38th ANNUAL PROGRESS REPORT

2023-24

Department of Plant Pathology

College of Agriculture

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

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ACKNOWLEDGEMENT

The 37th 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. Pardeep Kumar, Dr. Deepika Sud and Dr. Shikha Sharma 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.

Date: 16.8.2024 *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 Pathology 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), 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, whereas, the research on diseases of pulses is carried out at Palampur and Berthin 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, JICA, RKVY, ICAR, 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 D K Banyal	Professor & Head	dkbanyal@gmail.com
Dr Amar Singh	Principal Scientist	singhamar008@gmail.com
Dr. Pardeep Kumar	Programme Director (CMRT) cum Subject Matter Specialist	pkdogra2007@rediffmail.com
Dr Deepika Sud	Subject Matter Specialist	deepika_agri@rediffmail.com
Dr. Shikha Sharma	Assistant Professor	shi.bha.80@gmail.com
Hill Agricultural Research & Extension Centre, Bajaura – 175125		
Dr R K Devlash	Principal Scientist	devlashbajaura@rediffmail.com
Vacant	Senior Scientist	-
Hill Agricultural Research & Extension Centre, Dhaulakuan – 173031		
Vacant	Scientst	-
Hill Agricultural Research & Extension Centre, Kukumseri - 175142		
Vacant	Scientist	-
Mountain Agricultural Research & Extension Centre, Sangla – 172106		
Vacant	Scientist	-
Shivalik Agricultural Research & Extension Centre, Kangra – 176001		
Vacant	Scientist	-
Rice & Wheat Research Station, Malan – 176047		
Vacant	Scientist	-
Research Sub-Station, Akrot – 177211		
Vacant	Principal Scientist	-
Research Sub-Station, Sunder Nagar - 175019		
Vacant	Scientist	-
Directorate of Extension Education, Palampur - 176062		
Dr Suman Kumar	Principal Extension Specialist	sumanhpkv@gmail.com
Research Sub-Station, Lari		
Dr Joginder Pal	Scientist	jpal15889@gmail.com
Krishi Vigyan Kendra, Dhaulakuan - 173031		
Dr Shiwali Dhiman	Subject Matter Specialist	shiwalidhiman7@gmail.com
Krishi Vigyan Kendra, Kukumseri – 175142		
Dr. Shabnum Katoch	Subject Matter Specialist	skatoch6292@gmail.com
Krishi Vigyan Kendra, Bara - 177044		
Vacant	Subject Matter Specialist	-
Krishi Vigyan Kendra, Kangra - 176001		
Vacant	Subject Matter Specialist	
Krishi Vigyan Kendra, Berthin - 174029		
Vacant	Scientist	
Krishi Vigyan Kendra, Una - 174303		
Vacant	Subject Matter Specialist	-

(b) Staff

The department is having a total strength of 6 staff members borne on various teaching and research schemes as given below.

Staff	Name & Designation
Ministerial Staff	
	Sh Ravi Kumar, Suptd. (EC)
	Sh Rajinder Kumar, Clerk
Technical Staff	
	Sh Balwant Singh (Tech Asstt Gr-II) (Deputed at Salooni from 19.6.2018)
	Sh Subhash Chand, Lab Attendent
	Ms. Anita Thakur, Lab Attendent
Supporting Staff	
	Sh Desh Raj, Beldar (upto May, 2024)

3. FINANCIAL OUTLAY AND STAFF POSITION IN DIFFERENT SCHEMES

The expenditure of funds under plan and non plan schemes for 2023-24 financial year is given as under:

Name of the Scheme	Expdt (Lakh)	Staff
Creation of facilities for Postgraduate Studies in the Department (APL-001-17)	11.42	Sh. Harbans Lal, Sr Asstt (Biotech) upto June, 2023 Sh. Subhash Chand, LA (w.e.f. 01.09.2022)
Facilities for teaching in the Department/ College of Agriculture (APL-010-17)	42.27	Sh. Ravi Kumar, Supdt. Upto august, 2023 Sh. Balwant Singh,Tech Asstt G-II(RRS Salooni)
Strengthening of facilities for research in the Department (APL-021-17)	12.45	Sh. Sarwan Kumar, Beldar Vety. Pathology upto 30.11.2023 Sh. Desh Raj, Beldar upto May, 2024
Strengthening of facilities for research in the Department APL-101-17	7.58	Sh. Rajinder Kumar, Clerk w.e.f. 14.10.2022
All India Coordinated Research Project on Seed Technology Research under NSP (ICAR-017-17 Pt-II)	26.38	Dr. Pardeep Kumar, SMS (Plant Pathology)
All India Coordinated Mushroom Improvement Project (ICAR-056-17)	10.93	-
Fungicide testing (Ad Misc 626-17)	9.10	-
Protected Agriculture and Natural Farming (PANF) under NAHEP-CAAST Programme (NAHEP-ICAR-231-17)	17.0	-
Assessment, Validation and refinement of disease management technology for vegetable crops (Misc-2284-17)	6.25	Mr. Vakul Sood, JRF upto 31.3.2024
Self Finance Scheme (SFS-001-17)	1.50	-
Revolving Fund (RF-A-46-036-17)	4.84	-
Revolving Fund Scheme under SFS (Experiential Learning) (RF-B-61-142-17)	0.20	-
Central Assistance Development (CDA-011-17)	0.25	-
Total	**150.17**	

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. Pardeep Kumar Dr. Shikha Sharma
Pl Path 353	Diseases of Field & Horticultural Crops and their Management-I	2+1	Dr. Suman Kumar/ Dr. Deepika Sud
Pl Path 121	Fundamentals of Plant Pathology	2+1	Dr Amar Singh Dr. Shikha Sharma
Pl Path 364	Diseases of Field & Horticultural Crops and their Management-II	2+1	Dr Pardeep Kumar Dr Deepika Sud
Pl.Path. 475	Mushroom Cultivation (Semester-II) Exp Learning	0+10	Dr Pardeep Kumar Dr Deepika Sud
(UG courses offered by other Departments)			
Agron 3613	Agrochemicals	2+1	Dr. D. K. Banyal

