations of different crops, Ramban (Tamarlassi + Jeevamrit @ 10%) was applied at 7 days intervals while Jeevamrit (10%) was applied at 15 days intervals. In addition, Eupatorium extract, Saunthastra and Tamarlassi sprays @ 10% (two alternate sprays of each) were also given at the appearance of disease(s) at 7-10 days intervals. The terminal incidence/ severity of diseases recorded on different crops in demonstrations conducted under ZBNF, Organic and control demonstrations are given in Table 40 as under:

Table 40: Incidence/ severity of different diseases on various crops under ZBNF

Crop	Disease recorded	Incidence/ Severity (%)			Disease control (%) under ZBNF
		ZBNF	Organic	Control	
Cauliflower	Black rot	2.7	3.0	2.7	0.0
Cabbage	No disease	-	-	-	
Raddish	No disease	-	-	-	
Garlic	No disease	-	-	-	
Onion	No disease	-	-	-	
Peas	Root rot Powdery mildew	11.0 3.0	10.6 3.0	11.0 7.0	0.0 57.1
Wheat	No disease	-	-	-	
Gram	Root rot wilt complex	12.5	12.7	12.5	0.0
Wheat + Gram	No disease Root rot wilt complex	- 12.3	- 12.5	- 12.0	 0.0
Linseed	No disease	-	-	-	
Gobhi Sarson	No disease	-	-	-	
Wheat + Sarson	No disease	-	-	-	
Wheat + Lentil	No disease Root rot	- 1.3	- 1.5	- 1.2	 0.0
Wheat + Linseed	No disease No disease	-	-	-	

The data indicated that root rot-wilt complex due to *Fusarium oxysporum* is a major problem on Chickpea/ Gram and Peas resulting into rotting of roots, wilting and drying of plants. The sprays of ZBNF preparations did not give any control of this problem. The application of ZBNF preparations especially Tamarlassi/ Ramban gave good control (57.1 %) of powdery mildew disease.

Management of root rot wilt complex of chickpea under ZBNF:

The trial on root rot wilt complex was laid using variety Chana-18-2 with 4 treatments (including check) and 4 replications on 08.11.2019 in RBD. For the management of root rot and other diseases of gram three schedules of ZBNF preparations considered to be as three independent treatments were evaluated as given in Table 41. The sprays of Eupatorium extract, Khatti Lassi and Sonthastra (all @ 10%) were started just at the appearance of root rot while four drenches of Eupatorium extract (10%) were given in the month of April. The diseases were monitored twice during February and March before lock down and by research staff during the lock down period. The terminal disease incidence of root rot wilt complex recorded by research staff was considered after authentication with the earlier observations (Table 42).

Table 41: Evaluation of sprays/ drenches schedules of ZBNF preparations for the management of chickpea disease(s)

Spray/ drench date	Spray/ drench schedule-I (T1)	Spray/ drench schedule-II (T2)	Spray/ drench schedule-III (T3)
17.03.20	Eupatorium extract	Saunthastra	Tamarlassi
24.03.20	Saunthastra	Tamarlassi	Eupatorium extract
31.03.20	Eupatorium extract	Saunthastra	Tamarlassi
07.04.20	Saunthastra	Tamarlassi	Eupatorium extract
08.04.20	Eupatorium extract drench	Eupatorium extract drench	Eupatorium extract drench
14.04.20	Eupatorium extract	Saunthastra	Tamarlassi
15.04.20	Eupatorium extract drench	Eupatorium extract drench	Eupatorium extract drench
18.04.20	Eupatorium extract drench	Eupatorium extract drench	Eupatorium extract drench
21.04.20	Saunthastra	Tamarlassi	Eupatorium extract
22.04.20	Eupatorium extract drench	Eupatorium extract drench	Eupatorium extract drench
28.04.20	Eupatorium extract	Saunthastra	Tamarlassi
05.05.20	Saunthastra	Tamarlassi	Eupatorium extract

Table 42: Disease incidence of root rot wilt complex in chickpea under different schedules/ treatments

Treatment	Disease incidence (%)	Disease control (%)
T1	8.13 (16.42)	27.73
T2	8.75 (16.99)	22.22
T3	7.50 (15.78)	33.33
Control	11.25 (19.45)	
CD (0.05)	NS	

In this trial except root rot and wilt complex no other disease appeared/ was recorded. The data (Table 42) indicated that the spray/ drench schedule III (T3) was most effective giving 33.3% control of the disease followed by T1 and T2 respectively. However, statistically they were non-significant. The sprays of these preparations as such were not effective in managing root rot wilt complex of chickpea as also observed in case of demonstrations however, the drenches of Eupatorium extract definitely contributed in lowering the incidence of this disease as observed under this trial. The control achieved with these schedules is less than 50% which is the minimum desirable level of control.

I. Seed Pathology

Monitoring and detection of rice diseases in processed, unprocessed and farmers' seed samples: Rice bunt infection was assessed in 178 farmers saved seeds samples collected from different districts of Himachal Pradesh. 37 rice seed sample showed the presence of rice bunt with an incidence of 0.2-1.0 percent, maximum being in Sambuwala location of district Sirmaur. However, grain discoloration incidence was recorded in many locations. Grain discolouration incidence ranged between 0.8-8.6 per cent. The representative rice seed samples analyzed for seed mycoflora revealed the presence of ten fungi *viz., Fusarium sp., Penicillium sp., Alternaria* sp., *Curvularia lunata, Drechslera oryzae, Aspergillus* sp., *Pestolotia* sp., *Helminthosporium* sp., *Rhizoctonia* sp. and *Trichoderma* sp. in two categories of seed (sterilized and unsterilized). In Kangra district, *Fusarium* sp. with the frequency range of 16-80 predominated in unsterilized seed samples followed by *Curvularia lunata* (20-100%). Whereas, *Aspergillus* and *Ttrichoderma* spp. were noticed in four locations of the district. Predominace of fungi *Curvularia* (8-60%) and *Aspergillus* sp. (16-72%) was observed in Una. Five samples analyzed from Sirmour district reveled the dominance of *Fusarium* sp.(8 samples) with a frequency range of 8-80% followed by *Curvularia* sp. (8-80%) and *Aspergillus* sp. (12-20%). Similar in Solan district the maximum frequency of *Fusarium* sp.(8-80%) followed by *Aspergillus* sp.(12-36%) was observed. *Fusarium* sp. was observed in 10 samples collected from the different location of Mandi followed by *Curvularia* sp.in 8 with the frequency range of 12-80 and 12 60%, respectively.

Status of loose smut in framers own saved wheat samples: 217 farmers own saved seed samples collected from different districts of Himachal Pradesh were tested by GOT to see the prevalence of loose smut disease under field conditions during the *Rabi* season of 2018-19. Out of 217 seed samples, loose smut was observed only in 8 samples with a incidence of 0.1-0.2 percent, in local varieties grown by the farmers.

District wise and variety wise karnal bunt detected in unprocessed farmers wheat seed sample and seed production plots in Himachal Pradesh: 300 wheat seed samples were collected during the year 2019-20, from eight district of Himachal Pradesh to assess the prevalence of karnal bunt disease in farmer's unprocessed seed samples Karnal bunt was recorded in only 245 seed samples with an incidence ranging from 0.05 to 3.85 percent with a maximum incidence of 3.85 % in Jihan area of district Hamirpur. 178 samples were found to have infection above seed certification level.

The representative samples selected at random from different locations of the state were analysed for the prevalence of seed mycoflora. In Hamirpur district *Alternaria* sp. was predominant both in sterilized (2-96%) and unsterilized (28-80%) seed samples followed by *Fusarium* sp. (8 samples) with the frequency range of 8-32% in sterilized and 8-42% in unsterilized samples, respectively. In the samples collected from Bilaspur district, *Fusarium* sp. was major fungus both in sterilized (20-92%) as well unsterilized (16-100%) seeds followed by. *Alternaria* sp. in 8 seed samples with the range of 20-72% and 24-92% in sterilized and unsterilized seed. Similar results was observed in seed samples collected from Kangra Una and Sirmour districts where again *Alternaria* sp. and *Fusarium* sp. were noticed in all the seed samples followed by *Rhizopus* and *Rhizoctonia* sp. Samples collected from Solan and Mandi district also resulted the same mycoflora where *Alternaria*, *Fusarium* and *Rhizopus* sp. were observed in 2 seed samples from Solan and in 3 seed samples from Mandi with the frequency range of 16-92% in sterilized in case of *Alternaria* sp. whereas frequency of *Fusarium* sp was observed in 4-8% and 12-16% in sterilized as well as unsterilized seeds.