(ii) PG courses			
Pl Path 501	Mycology	2+1	D.r Deepika Sood
Pl Path 502	Plant Virology	2+1	Dr. Shikha Sharma
Pl Path 503	Plant Bacteriology	2+1	Dr. Pardeep Kumar Dr. Shabnam Katoch
Pl Path 504	Plant Nematology	2+1	Dr. Sharmisatha Thakur
Pl.Path.505	Principles of Plant Pathology	2+1	Dr. Amar Singh Dr. Joginder pal
Pl Path 506	Techniques in Detection and Diagnosis of Plant Diseases	0+2	Dr. Amar Singh/ Dr. Pardeep Kumar/ Dr Deepika Sud/Dr. Shikha Sharma/ Dr. Joginder Pal/ Dr. Shabnam Katoch/ Dr. D. K. Banyal
Pl Path 507	Principles of Plant Disease Management	2+1	Dr Amar Singh Dr. D.K. Banyal
Pl.Path.508	Epidemiology and Forecasting of Plant Diseases	2+1	DR. D. K. Banyal Dr. Joginder Pal
Pl Path 515	Diseases of field and medicinal crops	2+1	Dr. Pardeep Kumar Dr. Deepika Sud
Pl Path 518	Epidemiology and Forecasting of Plant Diseases	2+1	Dr D K Banyal Dr Joginder Pal
Pl Path 591	Master's Seminar -I/II	1+0	Dr Amar Singh Dr. D.K. Banyal
Pl Path 599	Master's Research	1-18	Major Advisors
Pl Path 601	Advances in Mycology	2+1	Dr Deepika Sud
Pl Path 602	Advanceds inVirology	2+1	Dr Shikha Sharma
Pl Path 603	Advances in Plant Pathogenic Prokaryotes	2+1	Dr Pardeep Kumar
Pl Path 604	Molecular Basis of Host Pathogen Interaction	2+1	Dr. Sikha Sharma Dr Joginder Pal
Pl Path 691/692	Doctoral Seminar-I/ II	1+0	Dr Amar Singh Dr. D.K. Banyal
Pl Path 699	Doctoral Research	0+18	Major Advisors

b. Students admitted:

S. No.	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Abhisek Jena (A-2023-30-083)	Dr. Shabnam Katoch	Studies on perpetuation and management of common bean bacterial blight caused by *Xanthomonas axonopodis* pv. *phaseoli*
2	Abhisehk Kaundal (A-2023-30-084)	Dr. Rakesh Devlash	Studies on damping off in tomato (*Solanum Lycopersicum* L)
3	Anchal Thakur (A-2023-30-085)	Dr. Shikha Sharma	Investigations on biomanagement and host plant resistance against *Ralstonia solanacearum* inciting bacterial wilt in capsicum
4	Anshika (A-2023-30-086)	Dr. Deepika Sud	Antagonism of *Agaricus bisporus* Mushroom Substrate against potential soil borne pathogens
5	Diksha (A-2023-30-087)	Dr. Shiwali Dhiman	Epidemiology and management of bacterial stalk rot of maize
6	Sakshi (A-2023-30-088)	Dr. Deepika Sud	Antimicrobial potential of Spent Mushroom Substrate of Lentinula edodes , Berk. Pegler
7	Sakshi Sharma (A-2023-30-089)	Dr. Pardeep Kumar	Management of bacterial wilt of tomato caused by *Ralstonia solanacearum*
8	Sherin (A-2023-30-090)	Dr. Suman Kuma	Etiology and management of leaf spot disease of broad bean (*Vicia faba* L.)
9	Tanish Dhiman (A-2023-30-091)	Dr. Joginder Pal	Unveiling the biocontrol potential of native endophytic bacteria for the management of Fusarium wilt of pea
Ph. D. Programme			
1	Anjali (A-2023-40-033)	Dr. D.K. Banyal	Pathogen dynamics of *Pyricularia grisea* (Cooke) Sacc. Causing pearl millet blast, its epidemiology and eco-friendly management
2	Gaurav Katoch (A-2023-40-034)	Dr. Suman Kumar	Epidemiology and management of anthracnose disease of cucumber (*Cucumis sativus* L.)
3	Nikita Sharma (A-2023-40-035)	Dr. D.K. Banyal	Pathogen variability of *Gloeocercospora sorghi* Bain and Edgerton, causing zonate leaf spot of sorghum, its epidemiology and eco-fr iendly management
4	Twinkle (A-2023-40-036)	Dr. Pardeep Kumar	Integrated management of bacterial wilt of tomato caused by *Ralstonia solanacearum*

c. Ongoing students:

S No	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Arushi Chauhan (A-2022-30-083)	Dr. Subnum Katoch	Diversity analysis of *Colletotrichum lindemuthianum* isolates and identification of resistace sources against been anthracnose
2	Mahima Sharma (A-2022-30-085)	Dr. Deepika Sud	Evaluatiton of agro-waste substrates for the cultivation of *Lentinula edodes* (Berk) Pegler
3	Mukul Sharma (A-2022-30-086)	Dr. Shiwali Dhiman	Epidemiology and management of leaf spot of ginger cauded by *Phyllosticta zingiberi* Remakr
4	Piyush (A-2022-30-087)	Dr. Rakesh Devlash	Investigtion on maydis leaf blight of maize caused by *Bipolaris maydis* (Nisik and Miake) Shoemaker
5	Pragati Gautam (A-2022-30-088)	Dr Joginder Pal	Deciphering endophyteic fungi for the management of damping-off of okra caused by *Rhizoctonia solani* Kuhn
6	Ritvik Katoch (A-2022-30-089)	Dr. Suman Kumar	Investigation on the status and characterization of the pathogen associated with stem gall disease of coriander
7	Sonali Katoch (A-2022-30-090)	Dr. Shikha Sharma	Etiology and biological management of cabbage wilt
Ph D Programme			
1	Riya (A-2021-40-052)	Dr. Deepika Sud	Evaluation of germplasm and organic additives for quality production of *Lentinula edodes* (Berk.) Pegler
2	Akshay Pathania (A-2021-40-051)	Dr. Sachn Upmanyu/ Dr Pardeep Kumar	Virulence diversity of *Pyricularia oryzae* Cavara and identification of resistant sources against rice blast
3	Somya Hallan (A-2021-40-032)	Dr. Suman Kumar	Etiology and management of storage rot of garlic
4	Sonali Parwan (A-2021-40-033)	Dr. D. K. Banyal	Epidemiology, variability and management of purple blotch of garlic cused by *Alternaria porri* (Ellis) Cif.
5	Chetna Mahajan (A2021-40-031)	Dr. Rakesh Devlash	Epidemiology and manament of brown spot of maize (*Zea mays* L.) caused by *Physoderma maydis* (Miyabe) Miayabe
6	Tanvi Vishisth (A-2022-40-029)	Dr D K Banyal	Virulence diversity of *Drechslera avanae* inciting oat leaf blight and its management

d. Students completed M Sc / Ph D programme:

S No.	Name of student	Major advisor	Title of thesis
	M Sc. programme		
1	Pragti Shree (A-2021-30-047)	Dr. Amar Singh	Ecofriendly management of false smut of rice caused by Ustilaginoidea virens (Cke) Tak.
2	Shilpa Sharma (A-2021-30-050)	Dr. Pardeep Kumar	Biological management of bacterial wilt of tomato caused by *Ralstonia solanacearum*
3	Dipanshi Thakur (A-2021-30-068)	Dr. Deepika Sud	Evaluation of organic additives on bio efficacy of Pleurotus ostreatus (Jacq.) P. Kumm.
4	Gaurav Katoch (A-2021-30-069)	Dr. Suman Kumar	Studies on collar rot of elephant foot yam caused by *Sclerotium rolfsii*
5	Shiwali Thakur (A-2021-30-071)	Dr. Amar Singh	Eco-friendly management of collar rot of soybean caused by *Sclerotium rolfsii* Sacc.
6	Tanisha Gupta (A-2021-30-072)	Dr. Rakesh Devlash	Investigations on banded leaf and sheath blight of maize cused by *Rhizoctonia solani* Kuhn
7	Twinkle (A-2021-30-073)	Dr. Amar Singh	Detection and management of seed borne mycoflora of soybean (*Glycine max* (L.) Merrill)
8	Mansi Arora (A-2021-30-117)	Dr. Shikha Sharma	Characterization of viruses associated with capsicum under protected cultivation I Himachal Pradesh
9	Kavita Kushwaha (A-2021-30-118)	Dr Joginder Pal	Fungal root endophytes mediated management of pea root rot in Himachal Pradesh
	Ph.D. programme		
1	Diksha Sinha (A-2019-40-024)	Dr D K Banyal	Biology and management of early blight of tomato caused by *Alternaria Solani*
2	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 Amar Singh	Studies on variability in pathogen(s) causing root rot of okra and its integrated disease management

e. Students' placement

Name of Student & Admission No.	Name of Major Advisor	Nature of Placement along with Details
Ms. Dipanshi Thakur (A-2021-30-068)	Dr. Deepika Sud	AEO, HPCDP, JICA,ODA Phase-II
Dr. Diksha Sinha (A-2019-40-024)	Dr. D. K. Banyal	Research Associate, Indian Institute of Agricultural Biotechnology, Ranchi
Ms. Mansi Arora (A-2021-30-117)	Dr. Shikha Sharma	Forest Office, Department of Forest, Utrakhand Govt.
Mr. Ansul Kumar Sharma (A-2020-30-049)	Dr. Amar Singh	Research Assistant (R&D) Syngenta, India Ltd.

f. Thesis Abstracts of PG students

A. M. Sc.

1. Pragti Shree (A-2021-30-047), Advisor: Dr. Amar Singh

Title of thesis: Ecofriendly management of false smut of rice caused by Ustilaginoidea virens (Cke) Tak.

Abstract: The investigation entitled **"Ecofriendly management of false smut of rice caused by *Ustilaginoidea virens* (Cke.) Tak."** was conducted at the Department of Plant Pathology, CSKHPKV, Palampur during 2021-2023. False smut pathogen was isolated from diseased samples collected from the experimental farm of Plant Pathology and pathogenicity test was proved on rice hybrid PAC 807 plus. The pathogen was confirmed as *Ustilaginoidea virens* on the basis of morpho-cultural characteristics. Out of six solid media evaluated for culturing of the pathogen *in vitro*, Potato sucrose agar was found as best medium providing maximum mycelial growth of 60.73 mm after 45 days of incubation. pH 6.0 and 26ºC temperature were optimum conditions for *in vitro* culturing of the pathogen with maximum mycelial growth of 65.80 mm and 72.00 mm, respectively at 45 DAI. Eleven native *Trichoderma* spp. isolates isolated from rice rhizosphere and five standard *Trichoderma* isolates from the department of Plant Pathology were evaluated for their antagonistic activity against the pathogen. Among *Trichoderma* spp. isolates, *Trichoderma* sp. (TR-2) was most effective against the pathogen, resulting in maximum mycelial inhibition (75.13%) in dual culture. This isolate also exhibited maximum mycelial inhibition of 68.55, 74.96 and 61.81 per cent with its sterilized cultural filtrate, unsterilized cultural filtrate and volatile compounds, respectively. Under *in vitro* conditions, aqueous (25% concentration) and alcoholic extract (5, 10, 15, 20 and 25% concentration) of *Acorus calamus* recorded maximum mycelial inhibition of 72.11 per cent and 100.00 per cent, respectively. Among natural farm formulations, Dashparni ark was most effective against the pathogen with 67.59 per cent mycelial inhibition, at 25 per cent concentration. Under field conditions, two sprays (1st at panicle emergence and 2nd spray 10 days later) of Dashparni ark @3% were most effective in managing the disease resulting in maximum reduction in disease incidence (31.09%) and maximum yield (51.81 q/ha) of the crop in comparison to control (45.82 q/ha). In Integrated disease management, sprays of *Trichoderma* sp. (TR-2) (bioagent), *Acorus calamus* (botanical) and Dashparni ark (natural farm formulation) were most effective for managing the disease resulting in maximum reduction in disease incidence (35.09%) and higher yield (52.83 q/ha) in comparison to control (45.95 q/ha).