Status of seed borne diseases in Hybrid Rice Varieties cultivated by farmers: During the year under report, different rice growing areas f the state were surveyed for the occurrence of diseases in rice varieties and hybrids being grown by the farmers. The data on disease incidence and severity given in Table 43 reavled the prevelanece of almost all the important diseases on rice hybrids and improved varieties. The false smut severity ranged between 1-9 on 0-9 point scale with average incidence of 5.0 to 32.5%. The rice hybrid Arize 6444 and Mahuindra NP3030 recorded maximum incidence of 32.0% in Churk Majri and Dhaulakuan areas of district Sirmaur. The neck blast was also recorded on different hybrids with a incidence of 3.5 to 32.5%. The sheath rot was observed in almost all the localities with incidence ranging between 7.5 –28%. BLB was recorded only in two locations, whereas brown spot incidence was in traces except in Solan and Sirmaur districts.

Table 43: Status of seed borne diseases in Hybrid Rice Varieties cultivated by farmers in Himachal Pradesh during *Kharif* 2019

Locatio District/ region	Variety	False Smut Inciden (%)	False Smut Inciden (Scale	BLB Severity	Neck Blast	Sheath Rot	Sheath Blight Inciden	Brown Spot
Kangra								
Nagrota Bagwan	Arize 6508	12.5	5	-	-	12.5	-	T
	Arize 6741	7.5	3	-	-	-	5.0	-
	Shahi Dawat,	5.0	1	-	32.5	10.0	17.5	T
	Arize 6129 Gold	17.5	5	-	-	10.0	-	-
Rait	Arize 6129	7.5	3	-	-	17.5	-	-
Pathiar	Shahi Dawat	-	-	-	25.0	12.5	7.5	T
Dadh	Arize 6508	7.5	3	-	-	7.5	7.5	-
Hatwas	Adventa 812, Adventa 834	7.5	3	-	32.5	17.5	T	-
Mandi								
Bheora, Balh valley	US 312	12.5	5	-	-	17.5	5.0	5.0
	PAC 807	7.5	3	-	5.0	12.5	T	-
Una								
Basal	Arize 6444	5.0	1	-	-	7.5	-	T
	Arize 6129 Gold	17.5	5	-	3.5	17.5	-	T
Nangalkalan	Arize 6444	12.5	5	-	5.0	17.5	T	T
Solan								
Nalagarh	Arize 6444	17.5	5	-	7.5	12.5	5.0	12.5
Sirmour								
Shambhu-wala	Arize 6444	7.5	3	-	-	12.5	T	5.0
Kolar	Hyb. 25P35	17.5	5	12.5	-	27.5	7.5	5.0
	Varsha Gold	7.5	3	-	-	7.5	5.0	T
Churk Majri	Arize 6444	32.5	7/9	7.5	5.0	12.5	12.5	5.0
Dhaulakuan	Mahindra NP 3030	32.5	7/9	-	-	28.0	12.5	T

***T=** Traces

Status of head blight pathogen in processed wheat seed samples: The processed seed samples of wheat varieties developed/recommended by the CSK HPKV, Palampur and multiplied in various seed multiplication farms of the university were analyzed to assess the status of head blight pathogens and associated seed during 2017-18 and 2018-19, the seed samples of different varieties were found to harbor only two head blight pathogens *viz., Fuasrium graminearum* and *F. poae*. The *F. graminearum* was recorded in almost all the varieties whereas *F. poae* was isolated only from 25 samples using blotter and agar plate method of detection

J. Molecular Plant pathology

a. Molecular mapping of anthracnose resistance gene in common bean landrace KRC8

i. Development and generation advancement of mapping population: Using single seed descent method a set of ~200 F_9 RIL individuals seeds derived from the cross between an elite susceptible common bean cultivar 'Jawala' and resistant landrace 'KRC-8' were developed from generation F_5 to F_9alternatively at the MAREC, Sangla, Kinnaur and CSK HPKV, Palampur (HP). Finally one hundred seventy two ($F_{2:8}$) RIL individuals along with ninety three F_2 population was also generated by making crosses between Jawala X KRC-8 and used to study the inheritance pattern of R-gene present in KRC-8.

ii. Maintenance and reconfirmation of pure cultures of *Colletotrichum lindemuthianum* : The cultures of three *C. lindemuthianum* races *viz.*3, 87, 211 were revived on Potato Dextrose Agar medium and Mathur's medium (sporulated on) from the infected bits of susceptible cultivar Jawala, maintained at refrigerator (4ºC) in the Department of Plant Pathology. To confirm their identity, sporulating culture of each race was inoculated on the set of bean differential cultivars separately and the reaction type observed is presented in the Table 44.

Table 44. Confirmation of race identity of *C. lindemuthianum* isolates on CIAT differential bean varieties

Isolate number	Reaction of common bean differentials												Race designation
	A	B	C	D	E	F	G	H	I	J	K	L	
	Co-11	*Co-1, Co-3*	*Co-1³, Co-13*	*Co-2*	*Co-1⁵, Co-3*	*Co-1²*	*Co-3*	*Co-4³, Co-9*	*Co-4*	*Co-5*	*Co-6, **co-8***	*Co-4², Co-5, Co-*	
Cl- 186a	+	+	-	-	-	-	-	-	-	-	-	-	3
Cl- 222	+	+	+	-	-	+	+	-	-	-	-	-	**87**
Cl- 231	+	+	-	-	+	-	+	+	-	-	-	-	**211**

+: Susceptible; –: Resistant; '*Co'* represents different anthracnose resistance gene(s); Differential cultivars and their binary values (In parentheses): A- Michelite (1), B-Michigan dark red kidney (MDRK) (2), C- Perry Marrow (4), D- Cornell 49242 (8), E- Widusa(16), F- Kaboon (32), G- Mexique 222(64), H- PI 207262 (128), I- TO (256), J- TU(512), K-AB136 (1024) and L-G2333 (2048)

iii. Inheritance of anthracnose resistance: To know the genetics of resistance present in the land KRC-8 ninty three F_2 individuals derived from the cross between Jawala x KRC-8 were inoculated at their adult plant stage with the race-87 of *Colletotrichum lindemuthianum*, among them 28 plants showed the resistant reaction and 65 showed the susceptible reaction (Table 45).

Table 45. Phenotypicreaction of $F_{2:9}$RIL Population of cross KRC8 x *Jawala* against race 87 of *C. lindemuthianum*

SR. No.	Plant No.	Disease Scale	Reaction	SR. No.	Plant No.	Disease Scale	Reaction	SR. No.	Plant No.	Disease Scale	Reaction
1	JB-5	5	S	59	JB-112	7	S	117	JB-230	1	R
2	JB-7	5	S	60	JB-113A	7	S	118	JB-238	3	R
3	JB-9	5	S	61	JB-121	5	S	119	JB-239	1	R
4	JB-10	3	R	62	JB-122	5	S	120	JB-243	0	R
5	JB-11A	5	S	63	JB-124	0	R	121	JB-245	0	R
6	JB-11B	5	S	64	JB-126	3	R	122	JB-248	0	R
7	JB-15	5	S	65	JB-136	0	R	123	JB-250	7	S
8	JB-16A	5	S	66	JB-136-1	7	S	124	JB-253	5	S
9	JB-16-2	1	R	67	JB-137	7	S	125	JB-254	0	R