2. Shilpa Sharma (A-2021-30-050), Advisor: Dr. Pardeep Kumar

Title of thesis: Biological management of bacterial wilt of tomato caused by *Ralstonia solanacearum*

Abstract: Bacterial wilt incited by *Ralstonia solanacearum* (Smith) Yabuuchi et al., is one of the devastating diseases of tomato crop in the tropical and subtropical areas of the world and reported to be the most rampant disease in tomato production. The investigation on the "Biological Management of bacterial wilt of tomato caused by *Ralstonia solanacearum"* was undertaken during 2022-23 in the Department of Plant Pathology, CSK HPKV, Palampur. The pathogen was isolated and confirmed as *Ralstonia solanacearum* on the basis of physiological, biochemical characteristics and pathogenicity test. The positive reaction of the bacterium to tests *viz.,* ooze test, potassium hydroxide solubility test, gelatin liquification, indole and H_2S production test and negative reaction towards starch hydrolysis and gram staining test further reconfirmed the pathogen as *Ralstonia solanacearum*. A total of 13 isolates of bioagents *viz.,* five strains of fungal antagonists (TH-5, JMA-11, TH-11, DMA-8 and TV-1), four isolates of *Pseudomonas fluorescens* (Pf 1, Pf 2, Pf 3 and Pf 4) and four *Bacillus* spp. (Bc 1, Bc 2, Bc 3 and Bc 4) isolates were screened against *R. solanacearum* by agar well diffusion technique under *in vitro* conditions. The maximum inhibition zone of 17.24 mm was exhibited by the isolate Pf 3 followed by 14.67 mm in *T. koningii* (DMA -8). Different talc based formulations amended with additives were evaluated for survival of potential *Bacillus* spp.(Bc 1) and *Pseudomonas fluorescens* (Pf 3) under *in vitro* conditions and among these treatments with 2 per cent tryptone supplemented with 2 per cent glycerol enhanced the shelf life of Pf 3 with highest population of 11.80 x 10^6 cfu/g observed at 90 days and treatment with 2 per cent yeast

extract supplemented with 2 per cent glycerol helped in better survival of Bc 1 with highest population of 9.90 x 10^6 cfu/g at 90 days. The combined application of Bc 1 and Pf 3 enriched with 2 kg FYM was most effective than individual treatments in increasing shoot length (79.24 cm), number of branches/plants (10.66) and number of fruits/plant (8.7). The highest reduction in wilt incidence was observed in T_7 treatment enriched with Bc1+ Pf 3 along with 2 Kg FYM which was statistically at par with another treatment T_7 enriched with Bc1+ Pf 2 along with 2 Kg FYM and the disease control was upto 66.70 per cent. The lowest population density of 40.33 x 10^6 cfu/g of soil was also recorded in treatment T_7 which was enriched with 2kg FYM along with Bc 1+Pf 3. The effect of different biochar amendment for the management of bacterial wilt was evaluated under greenhouse conditions and the biochar prepared from soybean straw reduced the wilt incidence upto 51.12 per cent as compared to the control. Among different crop substrates the treatment with soybean straw biochar was most effective in reducing population density to 68.40×10^6 cfu per g soil followed by rice husk biochar with population density of 71.33×10^6 cfu per g soil. The effect of different biochar amendment on soil properties was also studied and it was observed that soybean straw biochar increased the total N, total P and total K content of soil with 218.68 mg/kg, 98.45 mg/kg and 348.31 mg/kg respectively compared to control with 98.42 mg/kg total N, 12.68 mg/kg total P and 174.38 mg/kg total K.

3. Dipanshi Thakur (A-2021-30-068), Advisor: Dr. Deepika Sud

Title of thesis: Evaluation of organic additives on bio efficacy of Pleurotus ostreatus (Jacq.) P. Kumm.

Abstract: The present investigation entitled "Evaluation of organic additives on bio efficacy of *Pleurotus ostreatus* (Jacq.) P. Kumm." were undertaken to evaluate the effect of supplementation of organic additives on linear mycelial growth and MRR of wheat grain spawn and substrate fortification on yield and morphological characters. It was concluded that 6 per cent wheat flour (120.43 mm), 4 per cent gram (120.43mm) and black gram flour (120.48 mm) supported significantly maximum linear mycelial growth and MRR and took lesser time for spawn production of oyster mushroom. Soybean flour showed minimum growth but was significantly superior to control. Various agro waste substrates were also evaluated with fortification of organic additives in three different concentrations and it was observed rice straw supplemented with 6 per cent wheat flour (cereals), soybean flour (pulse) and rice bran (cereal bran) enhanced the morphological characters and biological efficiency (99.13%, 99.40 % and 94.19%) respectively. Soybean straw was most effective substrate among the leguminous substrates. When soybean straw was enriched with 4 per cent rice flour (85.24%), it outperformed other combinations. Among pulse flours, the addition of 4% per cent soybean flour (88.27%) and wheat bran (83.59%) from cereal brans enhanced both the morphological attributes and the biological efficiency of *P. ostreatus*. Among the oilseed substrate mustard straw exhibited best parameter. The results indicated that addition of 4 per cent rice flour (88.17%), 6 per cent soybean flour (85.36%) and rice bran (81.05%) on mustard straw led to improved morphological characteristics and resulted in higher biological efficiency of *P. ostreatus.* Nutritional parameters were analysed in dried fruit bodies harvested from the substrates which gave best biological efficiency. Among all the tested substrates, the maximum protein (30.93%), fat (2.56%) and fibre (16.74%) were observed on soybean straw supplemented with soybean flour at 4 per cent concentration. Maximum carbohydrate (53.48%) was recorded on mustard straw supplemented with 4 per cent concentration of rice flour however, the highest moisture content (88.23%) was recorded on rice straw at 6 per cent concentration of soybean flour.

4. Gaurav Katoch (A-2021-30-069), Advisor: Dr. Suman Kumar

Title of thesis: Studies on collar rot of elephant foot yam caused by *Sclerotium rolfsii*

Abstract: The present research entitled as "Studies on collar rot of elephant foot yam caused by *Sclerotium rolfsii"* was carried out with an objective to study the prevalence of collar rot of elephant foot yam in Bilaspur district of Himachal Pradesh, morpho-cultural characteristics of the pathogen, physiological factors affecting the viability of the pathogen, efficacy of the fungicides, plant extracts and bioagents against the pathogen associated with collar rot of elephant foot yam. Collar rot of elephant foot

yam was found as a major disease in Bilaspur district of Himachal Pradesh with per cent disease incidence (PDI) recorded between 4.80-13.20 per cent. The pathogen associated with the disease was isolated on potato dextrose agar and identified as *Sclerotium rolfsii* based on symptomatology, morpho-cultural characters and molecular characterization. *In vitro* culturing of the pathogen was found best on PDA and oat meal agar media at 30°C for mycelial growth as sclerotial formation. Viability of sclerotia decreased with time duration and soil depth. Temperature and relative humidity had a significant impact on disease development showing negative (-0.643) and positive correlation (0.564) respectively. Propiconazole (25 % EC) proved to be most effective with 99.87 per cent mycelial inhibition while least mycelial inhibition (2.38 %) was observed by carbendazim 50 WP. Among the botanicals tested maximum mycelial inhibition was expressed by aqueous and alcoholic extracts of *Eucalyptus* sp. (82.54 % and 87.95 % respectively). Among the bioagents *Trichoderma harzianum* proved to be most effective that exhibited 96.48 per cent mycelial inhibition while least effective was *Pseudomonas fluorescens* with 54.78 per cent mycelial inhibition.