10	JB-16-4	1	R	68	JB-137-1-1	5	S	126	JB-256	5	S
11	JB-16-6	1	R	69	JB-145	3	R	127	JB-258	7	S
12	JB-17	5	S	70	JB-153A	5	S	128	JB-260-1-1	1	R
13	JB-18-1	9	S	71	JB-156	7	S	129	JB-260-1-2	1	R
14	JB-18-2	5	S	72	JB-157	7	S	130	JB-260-1-3	5	S
15	JB-19	5	S	73	JB-157-2	7	R	131	JB-261	3	R
16	JB-20	1	R	74	JB-158A	3	R	132	JB-263	5	S
17	JB-21	7	S	75	JB-160	1	R	133	JB-264	1	R
18	JB-24A	7	S	76	JB-163	3	R	134	JB-266	7	S
19	JB-25	5	S	77	JB-165	3	R	135	JB-273	0	R
20	JB-30	5	S	78	JB-167-1	7	S	136	JB-274	7	S
21	JB-31	1	R	79	JB-167-5-2	7	S	137	JB-275	1	R
22	JB-34	5	S	80	JB-168	0	R	138	JB-280	3	R
23	JB-34-2	0	R	81	JB-170	1	R	139	JB-289	5	S
24	JB-35	5	S	82	JB-172	1	R	140	JB-296-1-1	5	S
25	JB-36	7	S	83	JB-175	0	R	141	JB-301	1	R
26	JB-37B	5	S	84	JB-177	5	S	142	JB-303	5	S
27	JB-39	7	S	85	JB-178	1	R	143	JB-307	1	R
28	JB-40-2	5	S	86	JB-179	1	R	144	JB-308	7	S
29	JB-42	3	R	87	JB-180	0	R	145	JB-309B	5	S
30	JB-47	7	S	88	JB-182	1	R	146	JB-312	5	S
31	JB-50	1	R	89	JB-184	3	R	147	JB-313	1	R
32	JB-52	1	R	90	JB-186	0	R	148	JB-315	5	S
33	JB-56B	0	R	91	JB-187-1	5	S	149	JB-318	0	R
34	JB-64	3	R	92	JB-190	5	S	150	JB-327A	5	S
35	JB-65A	9	S	93	JB-192	5	S	151	JB-328	5	S
36	JB-66	5	S	94	JB-193	3	R	152	JB-331	1	R
37	JB-74A	7	S	95	JB-195	5	S	153	JB-335	5	S
38	JB-74B	7	S	96	JB-197	1	R	154	JB-340A	1	R
39	JB-75	7	S	97	JB-197-1-1	5	S	155	JB-344	1	R
40	JB-76	0	R	98	JB-199	0	R	156	JB-348	5	S
41	JB-80A	5	S	99	JB-201	9	S	157	JB-350	9	S
42	JB-80B	3	R	100	JB-202	7	S	158	JB-355-1	5	S
43	JB-81	3	R	101	JB-204	1	R	159	JB-361A	5	S
44	JB-82	7	S	102	JB-206	0	R	160	JB-364	5	S
45	JB-82-2	7	S	103	JB-207	3	R	161	JB-365A	5	S
46	JB-83B	9	S	104	JB-210	5	S	162	JB-366	5	S
47	JB-84	7	S	105	JB-212	0	R	163	JB-367	0	R
48	JB-88	5	S	106	JB-214-1-1	0	R	164	JB-368	0	R
49	JB-90A	9	S	107	JB-214-1-3	1	R	165	JB-377	5	S
50	JB-91	7	S	108	JB-215	5	S	166	JB-377-1	5	S
51	JB-93A	5	S	109	JB-216	0	R	167	JB-378	5	S
52	JB-95	3	R	110	JB-217	5	S	168	JB-381	3	R
53	JB-96-2	1	R	111	JB-219	9	S	169	JB-382	5	S
54	JB-99	5	S	112	JB-223B	0	R	170	JB-383	0	R
55	JB-103	7	S	113	JB-224	9	S	171	JB-384-1	5	S
56	JB-106	1	R	114	JB-226	5	S	172	JB- JB-393-2	5	S
57	JB-109	3	R	115	JB-227	1	R	P1	JAWALA	9	S
58	JB-110	3	R	116	JB-228	0	R	P2	BASPA	0	R

After counting the number of resistant and susceptible plants the data was subjected to the Chi square analysis to test the goodness of fit to a Mendelian ratio and it was noticed that F_2 population showed good fit to the 1R:3S monohybrid ratio there by indicating the presence of resistance gene in land race KRC-8 against race-87 is controlled by single recessive gene (Table.46). Similar results were obtained in $\mathbf{F_{2:9}}$ RIL individuals when inoculated with race-87 of the *C. lindemuthianum*, where 76 plants showed the resistance and 96 showed susceptible type reaction out of 172 tested individuals, thus Chi square analysis showing the good fit to the expected ratio 1:1 presented in the Table 46.

Table 46. Segregation of resistance in F_2 and RIL ($F_{2:9}$) progenies of the cross between common bean resistant landrace KRC-8 and susceptible genotype Jawala against race 87 of *C. lindemuthianum*

Parents/ Pathogen	Generation	Number of plants		Expected ratio (R:S)	(χ 2)	P-value
		Resistant	Susceptible			
KRC-8	P_2	10	-			
Jawala	P_1	-	10			
	F_2	28	65	1:3	1.29	0.26
KRC-8	P_2	10	-			
Jawala	P_1	-	10			
	F_{2-9}	76	96	1:1	2.33	0.13

[a]R= Resistant; S= Susceptible, χ 2= The actual value of Chi-square test for resistant/ susceptible ratio

iv. Parental polymorphism survey using ISSR, SSR and RAPD primers: For polymorphism survey on two parental genotypes a set of 48 ISSRs, 287 RAPDs and 212 SSRs primers those were already synthesized, procured from the department along with the 205 newly synthesized SSRs primers including 118 chromosome specific SSRs, 48-Indel markers, 21-IAC markers and 18PvBR series were tested. From forty eight ISSRs primers five were found to be parental polymorphic (Fig. 1) and these were ISSR- 811, ISSR -818, ISSR -824, ISSR- 827and ISSR -846. Out of two hundred eight seven RAPDs only nineteen RAPDs were noticed to be parental polymorphic and these were including OPAA-3,OPH-4,OPE-4,OPAM-6, OPY-7, OPAM-7,OPC-8, OPV-10,OPG-10,OPAM-10, OPAD-11, OPC-11, OPH-12,OPW-13, OPE-14, OPG-16,OPI-18, OPAD-19 and OPO-20 (Fig. 2). In case of SSRs screening on two distinguishing resistant and susceptible parents, only fourteen SSRs were found to be polymorphic and these were BM-134, BM-140, BM-152, BM-172, BM-146, BM-175, BMD-3,BMD-12, BMD-18, IAC-238, IAC-223, IAC-252, PVBR-61 and INDEL-14 (Fig. 3).

v. BSA analysis using parental polymorphic markers: The molecular markers found polymorphic on the parents were used in BAS using two contrasting DNA bulks prepared by pooling equal amounts of DNA of 10 homozygous resistant and 10 homozygous susceptible F_{2-9} individuals of Jawala x KRC-8 cross. In ISSR primers only five primes were parental polymorphic but when they checked on bulks they not segregated as that of parent and hence found to be monomorphic on the bulks. From RAPDs out of nineteen parental polymorphic primers only five i.e., OPO-20, OPAM-7, OPW-13, OPAD-19 and OPV-10 generated polymorphism on the two bulks also (Fig.10) but when they checked on bulks individuals they not segregated as that of parents and bulks, hence rejected, whereas in case of SSRs among fourteen parental polymorphic primers only one i.e., IAC-238 was found to be polymorphic (fig. 11) withcontrasting amplification pattern in the resistant and susceptible bulks same as that of parents. The co-dominant nature of this marker resulted the amplification ~230 bp of product in susceptible parent (Jawala) and susceptible bulk whereas ~220 bp of amplification product in resistant parent (KRC-8) and resistant bulk. The work on BSA is in progress.

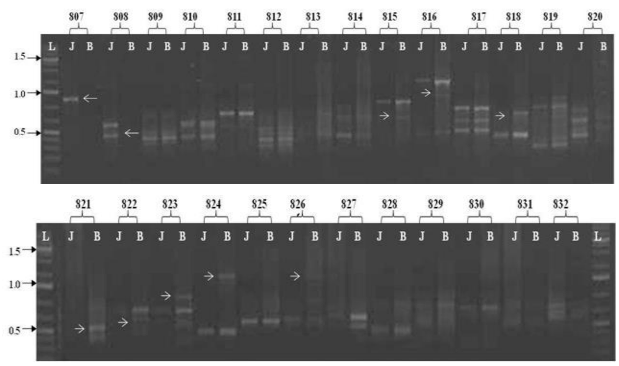

Fig. 1. Polymorphism survey of parental genotypes Jawala and KRC-8 using ISSR markers on 1.6 per cent agarose gel electrophoresis where L: 100bp molecular marker; J: Jawala; B: KRC-8 and white arrow indicating the parental polymorphic markers

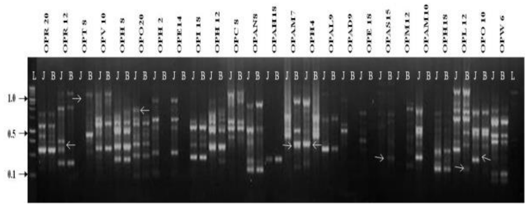

Fig.2. Polymorphism survey of parental genotypes Jawala and KRC-8 using RAPD markers on 1.2 per cent agarose gel electrophoresis where L: 100bp molecular marker; J: Jawala; B: KRC-8 and white arrow indicating the parental polymorphic markers

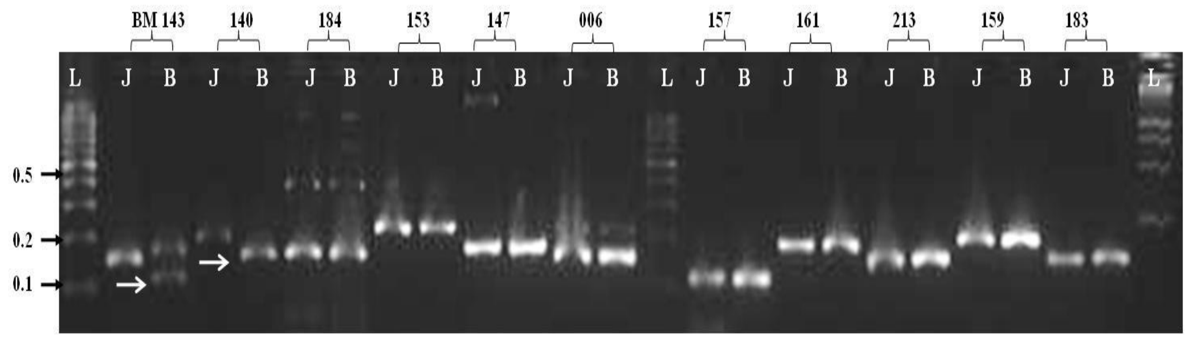

Fig. 3.. Polymorphism survey of parental genotypes Jawala and KRC-8 using SSR markers on 3 per cent agarose gel electrophoresis where L: 100bp molecular marker; J: Jawala; B: KRC-8 and white arrow indicating the parental polymorphic markers

b. Identification of adult plant resistance components in land race KRC-8: In order to identify the APR components, an experiment was conducted in which common bean landrace KRC-8 along with the Jawala as control was divided into five growth stages (As per CIAT standards) according to their life span.

All these five stages of the beans were artificially inoculated with the three races of the pathogen i.e., Race-3,87,211 under greenhouse conditions to maintain the appropriate conditions (≥90 percent relative humidity, 20±1°C temperature, 12hr photoperiod) for the development of disease. Nine replication were taken for the each stage of the plant and inoculated in the separate green house to avoid the mixing of the spores of different races. On the development of disease data was recorded on incubation and latent period, lesion size and disease reaction.

The cultivars Jawala and KRC 8 were compared for their APR parameters to find out the difference in their response towards anthracnose with three widely prevalent races *viz.*, race 3, 87 and 211 at different growth stages. The cultivars were compared for their APR traits *viz.*, incubation period, latent period and disease score using Students't test. In the seedling stage, average incubation periods of anthracnose races in Jawala and KRC 8 were found to vary non-significantly with the range of 5.33-7.67 days in leaves and 5.00-7.33 days in stems of plants (Fig 13). At trifoliate stage, in Jawala, the incubation period of all races varied from 7.33 to 8.67 days in leaves and 6.00 to 8.00 days in stems while in KRC 8, variation was with range 8.33-8.67 days in leaves and 6.33-8.33 days in stems. At pre-flowering stage, the average incubation time for anthracnose lesions to be evident was found to vary from 7.67 to 9.33 days in leaves and from 9.00 to 9.67 days in stem of Jawala. As the typical anthracnose lesions were absent in KRC 8 at pre flowering, pod development and pod filling stages, the incubation period was taken as zero. At the pod development stage, ranges of incubation time in Jawala were observed to be 8.00 (race 87)-10.00 (race 3) days at leaves, 9.67 (race 87)-11.33 (race 3) days at stems and 9.33 (race 211)-12.00 (race 87) days at pods.

Similar pattern of non-significant difference was observed in the mean latent periods of all anthracnose races among both cultivars plants *w.r.t.* leaves (6.67-8.67 days) and stems (6.00-8.33 days) (Fig. 14). At trifoliate stage, average time to sporulation (latent period) also showed variation with ranges 7.67-9.67 and 7.00-9.00 days in leaves and stems of Jawala, respectively (Fig. 2). KRC 8 revealed non-significantly high latent period in both plant parts *i.e.*, leaves (8.33-10.33 days) and stem (7.33-10.00 days). Latent period of anthracnose races in Jawala varied from 8.67 days (race 3 and 87) to 10.33 days (race 211) in leaves while from 10.00 days (race 87) to 10.67 days (race 3 and 211). Like incubation period, latent period was also taken as zero at pre flowering, pod development and pod filling stages due to complete absence of typical anthracnose lesions in KRC 8. In Jawala at pod development stage, latent period varied from 9.00 (race 87) to 10.00 (race 211) days in leaves, 10.67 (race 87) to 11.33 days (race 3) in stem and 10.33 (race 211) to 11.67 (race 87) days in pods though the difference was non-significant among races. Similarly in the pod filling stage, the latent period was recorded to vary between 9.00-11.00 days (leaves), 10.67-12.33 days (stem) and 10.33-13.00 days (pods) among all the races.

The disease score in the emergence stage in Jawala was 4.00 in leaves and 5.00 in stems which was found to be reduced non-significantly in KRC 8 showing mild variation in leaves (3.33-3.67) as well as stems (4.00-4.67) (Table 47). The overall disease scores in Jawala at trifoliate stage followed a range of 8.33-7.67 in leaves and 6.33-7.00 in stem whereas in KRC 8, it varied from 5.67 to 7.67 in leaves and 5.76 to 6.33 in stem. In pre-flowering stage, the disease score in Jawala leaves ranged from 7.00 to 7.67 while in stem it was observed to be 6.33. On the contrary, in KRC 8 the disease score was recorded to be zero in pre flowering, pod development and pod filling due to complete absence of typical anthracnose lesions. Similar was the scenario for Jawala at pod development stage where it varied from 6.33 to 7.67 (leaves), 5.67 to 6.33 (stem) and 7.00 to 7.67 (pods). At pod filling stage, disease score was observed to be ranging between 5.67-7.00 in leaves, 5.67 in stem and 7.67-8.33 in pods.

Table 47. Disease score on parents at different five growth stages using three races (Race-87, 3, 211) of *C. lindemuthianum*

D	Disease score with race-87						Disease score with race-3						Disease score with race-211					
	Leaf		Stem		Pod		Leaf		Stem		Pod		Leaf		Stem		Pod	
Stage	J	B	J	B	J	B	J	B	J	B	J	B	J	B	J	B	J	B
I	4.00 (2.23)	4.00 (2.24)	5.00 (2.45)	4.33 (2.31)*	-	-	4.00 (2.24)	3.67 (2.16)	5.00 (2.45)	4.67 (2.38)*	-	-	3.67 (2.15)	4.00 (2.24)	5.00 (2.45)	5.00 (2.45)*	-	-
II	8.33 (3.05)	7.00 (2.81)*	6.33 (2.70)*	6.33 (2.70)*		-	7.67 (2.94)	7.67 (2.58)*	7.00 (2.81)*	6.33 (2.70)*	-	-	8.33 (3.05)*	7.67 (2.94)*	7.00 (2.94)*	6.33 (2.70)*	-	-
III	7.67 (2.94)	1.67 (1.61)	6.33 (2.70)*	0.00 (1.00)		-	7.00 (2.83)	0.00 (1.00)	6.33 (2.70)	0.00 (1.00)	-	-	7.67 (2.94)	0.00 (1.00)	6.33 (2.70)	0.00 (1.00)	-	-
IV	7.67 (2.94)	1.67 (1.61)	5.67 (2.58)	0.00 (1.00)	7.67 (2.94)*	0.00 (1.00)	7.00 (2.81)	0.00 (1.00)	6.33 (2.70)	0.00 (1.00)	7.00 (2.83)*	0.00 (1.00)	6.33 (2.70)	0.00 (1.00)	5.67 (2.58)	0.00 (1.00)	7.67 (2.94)*	0.00 (1.00)

V	7.00 (2.81)	1.00 (1.41)	5.67 (2.58)	0.00 (1.00)	8.33 (3.05)*	0.00 (1.00)	6.33 (2.70)	0.00 (1.00)	5.67 (2.58)	0.00 (1.00)	7.67 (2.94)*	0.00 (1.00)	5.67 (2.58)	0.00 (1.00)	5.67 (2.58)	0.00 (1.00)	8.33 (3.05)*	0.00 (1.00)
CD	**0.41**	**0.49**	**0.01**	**0.21**	**0.22**		**0.38**	**0.21**	**0.01**	**0.21**	**0.05**		**0.40**	**0.16**	**0.01**	**0.21**	**0.23**	
SE	**0.17**	**0.22**	**0.04**	**0.35**	**4.31**		**0.18**	**0.22**	**0.84**	**0.38**	**0.46**	-	**0.13**	**0.20**	**0.051**	**0.36**	**0.49**	