5. Shiwali Thakur (A-2021-30-071), Advisor: Dr. Amar Singh

Title of thesis: Eco-friendly management of collar rot ofsoybean caused by *Sclerotium rolfsii* Sacc.

Abstract: The present investigation on "Eco-friendly management of collar rot of soybean caused by *Sclerotium rolfsii* Sacc." was undertaken during 2021-2023 in Department of Plant Pathology, CSK HPKV, Palampur. Pathogen was isolated from disease samples of soybean collar rot and pathogenicity was proved. Best inoculation technique was standardized as spread of inoculum on the soil surface and covered with soybean leaf debris resulting highest disease incidence (85.33%) and mortality (46.47%). Fifteen isolate of *Trichoderma* spp. were isolated from the soybean rhizosphere and five available isolates were evaluated against pathogen. *Trichoderma* sp. (SRT-9) isolate showed maximum mycelial inhibition 57.04 per cent in dual culture and 71.48 per cent in culture filtrate method whereas in volatile compounds maximum inhibition (16.85 %) was shown with *Trichoderma* sp. (SRT-4). In roll paper towel method, highest soybean seed germination (82.00%) was with *Trichoderma* sp. (SRT-4) and maximum seedling vigour index value of 1241 with *Trichoderma* sp. (SRT-9). Under *in vitro* aqueous and alcoholic plant extracts of *Lantana camara, Eupatorium adenophorum, Ageratum conyzoides, Eucalyptus sp., Vitex negundo, Melia azedarach* and *Albizia chinensis* were assessed against pathogen at different concentrations. The least mycelial growth (23.67 mm) of pathogen and maximum inhibition (73.70%) was observed with aqueous extract of *A. conyzoides* at 50 per cent conc. whereas 5 per cent alcoholic extract of *M. azedarach* was the most effective and showed mycelial growth of 11.33 mm and 87.41 per cent inhibition. *In vitro* evaluation of organic and natural formulations *viz*., *eupatorium extract, beejamrit, jeevamrit, darekastra, dashparni, compost tea and ghanjeevamrit* were assessed against pathogen and *dashparni* was found most effective which showed least mycelial growth (5.00 mm) and maximum inhibition (94.44%) at 50 per cent conc. Seven potential bioagents found effective under *in vitro* were evaluated for their efficacy in pot experiments as seed treatment and soil application. Among the biological control isolates, highest germination (81.33%), least overall mortality (40%) and highest seedling vigour index (2174) was observed with *Trichoderma* sp. (SRT-9) as seed treatment and whereas highest germination (82.67%) was observed with *Trichoderma* sp. (SRT-9) and *T. koningii* (DMA-8), least mortality (42.67%) and high seedling vigour index (2251) was observed with *Trichoderma* sp. (SRT-9) as soil application. The botanicals and organic inputs were evaluated *in vivo*, least mortality (50.57%) was observed with *M. azedarach,* among the botanicals whereas least overall mortality (41.33%) was observed with *dashparni,* among organic inputs. Out of hundred soybean germplasm, none of genotype was found to be resistance under *in vitro* and *in vivo* evaluation against *S. rolfsii*.

6. Tanisha Gupta (A-2021-30-072), Advisor: Dr. Rakesh Devlash

Title of thesis: Investigations on banded leaf and sheath blight of maize cused by *Rhizoctonia solani* Kuhn

Abstract:: The investigation on banded leaf and sheath blight of maize caused by *Rhizoctonia solani* was undertaken in the Department of Plant Pathology, College of Agriculture, CSK HPKV, Palampur during

2021-23. The pathogen was isolated from the diseased maize samples and pathogenecity of the associated pathogen was proved. On the basis of symptoms, the disease was identified as banded leaf and sheath blight of maize and on the basis of morpho-cultural characteristics the pathogen was identified as *Rhizoctonia solani*. Among different media, czapek dox agar followed by potato dextrose agar medium was found to be best for mycelial growth and sclerotial production. Corn meal agar proved to be least supportive for the growth of fungus. Among carbon sources Sucrose followed by Glucose supported maximum growth. However, Glucose exhibited maximum sclerotia formation. Temperatures between 25°C and 30°C supported maximum growth. The pH level of 7.0 was found ideal for growth and sclerotia formation. Among all the tested botanicals, *Eucalyptus camaldulensis* was found most effective in inhibiting the mycelial growth of the pathogen at 50 percent concentration. Bioagent *Trichoderma spp*. (TV-1) provided maximum disease control. Dashparni as organic input provided maximum mycelial inhibition of *R. solani* at 40 % concentration. Fourteen inbreds viz., 52047, CML424, BAJIM605, B52, VL181486, CML575, BAJIM359, LKL153018, VL181499 ,LM23 (medium maturity), LQPM36128, LQPM34-1/10 (QPM), BAJ PC1511 (Pop corn) and WIN SWEET-1 (Sweet corn) were found moderately resistant to banded leaf and sheath blight. Treatment T7 comprised of 1st spray of Amistar Top @ 0.1% followed by 2nd spray of *Trichoderma spp*. (TV-1) @ 0.5% and 3rd spray of aqueous leaf extract of *Eucalyptus camaldulensis* @ 50% at 10 days interval was found effective for the management of BLSB.