=at confidance interval of 0.05, J-Jawala, B-KRC-8, CD-critical difference at ±0.05% SE-standard error,- value with in parenthesis is root square transformed

c. Development of PCR based protocol for the detection of *Pepper mild mottle virus* (PMMoV) from chili seeds: The RT_PCR protocol developed for the detection of PMMoV from chilli seeds was valdidated on infected chilli seeds harvested from PMMoV infected plants. Randomly three fruits were picked from infected plants of each cultivar to assess the per cent seed transmission. The highest seed transmission was found in cv. California Wonder (50 to 66.67 %) followed by Doux des Landes (33.33 to 40 %) and Yolo Wonder (28.57 to 37.50 %), respectively (Table 48). Incase of cv. California Wonder, per cent seed transmission was 64.29, 50.00 and 66.67 per cent in three fruits, respectively with an average of 60.32 per cent, whereas in cv. Yolo Wonder it was 33.33, 37.50 and 28.57 per cent with an average of 33.13 per cent. The cv. Doux des Landes showed 40.00, 33.33 and 37.50 per cent seed transmission with an average of 36.94 per cent (Table9).The RT- PCR based protocol designed to detect the PMMoV from chili seeds during 2016-17 was validated for its authenticity and robustness using coat protein (CP) gene specific primer pair (CPF: CCAATGGCTGACAGATTACG, CPR: CAACGACAACCCTTCGATTT, Expected product size: ~730-743 bp). The total RNA isolation and cDNA synthesis protocols were similar as described in the previous reports. The RT_PCR profile consisted of 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 extensionof 7 min at 72°C. An amplification product of ~ 730 bp (Fig. 15) was obtained in case of seeds harvested from diseased fruits confirming the presence of PMMoV in the seeds. The protocol developed can be used for routine testing of the test virus (Fig. 16).

Table 48. PMMoV seed transmission assay in capsicum cultivars through RT-PCR in individual diseased fruits

***Capsicum annuum* cultivar**	**Number of fruits assayed**		**Number of seeds extracted per fruit for RT-PCR**	**Number of seeds showing amplification**	**Seed transmission (%)**	**Average seed transmission (%)**
California Wonder	3	1	14	9	64.29	60.32
		2	14	7	50.00	
		3	6	4	66.67	
Yolo Wonder	3	1	6	2	33.33	33.13
		2	8	3	37.50	
		3	7	2	28.57	
Doux des Landes	3	1	10	4	40.00	36.94
		2	9	3	33.33	

K. Mushrooms

Evaluation of selected white accessions of *Agaricus bisporus*for yield potential: Five strains were evaluated (Table 49) and AVTB-19- 201 gave the maximum yield of 20.50 kg/ 100kg compost having average fruit body weighing 15.7 grams. The average Pileus size was 10.2 cm having stipe size of 3.2 X2.1 cm. AVTB-19- 203 gave the yield of 17.92kg/ 100kg compost with having average fruit body weighing 14.20 grams. The average pileus size was 9.3 cm having stipe size of 2.4 X2.0 cm, followed by AVTB-19- 204 having maximum yield of 16.04 kg/ 100kg compost.AVTB-19- 205 gave the lowest yield of 14.00 kg/ 100kg compost .The average Pileus size was 9.5 cm having stipe size of 2.3 X 2.0 cm.

Table 49: Advance Varietal trial -1 for selected white accessions of *Agaricus bisporus*

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
AVTB-19-201	20.50	21	15.70
AVTB-19-202	15.29	21	14.25
AVTB-19-203	17.92	21	14.20
AVTB-19-204	16.04	21	14.15
AVTB-19-205	14.00	21	12.60
SE (m+-)	0.53	0.92	0.96
LSD (P=0.05)	1.08	2.02	2.02

Evaluation of selected white accessions of *Agaricus bisporus* in Advance Varietal trial -2:Six strains viz; AVTB-19-101 to AVTB-19-106, in AVT-II were evaluated and AVTB-19-101 gave the maximum yield of 19.28 kg/ 100kg compost having average fruit body weighing 11.25 grams. The average Pileus size was 8.5 cm having stipe size of 3.0 X 2.3 cm.AVTB-19- 104 gave the yield of 18.56kg/ 100kg compost with having average fruit body weighing 12.25 grams. The average pileus size was 8.7 cm having stipe size of 3.5 X 1.9 cm, followed by AVTB-19- 105 (18.13 kg yield) and AVTB-19- 106 (18.12 kg yield).AVTB-19-102 gave the lowest yield of 15.25 kg/ 100kg compost .The average Pileus size was 9.2 cm having stipe size of 2.6 X 1.6 cm (Table 50).

Table 50: Advance Varietal trial -2 for selected white accessions of *Agaricus bisporus*

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
AVTB-19-101	19.28	21.75	11.25
AVTB-19-102	15.25	21.00	10.75
AVTB-19-103	17.34	20.25	11.75
AVTB-19-104	18.56	20.75	12.25
AVTB-19-105	18.13	20.75	13.5
AVTB-19-106	18.12	21.50	12
SE (m+-)	0.47	1.958	1.367

LSD (P=0.05)	2.064	2.064	2.064

Evaluation of high yielding varieties/strains of Oyster Mushroom (*Pleurotus* spp) of AVT-I on Wheat straw Substrate: The experiment was conducted with seven strains of PL-19-101 to Pl-19-107 *Pleurotus* spp having 3 replications with 10 bags of 1 kg dry weight wheat straw in each replication (Table 51). The spawn rate was 1% of dry substrate. PL-19-101 gave the highest yield of 90.0 kg /100 kg dry weight of wheat straw having average weight per fruit body was 15.0 grams. The pileus size was 8.7X6.5 cm with stipe of 6.1 X 1.3 cm. This was followed by PL-19-105 recorded the yield of 70.0 kg /100 kg dry weight of wheat straw having average weight per fruit body was 11.0 grams. The pileus size was 4.7X3.5 cm with stipe of 6.9X1.2 cm followed by PL-19-104 (65.0), PL-19-102 and 103 (60.0 kg each). PL-19-107 gave lowest yield of 32.50 kg /100 dry weight of wheat straw kg, having average weight per fruit body was 9.0 grams. The pileus size was 10.1X7.1 cm with stipe of 4.5X 1.1cm.

Table 51: Advance Varietal trial -1 of high yielding varieties/strains of Oyster Mushroom (*Pleurotus* spp) on Wheat straw Substrate

Strains	**Yield kg/100kg dry straw**	**Time take for first harvest**	**Average fruit body weight (g)**
PL-19-101	90.00	42	15
PL-19-102	60.00	45	15
PL-19-103	60.00	50	13
PL-19-104	65.00	45	13
PL-19-105	70.00	54	11
PL-19-106	55.33	43	9
PL-19-107	32.50	39	9
SE (m+-)	29.08	0.75	0.69
LSD (P=0.05)	13.35	1.63	1.51

6. EXTENSION EDUCATION

The faculty of Plant Pathology posted at head quarter, research stations and KVKs undertook/ participated in different extension activities as given below:

Advisory	Advisory and consultancy services to farmers and visitors regarding diagnostic and management of diseases of cereals, pulses, oilseeds, vegetable & horticultural crops and mushroom cultivation was provided to more than **2000 farmers**
Advisory through news papers	**15**
Liaison/ collaboration with National/ International bodies/ agencies	Liaison was established with various agencies like ICARDA, AVRDC, ICRISAT, NBPGR, MYMV, RKVY, ATMA, ZICA etc.
Trainings conducted	**114 training programmes** on different topics were conducted at head quarter (DEE) and out stations/ KVKs and more than **4000 farmers** were trained
Participation in Extension Training Programmes	**230 numbers of lectures** were delivered to farmers in various training programmes conducted at head quarter and out stations/ KVKs / other agencies
Front Line Demonstrations	**14 numbers** of Demonstrations were conducted (KVKs)
On farm trials	**14 numbers** of on farm trials were conducted
Field demonstrations	**70 numbers** of field demonstrations were conducted (Research Stations/ KVKs)
Adaptive trials	**21 numbers** of adaptive trials were conducted
Kisan melas/ divas	**29 numbers** of kisanmelas/ divas were organized (KVKs)
Workshops organized/ attended	Faculty participated in **35 numbers of workshops**
Radio & TV talks	The faculty delivered **7 radio/ TV talks**
Mushroom cultivation	36.3 q of spawn produced to sold to 199 growers 3.8 q of fresh mushroom produced
Disease samples analyzed	**316 numbers**

7. MISCELLANEOUS ACTIVITIES

i) Honour & Awards:

Dr D K Banyal, Principal Scientist was coferred with Fellow of Indian Phytopathological Society, IARI, New Delhi for the year 2020.

ii) Participation in Workshops/ Conferences/ Symposia/ Seminars/ Trainings/ Meetings

The faculty of Plant Pathology participated in 25 Workshops/ Conferences/ Symposia/ Trainings etc. during 2019-20 as enlisted below:

S No	Date	Detail of programme	Name of participating faculty
1	13.05.19 to 05.08.19	Training on establishment of shitake cultivation centre, organization of business meetings and on site visits for agricultural business in collaboration with YATS corporation Myagi Prefecture, Kurihara, Japan	Dr Deepika Sud
2	03-05.08.19	Annual Zonal Workshop of Zone1 at GBPUAT, Pantnagar	Dr Suman Kumar
3	24-26.08.19	58th All India Wheat and Barley Research Worker's Meet at IARI, Indore (MP)	Dr Rakesh Devlash
4	05-06. 09.19	Review Meeting related to KVK Issues at ATARI, Ludhiana (Zone-1)	Dr Suman Kumar
5	11.09.19	National Animal Disease Control Workshop at KVK, Bilaspur	Dr Suman Kumar
6	16-23.09.19	Model Training Programme on "Advances in protected cultivation of high value crops" at CSKHPKV, Palampur	Dr Pardeep Kumar
7	16.09.19 to 15.11.19	Agri-Entrepreneurship Orientation cum Incubation Programme, of Him Palam R-ABI Project in Professors' Hall, COA, CSKHPKV Palampur	Dr S K Rana (Inaugural & Closing)
8	18.10.19	Meeting on "Evolving strategies for the management of yellow rust and Karnal bunt" in The Department of Agriculture & Cooperation and Farmer Welfare, Ministry of Agriculture, Krishi Bhawan, New Delhi	Dr Sachin Upmanyu
9	30.10.19	Agricultural Officers' Workshop on Rabi Crops 2019 at DEE, CSK HPKV Palampur	All Plant Pathologists
10	15.11.19	Sensitization cum training programme on "Krishikosh repository for strengthening agricultural knowledge" in the conference hall of DEE, CSKHPKV Palampur	Dr S K Rana
11	02.12.19	ICAR short training course on 'Advances in micro-irrigation and fertigation for improving water use efficiency and crop productivity' organized by the Department of Soil Science in the Professor Hall, C.O.A., CSKHPKV Palampur	Dr S K Rana (Inaugural Session)
12	16-20.01.20	7th International Conference on "Phytopathology in Achieving UN Sustainable Development Goals", organized by Indian Phytopathological Society at ICAR-IARI, New Delhi	Dr S K Rana Dr D K Banyal Dr Amar Singh Ph D Students
13	22.01.20	National Workshop on "Sustainable Wheat Production and Nutritional Security in India" organized by Govt. of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Wheat Development at the National Centre for Organic Farming, Hapur Road, Kamla Nehru Nagar, Ghaziabad	Dr Sachin Upmanyu

14	09-10.02.20	National Seminar on ''Maize for Crop Diversification under Changing Climatic Scenario'', Ludhiana	Dr Rakesh Devlash
15	09-12.02.20	Training programme on "Integrated pest management for agricultural & horticultural crops of Punjab, Utrakhand, J&K and HP states at ATARI, Ludhiana	Dr Pardeep Kumar
16	10-12.02.20	International workshop on " Impact of Crop Diversification on Farmers Income and Food Security" organized by H.P Crop Diversification Promotion Project-JICA-ODA and Department of Agriculture, Himachal Pradesh	Dr Deepika Sud
17	17-18.02.20	Training Programme on "Students Counseling and Capacity Building at COA, Palampur	Dr Deepika Sud
18	18-19.02.20	International Convention Meeting at NASC, PUSA New Delhi	Dr Suman Kumar
19	19.02.20	7th Annual Hill Rice Group Meeting cum Workshop held in ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad	Dr Sachin Upmanyu
20	28.02.20 to 01.3.20	XI National Conference Meeting of KVKs at NASC, PUSA New Delhi	Dr Suman Kumar
21	20-22.04.20	63rd Annual Maize Workshop (AICRP, Maize) (Online through Zoom App)	Dr Rakesh Devlash
22	11-13. 05. 20	55th Virtual Annual Rice Research Group Meeting cum Workshop conducted/ held by ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad	Dr Sachin Upmanyu
23	20.05.20	50th Annual Meeting of AICRP on Soybean (Online)	Dr Amar Singh
24	01.06.20	National Group Meeting – *Kharif 2020* of All India Co-ordinated Research Project on Forage Crops (Online)	Dr. D.K. Banyal
25	08-09.06.20	Annual Workshop of AICRP Mushroom (online)	Dr A K Sud

8. PUBLICATIONS

a) Research papers with NAAS ratings

1. **Banyal, D.K**., Thakur, A. and Singh, Amar (2020). Management of leaf spot (*Cercospora canescens*) and powdery mildew (*Erysiphe polygoni*) of cowpea through fungicides. *Plant Dis. Res*. *34 (2)*: 119-123. NAAS: 4.58
2. Chauhan, S., Katoch, S., Sharma, S.K, **Sharma, P.N.**, Rana, J.C., Singh, Kuldeep and Singh, M. (2020). Screening and identification of resistant sources against *Sclerotinia sclerotiorum* causing white mold disease in common bean. *Crop Science* 1–11. https://doi.org/10.1002/csc2.20160. NAAS: 7.64
3. Katoch, Shabnam, Katoch, Abhishek, Dhiman, Shiwali, Sharma, Pratibha, **Rana, S.K.** and Sharma, P.N. (2019). Recitation of R-genes identified in common bean land races KRC-5 and KRC-8 native to Himachal Pradesh against *Colletotrichum lindemuthianum* virulences. *Himachal Journal of Agricultural Research* 45: 51-56. NAAS: 3.91
4. Katoch, S., Kumari, Nidhi, Sharma, Vivek, Salwan, R. and **Sharma, P.N.** (2020). Recent developments in social network disruption approaches to manage bacterial plant diseases. *Biological Control* (MS no.BCON_2020_33). NAAS: 8.61
5. Kaur, G. and **Banyal, D.K.** (2019). Management of buckeye rot of tomato caused by *Phytophthora nicotianae* var. *parasitica* under mid-hill conditions of Himachal Pradesh. *International Journal of Chemical Studies* 7(4): 1782-1786. NAAS: 5.31
6. Kaur, G. and **Banyal, D.K.** (2019). Sensitivity of *Phytophthora nicotianae* var. *parasitica* causing buckeye rot of tomato to commonly used fungicides in Himachal Pradesh. *International Journal of Chemical Studies* 8(8): 1198-1207. NAAS: 5.31
7. Kaur, G., Malannavar, A.B. and **Banyal, D.K.** (2019). Variability in *Phytophthora nicotianae* var. *parasitica* causing buckeye rot on tomato in North-Western Himalayas. *Pl. Dis. Res*. *34 (1)*: 16-21. NAAS: 4.58
8. **Kumar, Pardeep** (2020). Effect of different agro-waste substrates on yield performance of oyster mushroom (*Pleurotus sajor-caju*). *Journal of Krishi Vigyan* 8(2): 70-74. NAAS: 4.41
9. Kumar, Sawan, Chandel, Uttam, Guleria, Satish Kumar and **Devlash, R.** (2019). Combining ability and heterosis for yield contributing and quality traits in medium maturing inbred lines of maize (*Zea mays* L.) using line x tester. *International Journal of Chemical Studies* 7(1): 2027-2034. NAAS: 5.31
10. **Kumar, Suman**, Divyanshi, Bhatti, Kumar, S. and Singh, R. (2019). Prevalence distribution and symptomatology of bacterial canker of tomato in Himachal Pradesh. *Plant Dis. Res.* 34 (1):70-73. NAAS: 4.58
11. Kumari, Nidhi, Patel, P. and **Sharma, P.N.** (2020). Screening of capsicum exotic and indigenous lines for resistance against *Pepper mild mottle virus*. *Plant Dis. Res.* 34: 143-147. NAAS: 4.58
12. Kumari, Nidhi, Sharma, Vivek, Patel, P. and **Sharma, P.N.** (2020). Heterologous expression of pepper mild mottle virus coat protein encoding region and its application in immuno-diagnostics. *Virus Disease,* https://doi.org/10.1007/s13337-020-00597-9. NAAS: 5.90
13. Mehra, A.K., Malannavar, A.B. and **Banyal, D.K.** (2019). Prevalence of capsicum grey mould and characterization of the pathogen associated under protected cultivation in Himachal Pradesh. *International Journal of Chemical Studies* 7 (3): 14-18. NAAS: 5.31
14. Mehra, A.K., Malannavar, A.B. and **Banyal, D.K.** (2019). Factors affecting the growth of *Botrytis cinerea* and development of capsicum gray mould under protected cultivation *Plant Dis. Res.* 34 (1): 76-78. NAAS: 4.58
15. Patel, J.V., **Singh, Amar**, Kaur, K., Bhandhari, D. and Banyal, D.K. (2019). Biological control of damping off of okra caused by *Rhizoctonia solani. Int. J. Curr. Microbiol. App. Sci.* 8(12): 2277-2292. NAAS: 5.38
16. Patel, J.V. and **Singh, Amar** (2020). Compatibility of *Trichoderma* spp. with fungicides and efficiency against *Rhizoctonia solani*. *International Journal of Chemical Studies* 8(2): 2254-2257. NAAS: 5.31
17. Pathania Rahul, **Thakur, B.R.** and Rana, Dimple (2019). Efficacy of organic inputs against *Fusarium oxysporum* f. sp. *ciceris*. *Plant Dis. Res.* 34 (1): 51-53. NAAS: 4.58