7. Twinkle (A-2021-30-073), Advisor: Dr. Amar Singh

Title of thesis: Detection and management of seed borne mycoflora of soybean (*Glycine max* (L.) Merrill)

Abstract: In the present study, mycoflora associated with soybean seeds of Palam Soya, Shivalik and Hara Soya varieties grown in two conditions *i.e*., fungicide sprayed and unsprayed was detected by using agar plate and blotter paper method. The associated mycoflora detected from two seed categories (sterilized and unsterilized) revealed the presence of 13 fungal species *Aspergillus niger, A. flavus, Rhizopus* sp*., Alternaria alternata, Penicillium* sp*., Colletotrichum truncatum, Trichoderma* sp*., Curvularia* sp*., Fusarium proliferatum, F. equiseti, Phoma* sp*., Cladosporium* sp. *and Pestalotiopsis* sp. Among two detection methods, agar plate method was found more suitable than blotter paper method. Among seed associated mycoflora*, A. alternata, C. truncatum and A. niger* were more predominant, whereas *Trichoderma* sp*., Curvularia* sp. *and Pestalotiopsis* sp. were recorded only in few samples of these varieties. Furthermore, the impact of these isolated fungi on seed germination, shoot length, root length and seedling vigour index was assessed. Seed health parameters were adversely affected in artificially inoculated seed samples than apparently healthy seeds. It was observed that seeds inoculated with *A. niger* exhibited the lowest seed germination (56.19%), root length (5.27 cm), shoot length (3.14 cm) and seedling vigour index (473). During storage, *A. niger* consistently dominated over all other fungal species and was widely distributed in seed samples of various categories. The lowest frequency of mycoflora was observed at 2, 4, 6 and 8 months of storage in sterilized seeds of Hara Soya variety, which were obtained from the fungicide sprayed plot and stored in a polythene bag. In seed health parameters assessed through agar plate method, sterilized seeds of variety Hara Soya obtained from fungicide sprayed plot stored in polythene bag resulted in higher seed germination (98.75, 96.19, 93.40 and 91.75%), root length (3.25, 3.22, 3.20 and 3.18 cm), shoot length (4.96, 4.94, 4.91 and 4.88 cm) and seedling vigour index (811, 785, 760 and 742) after 2, 4, 6 and 8 months of storage, respectively. A similar trend was also observed in blotter paper method. In general, variety Hara Soya stored in polythene bag recorded the highest germination percentage, root -shoot length and seedling vigour index. Seed treatment with Vitavax power (carboxin 37.5% + thiram 37.5% DS) @ 2g/kg of seed was found most effective in maintaining seed health in all the tested varieties during storage. Under *in vitro* conditions, Vitavax power showed maximum mycelial inhibition of *A. niger* (100%), *C. truncatum* (100%) and *A. alternata* (98.27%) at 250, 250, 2500 ppm, respectively. Among biocontrol agents, *Trichoderma harzianum* (TH-11) was found most effective against *A. niger, C. truncatum and A. alternata* giving 46.16, 72.90 and 72.13 per cent mycelial inhibition, respectively. Among botanicals*, Eupatorium adenophorum* at 50 per cent concentration found most effective against *A. niger, C. truncatum* and *A. alternata* with 64.97, 51.90 and 59.72 per cent mycelial inhibition, respectively. Among natural/organic preparations, jeevamrit at 50 per cent concentration was

found to be the most effective against *A. niger, C. truncatum* and *A. alternata* with 72.69, 83.80 and 69.37 percent mycelial inhibition, respectively. Seed treatment with fungicide Vitavax power, biocontrol agent *T. harzianum* (TH-11), botanical *E. adenophorum* and natural /organic preparation jeevamrit gave highest reduction in seed borne mycoflora and considerably increased the seed germination, root length, shoot length and seedling vigour index than control.

8. Mansi Arora (A-2021-30-117), Advisor: Dr. Shikha Sharma

Title of thesis: Characterization of viruses associated with capsicum under protected cultivation I Himachal Pradesh

Abstract: Capsicum (*Capsicum annuum* L. var. *grossum* Sendt.) is popularly grown vegetable crop in the world. Diseases caused by viruses in the crop affect quality and quantity of produce significantly. Thus, this study entitled as **"Characterization of viruses associated with Capsicum under protected cultivation in Himachal Pradesh"** was undertaken to know the prevalence and further characterize the viral species associated with capsicum under protected cultivation. The roving surveys conducted during 2022-23 in three districts of Himachal Pradesh *viz.,* Kangra, Hamirpur and Mandi, revealed the highest viral mean disease incidence i.e. 32.77% per cent in district Kangra followed by district Hamirpur (18.75%) and district Mandi (15.74%). Samples collected during the survey were preliminary screened against antisera of four viruses *viz.,* CMV, PVY, TSWV and PMMoV *via* DAS-ELISA. Out of total 85 samples tested, 39 were found to be sero-positive against the target viruses. Mixed infections of CMV and PVY, CMV and PMMoV and PVY and PMMoV was also seen in DAS-ELISA. Per cent serological incidence was found to be highest for CMV i.e. 23.52 per cent followed by PMMoV (14.91%) and PVY (5.88%) in Himachal Pradesh. Viral infections in capsicum plants resulted in a wide array of symptoms. Study further revealed that mosaic, vein-banding, yellowing and chlorotic spots were the major symptoms associated with CMV infection. Symptoms associated with PVY infection were yellowing, mosaic, stunting, leaf-distortion and puckering. TSWV infection induced chlorotic or necrotic ringspot, yellowing and chlorosis in capsicum crop. Mild to severe mottling, mosaic, puckering and yellowing/chlorosis were found to be associated with PMMoV. In RT-PCR, amplicons of size ~730 bp for PMMoV using CP-F/CP-R, ~550 bp for CMV using CMV-F/CMV-R and ~350-450 bp for PVY using Nib2-F/Nib3-R, were obtained by employing respective conserved gene based primers. Further electron micrography results showed the presence of spherical to quasi-spherical CMV virions having diameter of 26-32 nm with electron dense centres. TSWV virions were spherical in shape having diameter of around 80 nm. Flexuous rod shaped PVY virus particle measuring around 694.68-962.12 nm were also present in sero-positive samples. The identification of Phytoplasma infection in capsicum plants showing phyllody, shortening of internodes symptoms was also done. The desired amplicons of size ~1.8 Kb and ~1.2 Kb were observed *via* nested PCR with P1/P7 and R16F2n/R16FR2 primers pair respectively. Presence of Phytoplasma was reconfirmed using secretory gene-based primer set SecAfor1/SecArev3 yielding an amplicon of size ~734bp. This study further confirms the first report of Phytoplasma infecting bell pepper in India.