18. **Rana, S.K.,** Katoch, S. and Sharma, P.N. (2019). Assessment of yield losses caused by *Stagonospora* leaf and glume blotch (SLGB) of wheat; its status and distribution in Himachal Pradesh. .*Indian Phytopathology*, https://doi.org/10.1007/s42360-019-00185-y. NAAS: 5.90
19. Singh, Jogendra, Gangwar, Om Prakash, Kumar, Sudheer, Shekhawat, Pradeep Singh, Kumar, Dinesh, Kumar, Vishnu, Kaur, Jaspal, Pandey, Mukesh Kumar, **Devlash, Rakesh,** Kharub, Ajeet Singh and Singh, Gynendra Pratap (2019). Identification of yellow rust resistance sources in advanced breeding lines of barley (*Hordeum vulgare* L.). *Journal of Cereal Research/ Journal of Wheat Research* 11(2): 159-164. NAAS: 4.42
20. Sood, T., Basandrai, D., **Basandrai, A.K.**, Sohu, V.S., Rana, V., Mehta, A., Sharma, B.K., Mavi, G.S., Kaur, J. and Bains, N.S. (2020). Stable sources of resistance to yellow rust and powdery mildew in Indian and exotic wheat germplasm. .*Journal of Cereal research* 12 (1):23-28. NAAS: 4.42
21. Thakur, Naresh, Lata, S., **Sharma, B.K.** and Devlash, R. (2019). Evaluation of maize genotypes against banded leaf and sheath blight under natural and artificial epiphytotic conditions. *Himachal J. Agric. Res*. 44 (1&2): 17-24. NAAS: 3.91

b) Book/ Book Chapters

1. Bhardwaj, N., **Upmanyu, S**., Pandey, D. P. and Srivastava, A. (2020). Dhan ki Adhik Upaj Hetu Pakritik Kheti ka Mahatva. Technical Bulletin (1st Edition). CSK HPKV Rice and Wheat Research Centre, Malan-176047, HP, India, 14pp.
2. Kumar, N., Sood, V.K., **Banyal, D.K.** and Katoch, R. (2019). Fodder and livestock scenario in Himachal Pradesh. In: Indian Fodder scenario: Redefining State Wise Status. (Eds: Roy A K., Agrawal, R.K. and Bhardwaj, N. R.). Darpan Printers and Lamination (ISBN: 978-93-5382-839-4). Pp 53-62.
3. Kumar, Naveen, Sood, V.K., **Banyal, D.K.** and Katoch, Rajan (2019). Fodder production strategies for the hill in Himachal Pradesh. National group meet - Rabi 2019 held at Central Agricultural University, Imphal on 30-31st August, 2018. *Souvenir,* 86-88pp.
4. Sharma, S. K., Sinha, B. N. and **Sharma, B.K.** (2019). Introducing Hydroponic Technique in Rural Areas. In: Contemplating Agricultural Growth through Farmers' Frugal Innovations. (Eds: Rana, Rajesh, Singh, K, Thakur, R, K, Ashok, Chahal, V. P. and Singh, A. K.). ICAR-ATARI, Zone-I, Ludhiana, Punjab. Pp 55-56.
5. Sinha, B. N., **Sharma, B.K.** and Sharma, S. K. (2019). Newspaper Wrapping for Tomato Ripening and Quality. In: Contemplating Agricultural Growth through Farmers' Frugal Innovations. (Eds: Rana Rajesh K, Singh R, Thakur Ashok K, Chahal V P and Singh A K). ICAR-ATARI, Zone-I, Ludhiana, Punjab. Pp 139-140.
6. **Sud, Deepika** (2019). Mushroom Cultivation: A Promising Avenue for Farmers to Boost Employment and Income. In: Model Training Course On Innovative Entrepreneurial Approaches in Hill Farming System for Doubling Farmer's Income (Complied & Edited by Devesh Thakur, Krishanender Dinesh, Manoj Sharma, Varun Sankhyan and AK Panda). Pp 60-65p.

c) Papers in Proceedings/ presented in different conferences/ symposia

1. **Banyal, D. K.,** Malannavar, A. B. and Singh, A. (2020). Effect of date of sowing and IDM components on the management of root rot and foliar diseases of forage cowpea. Presented (oral) in the 7th International workshop on "Phytopathology in Achieving UN Sustainable Development Goals" held on January, 16-20, 2020 at New Delhi.
2. **Devlash, R.** and Guleria, S.K. (2020). Field evaluation of maize hybrids for resistance to turcicum leaf blight. **Presented** in National Seminar on ''Maize for Crop Diversification under Changing Climatic Scenario'', Ludhiana, Feb 09-10, 2020.
3. Kaur, Gurpreet, Siddesh, S.K. and **Rana, S.K.** (2020). Evaluation of different agri-substrates for mass multiplication of potential fungal bio-agents for the control of sheath blight of rice. Presented (poster) in the 7th International Conference on "Phytopathology in Achieving UN Sustainable Development Goals" held at ICAR-IARI, New Delhi, India from January 16-20, 2020.
4. Kumar, S., Guleria, S.K., Chandel, U. and **Devlash, R.** (2020). Optimization of doubled haploid production using tropical adopted inducer lines in maize (*Zea mays*) under northern Himalayan

conditions. **Presented** in National Seminar on ''Maize for Crop Diversification under Changing Climatic Scenario'', Ludhiana, Feb 09-10, 2020.

5. **Rana, S.K.**, Siddesh, S.K. and Upmanyu, Sachin (2020). Evaluation of antagonistic potential of different biocontrol agents against *Rhizoctonia solani* causing sheath blight of rice. Presented (oral) in the 7th International Conference on "Phytopathology in Achieving UN Sustainable Development Goals" held at ICAR-IARI, New Delhi, India from January 16-20, 2020.
6. **Singh, Amar**, Katoch, S., Sharma, P. N., Banyal, D. K. and Rathour, R. (2020). Occurrence of mating types of *Phytophthora capsici* Leonian causing phytophthora blight of capsicum in North Western Himalayas. Presented in 7th International Conference on "Phytopathology in Achieving UN Sustainable Development Goals" held w.e.f January 16-20, 2020 at ICAR-IARI, Pusa New Delhi.
7. Thakur, A., and **Banyal, D. K.** (2020). Evaluation of Integrated disease management components on banded leaf and sheath blight (*Rhizoctonia solani* f. sp. *sasakii)* of fodder maize. Presented in the 7th International workshop on "Phytopathology in achieving NU sustainable development Goals" held on January, 16-20, 2020 at IARI, New Delhi.

d) Popular articles

1. **Banyal, D. K.,** Malannavar, A.B. and Thakur, Ashima. (2020). Matar ki Permukh Bimarian avam unki Roktham. Technological notes. *Himalayan Phytopathological Society*: 3 (1): 5-7
2. **Kumar, Pardeep** (2019). Shimla mirch ke pramukh rog avam upchar. *Giriraj* Saptahik: 5 (19 July 2019).
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9. SALIENT FINDINGS

CEREALS

- In **rice** seed samples collected from different districts of Himachal Pradesh, the incidence of rice bunt ranged from 0.2-1.0 % while, the incidence of grain discoloration varied between 0.8-8.6 per cent and ten fungi *viz., Fusarium sp., Penicillium sp., Alternaria* sp., *Curvularia lunata, Drechslera oryzae, Aspergillu*s sp., *Pestolotia* sp., *Helminthosporium* sp., *Rhizoctonia* sp. and *Trichoderma* sp. were traced in sterilized and unsterilized seed categories.
- Fungicides namely, Prochloraz 23.5% w/w + tricyclazole 20.0% w/w SE, Tricyclazole 75% WP and Azoxystrobin 18.2 % w/w + difenoconazole 11.4% W/W SC were found very effective in reducing neck blast of **rice** with 75.4, 70.3 and 70.1% reduction respectively.
- Avoidable yield losses due to *Maydis* leaf blight of **Maize** (MLB) varied from 11.12 to 39.99 percent.
- **Maize** hybrids viz., SMS-137, B-52 Gold, VNR 4343, PSC-3322 Gold, MM 9333, P 3378, B-52 Super, GX888, NMH 1277, Vyaas Gold and Super-9396 were found resistant against Turcicum leaf blight (TLB).
- **Maize** entries viz., APQH 1, FQH 165, HQPM 7, PMH 5, DKC 8191, JKMH 15303, DHM 121 and FQH 165, HQPM 7, DKC 9190 were found resistant to bacterial stalk rot and banded leaf & sheath blight respectively.
- Twelve genotypes of **wheat** viz., GW 1339, GW 1346(d), HPW 442, K 1601, MACS 4059(d), PBW 800, UP 3016, DBW 223, HI 1625, DDK 1054, HI 1624 and WH 1218 were found free from yellow rust, Karnal bunt and powdery mildew.
- **Wheat** varieties/ lines viz., WH1105, WH1142, VL829, VL616, VL404, VL829, VL832, VL421, Sarbati sonara, UP2338, HS542, PBW175 were found free from flag smut of wheat.
- In **wheat** seed samples collected from different parts of Himachal Pradesh, 82% showed the presence of Karnal bunt with an incidence of 0.05 to 3.85% while 59% samples were found to have infection above seed certification level.
- In **wheat**, the processed seed samples of wheat varieties developed/recommended by the CSK HPKV, Palampur and multiplied in various seed multiplication farms of the university were found to harbor only two head blight pathogens *viz., Fuasrium graminearum* and *F. poae.*

PULSES

- Root rot-wilt complex due to *Fusarium oxysporum* with incidence 12.5% and 11.0% was a major problem in **chickpea** and **peas** respectively under natural farming (ZBNF farm) resulting into rotting of roots, wilting and drying of plants.
- The presence of adult plant resistance has been established in **common bean** landrace KRC-8.
- Monogenic dominant resistance was confirmed/ found in **common bean** landrace KRC-5 against race 3 and 211 of *Colletotrichum lindemuthianum*.
- Linkage analysis using 1979 SNPs along with anchored markers showed the distribution of different SNPs and anchored markers on 11 **common bean** chromosomes and it is first SNP based linkage map.
- The SCAR markers $ScOPR15_{408}$ and $ScOPF6_{522}$ flanking the R-locus at 2cM distance can effectively be used in the anthracnose resistance breeding programs in **common bean**.

OILSEEDS

- Out of 17 **soybean** lines showing resistance in previous years, eight lines maintained high level of resistance against frogeye leaf spot (*Cercosporasojina*), eleven against pod blight (*Colletotrichumtruncatum*) and eight showed absolute resistance against both the diseases.
- The germplasm lines of **soybean** viz., EC 1619, EC 241771, DSb 21, EC 114573, CAT 195(BR4) VP 1164, JS 20-75 and EC 241778 were observed to possess multiple disease resistance against frogeye leaf spot (*Cercosporasojina*), pod blight (*Colletotrichumtruncatum*) and brown spot (*Septoriaglycines*).

VEGETABLES

- Soil application of neem cake at the time of sowing @ 2kg/ 6sqm followed by seed treatment with hot water at 51°C for 10 minutes and after that seed treatment with mancozeb (2.5g) + carbendazim (1g) per liter of water for 30 minutes and drying in shade gave minimum disease incidence (21.18%) of rhizome rot of **ginger** and the highest yield (88.2q./ha) of ginger.
- Maximum disease control of purple blotch and Stemphylium blight (86.1 and 83.2%) and highest yield (286.1 q/ha) of **onion** was recorded with foliar application of Ridomil Gold (0.25%).
- The screening of nineteen germplasm lines of **garlic** revealed three viz., G3, G14 and GHC-1to be resistant against *Stemphylium* blight.
- A combo fungicide viz., Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) @ 900g/ ha was found highly effective in controlling early and late blight of **tomato** providing 79.0 % disease control and 23.0 % increase in the yield.
- A new combo fungicide Oxathiopiprolin 1.5%+ Azoxystrobin 15.5% w/v (170 SC) @ 800g/ ha provided 74.9% and 75.65% control of early and late blight of **potato** with 23.9 (201.7q/ha) and 21.3 (203.3q/ha) % increase in yield respectively.
- The RT-PCR based protocol for the detection of PMMoV was validated and found suitable for detection of the virus in **chili** seed lots.
- The application of ZBNF preparations viz., Tamarlassi/ Ramban gave good control (57.1 %) of powdery mildew disease of **cucurbits.**

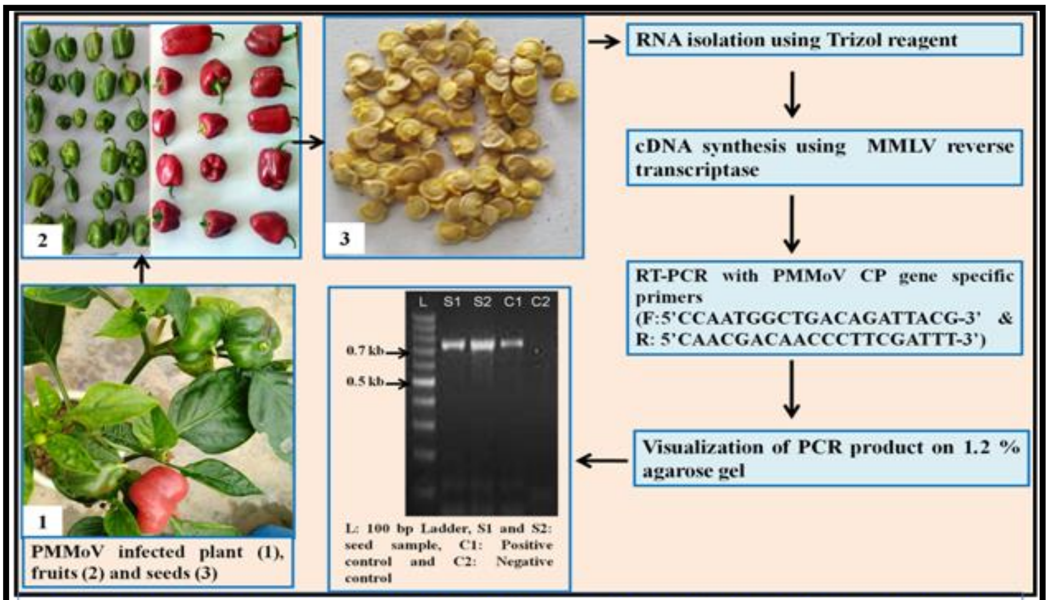
FORAGE CROPS

- Seed treatment with tebuconazole + trifloxystrobin @ 1 g/ kg seed followed by two sprays of same fungicide @ 0.4g/ l were found most effective giving 71.2 % control of leaf blast of forage **pearl millet** with 18.9 % increase in the green fodder yield over check.
- The seed treatment with carbendazim (0.1%) followed by two foliar sprays of combo-fungicide Tryfloxystrobin + Tebuconazole (0.1%) provided 74.5 % control of BLSB of **forage maize** with 7.2 per cent increase in green fodder yield over the check.
- The seed treatment with carbendazim (0.1%) followed by two foliar sprays of propiconazole (0.1%) provided 74.1 % control of zonate leaf spot of **forage sorghum** over the check with 8.2 % increase in green fodder yield over the control.
- Seed treatment with carbendazim @ 2 g/ kg seed followed by three foliar sprays of hexaconazole @ 0.1 % gave the best management of powdery mildew with 85.7 % disease control and 66.7 % disease control of soil borne disease in **red clover**.
- Seed treatment with carbendazim @ 0.02 % followed by foliar spray of carbendazim @ 0.01 % proved to be the best with 81.1 and 72.0 per cent control of root rot and leaf blight with maximum increase (5.2 %) in the GFY in **berseem.**
- Three lines of **oat** viz., KRR-AK-06, IG-03-203 and JPO-20 were identified as slow mildewers against *Blumeria graminis* f. sp. *avenae* by studying the components of slow mildewing under greenhouse conditions and through stereo zoom microscope in the laboratory.
- Among the biological management treatments three foliar sprays of *Trichoderma viride* @ 0.5% and three foliar sprays of *Trichoderma harzianum* @ 0.5% were found effective giving 51.0 and 50.00 % control of oat powdery mildew of **oat** with 5.1 and 3.7 % increase in the seed yield.

PHOTO GALLERY

Function organized to share the training experiences at Japan by Dr Deepika Sud

PG students trained to take disease data in the field



Protocol for the detection of PMMoV from infected seeds through RT-PCR using CP-gene specific primers

Students' Activities under Experiential Learning Programme on Mushroom Cultivation