9. Kavita Kushwaha (A-2021-30-118), Advisor: Dr Joginder Pal

Title of thesis: Fungal root endophytes mediated management of pea root rot in Himachal Pradesh

Abstract: The present investigation entitled as "Fungal root endophytes mediated management of pea root rot in Himachal Pradesh" was undertaken with the objective to ascertain the prevalence and pathogens associated with pea root rot complex (PRRC) in sub-humid and dry temperate zones of Himachal Pradesh. The most predominant pathogen associated with the disease complex and its management with the aid of indigenously isolated fungal endophytes was also assessed. Disease survey conducted during the year 2021-2022 revealed that overall disease incidence of PRRC ranged between 15.83- 58.17 per cent. The maximum mean incidence was recorded in Lahaul Spiti district (38.80 %) followed by Mandi (34.67 %) and Kangra (29.13 %) district. However, least disease incidence (24.87 %) was noted in Kinnaur district. A total of 45 isolates of pathogens associated with PRRC were obtained out of which *Fusarium oxysporum* isolate JPP1 was identified as the predominant pathogen based on morpho-cultural and molecular characterization. Pathogenicity test conducted for proving Koch's postulates led to the symptom

development and ultimately complete death of pea plant at 9 and 41 days after pathogen inoculation, respectively. Out of 51 fungal endophytes isolated, eight isolates exhibiting high antagonistic potential against *F. oxysporum* isolate JPP1*,* were subsequently subjected to morpho-molecular characterization and were identified as *Epicoccum* sp. isolate JPE2, *Fusarium osysporum* sp. isolate JPE6, *Aspergillus* sp. isolate JPE7, *Epicoccum sorghinum* isolate JPE13, *Schizophyllum* sp. isolate JPE19, *Fusarium solani* isolate JPE20, *Fusarium* sp. isolate JPE23 and *Talaromyces purpureogenus* isolate JPE38. Selected endophytes were further screened under *in vivo* conditions for their disease control potential and plant growth promotion activity where *Schizophyllum* sp. isolate JPE19, *Epicoccum* sp. isolate JPE2 and *Aspergillus* sp. isolate JPE7 proved to be most efficient. Root colonization assay revealed significantly higher colonization in plants treated with endophytes. Overall, total as well as recovered endophytic count was observed maximum in roots treated with *Schizophyllum* sp. isolate JPE19 suggesting the establishment and persistence of inoculated strain in endosphere of the pea plants. The data retrieved from the current research contribute to our knowledge on diversity, biocontrol and PGP potential of endophytic fungi and furthers our approach to develop commercial bio-formulation of these fungi which could be used as safe and environment friendly option for effective management of this dreadful disease.

B. Ph.D.

1. Diksha Sinha (A-2019-40-024). Advisor: Dr D K Banyal

Title of thesis: Biology and management of early blight of tomato caused by *Alternaria Solani*

Abstract: The present investigation entitled "Biology and management of early blight of tomato caused by Alternaria solani" was conducted in the Department of Plant Pathology, CSK HPKV, Palampur during 2019-2023. This study was aimed to ascertain the pathogen variability, factors affecting pathogen & disease development and evaluation of various disease management components. The variability among 40 isolates of *A. solani* was studied on the basis of morpho-cultural, molecular, pathogenic and biochemical characteristics and isolates were grouped into 5, 4, 3 and 3 groups, respectively. Spore concentration of $5x10^5$ spores/ml gave maximum disease severity (34.60%) with minimum incubation period of 3.0±0.71 days as compared to $5x10^3$, $1x10^4$, $5x10^4$, $1x10^5$ spores/ml concentrations. Fourteen days old pathogen culture was found most aggressive with highest mean disease severity (27.47%) and minimum incubation period (3.6±0.89 days). Among sub-cultures, the shortest incubation period (3.0±0.71 days) with maximum disease severity (31.13%) was observed with first sub-culture of *A. solani*. Tomato plants at 60 DAS were found highly susceptible to early blight infection with maximum disease severity (37.80%), AUDPC (520.10) and apparent infection rate (0.06 r/day) as compared to 30, 40 and 50 DAS. *A. solani* survived on infected tomato seeds stored at room temperature for 12 months from August 2021-August 2022. Linear regression showed a significant negative relationship (-0.98) of conidial viability with storage time. Fungal survival declined sharply during the period of over-wintering and increase in the depth of debris in soil. Dry conditions were better suited than wet conditions for the survival of pathogen. *A. solani* was found pathogenic to other members of the Solanaceae family like potato, brinjal and chilli. Tomato seedlings transplanted in the 1st week of April (2nd April) and at wider spacing (60x60 cm) resulted in higher fruit yield and less disease severity as compared to late transplanted crop (12th April) and close spacings (30x45 and 45x45cm) under both open field and polyhouse conditions. Early blight severity was found to be significantly positively correlated with maximum temperature and morning RH, while it negatively correlated with rainfall. Temperature was observed as the most important environmental factor in the disease development. Among the 4 tested biostimulants *i.e.* gallic acid, salicylic acid, Cusilano (gelatin with colloidal silver and colloidal copper) and chitosan, Cusilano (5 µg/ml) was found most effective against *A. solani* under both *in vitro* and *in vivo* conditions, with maximum mycelial inhibition (60.00%) and maximum disease control (52.48%) over check. Six systemic fungicides *viz.,* azoxystrobin 23EC (Amistar), trifloxystrobin 25% + tebuconazole 50%WG (Nativo), difenoconazole 25EC (Score), carbendazim 50WP (Bavistin), propiconazole 25EC (Tilt), tebuconazole 25EC (Folicur) and two non-systemic fungicides *viz.*, zineb 75WP (Indofil Z-78) and copper oxychloride 50WP (Blitox 50) were evaluated under *in vitro* and propiconazole 25EC was found most effective fungicide against *A. solani,*

which completely inhibited mycelial growth and conidial germination at 250 ppm followed by tebuconazole 25EC and trifloxystrobin 25% + tebuconazole 50% WG. Extracts of ten locally available botaniclals (*Ageratum conyzoides, Ajuga bracteosa, Albizia chinensis, Eucalyptus camaldulensis, Eupatorium adenophorum, Ocimum sanctum, Lantana camara, Melia azedarach, Pogostemon benghalensis* and *Vitex negundo*) were evaluated and aqueous leaf extracts of *A. chinensis* and *M. azedarach* were found most effective against *A. solani*. Fungal bioagents *i.e. T. viride* (Tv-1), *T. harzianum* (JMA-4 and SMA-5) and *T. koningii* (DMA-8 and JMA-11) and bacterial bioagent (*Pseudomonas fluoroscens* strain Pf-1*)* were evaluated under *in vitro* conditions and *T. koningii* (strain DMA-8) was found most effective with 35.65 per cent growth inhibition of the pathogen over control. Four organic inputs *viz*., Jeevamrit, Tamarlassi, Eupatorium ark and Sonth were evaluated *in vitro* and Eupatorium ark was observed most effective with complete mycelium inhibition at 10 per cent concentration followed by Jeevamrit with 88.70 per cent mycelial inhibition at 25 per cent concentration. Under polyhouse conditions, propiconazole 25EC was found most effective with 79.85 per cent disease control over check however, among non-chemical components *i.e.* Eupatorium ark (68.15%), *Albizia* extract (59.98%) and *T. koningii* (DMA-8) (53.99%) were also found promising. IDM trial for the management of early blight of tomato was conducted at Palampur and RSS Akrot under field conditions during 2022. Individually, among chemicals 3 sprays of propiconazole 25EC @1ml/l was found superior whereas, among non-chemical inputs, 3 sprays of Eupatorium ark @10ml/l was found most effective. Among integrated treatments of chemical with non-chemical components, two sprays of fungicide (propiconazole 25EC/tebuconazole 25EC @1ml/l) + one spray of Eupatorium ark @10ml/l resulted best with 49.66 and 47.86 per cent disease control, respectively. One spray each of fungicide (propiconazole 25EC/tebuconazole 25EC @1ml/l), *Albizia* extract @10ml/l and Eupatorium ark @10ml/l at 10 days intervals also exhibited effective disease control over check.

2. Khushwinder Kaur (A-2019-40-025), Advisor: Dr Amar Singh

Title of thesis: Diversity analysis of *Pseudocercospora griseola* populations causing angular leaf spot of common bean and identification of resistant sources

Abstract: The present investigation entitled "Diversity analysis of *Pseudocercospora griseola* populations causing angular leaf spot of common bean and identification of resistant sources" was undertaken during 2019-2023 to identify pathogen, standardization of culture technique, variability in *P. griseola* and evaluation of common bean germplasm for resistance sources. Angular leaf spot of common bean caused by *Pseudocercospora griseola* emerged as most destructive disease in Himachal Pradesh as 21.3 to 76.2 per cent disease severity was observed. Fifty isolates of *P. griseola* were collected from different locations of six districts (Chamba, Kangra, Kullu, Kinnaur, Mandi and Shimla) representing three agro-climatic zones of Himachal Pradesh. Isolations were done by using four different methods *viz.,* by infected leaf bits, sterilized toothpick, moist chamber method and by picking up synnemata from diseased leaves. Out of these methods, picking up synnemata from infected leaves was found most efficient with 58.0 per cent recovery efficiency. Total 40 isolates were recovered by using different isolation methods. These isolates were identified as *Pseudocercospora griseola* based on morpho-cultural characters and were confirmed further with molecular techniques. Among culture techniques, V8 juice agar medium at 24ºC temperature with pH level 6 and relative humidity levels of 85 to 90 per cent supported the maximum mycelial growth and sporulation. The pathogen was found variable on the basis of morpho-cultural characteristics and isolates were categorized into 8 groups i.e. PG-MV1-PG-MV8. The virulence structure and pattern of 40 isolates was studied on 9 differential lines and on basis of pathotype designation, *P. griseola* isolates were grouped into 5 pathotypes i.e. PPG1-PPG5. Among 5 pathotypes PPG1 was found highly virulent which gave susceptible reaction on 8 out of 9 differential lines used whereas PPG5 was least virulent which gave susceptible reaction against only 3 differential lines. PPG5 pathotype was found most frequently distributed which constituted of 23 isolates. Pathogen population was also characterised on molecular basis by using ISSR and RAMS markers. In POPGENE analysis, among all populations Kullu district population was found most diverse with highest Nei diversity (0.3161), Shanon information index (0.4763) and per centage

of polymorphic loci (92.48). ISSR markers had exhibited high genetic diversity in pathogen population and categorized the test pathogen population in 2 clusters that were further grouped into 7 groups while RAMS markers categorized the population in 3 groups. It was observed that in molecular variability analysis, some of the isolates were grouped according to geographical region while some isolates collected from distant regions were also grouped in single cluster indicating genetic variability had no or less correlation with pathogenic and morpho-cultural variability studied. Out of two hundred twelve common bean lines along with 3 checks i.e. Hans, Jwala and Contender evaluated under field conditions, 18 lines and variety Hans were found highly resistant. These identified highly resistant sources were screened against diverse pathotypes (PPG1-PPG5) under *in-vivo* conditions and four lines *viz.*, IC 243195, EC 500423, EC 500821, EC 405219 and variety Hans were confirmed to be highly resistant. Biochemical basis of resistance was studied in Hans (highly resistant) and the increased level of phenol and peroxidase after infection indicated their role in disease resistance. Inheritance of resistance for *P. griseola* was studied in Jwala x Hans crosses and results revealed that the inheritance was controlled by single-dominant gene.

3. Vakul Sood (A-2019-40-026), Advisor: Dr Amar Singh

Title of thesis: Studies on variability in pathogen(s) causing root rot of okra and its integrated disease management

Abstract: The present investigation entitled "Studies on variability in major pathogen causing root rot of okra and its integrated disease management" was undertaken to ascertain the status of root rot, etiology, pathogen morpho-cultural and pathogenic variability, evaluation of resistant sources and biochemical basis of resistance against the major pathogen causing root rot of okra in Himachal Pradesh. Root rot was prevalent as a major disease in all the six districts (Mandi, Bilaspur, Hamirpur, Una, Kangra and Chamba) surveyed and causing 12.50-61.05 % overall disease incidence. Three pathogens *viz*., *Fusarium solani*, *F. oxysporum* and *Rhizoctonia solani* were found associated with root rot of okra with 36.61, 15.94 and 15.95 per cent frequency. So, the major associated pathogen was *F. solani* thus, considered for further studies. The pathogen was found variable on the basis of morpho-cultural variability. A differential set of 12 genotypes showing the characteristic differential reaction was developed and used for analyse virulence in pathogen population. On the basis of disease reaction on differential set *F. solani* isolates were grouped into 19 pathotypes. Virulence analysis of the pathotypes (FPG-1 – FPG-19) revealed that FPG7, FPG11, and FPG13 were highly virulent among all the pathotypes, which gave susceptible reaction on 8-9 out of 12 differential genotypes whereas FPG7, FPG11, and FPG13 were least virulent which gave susceptible reaction to only 5 differential genotypes. Out of a total sixty genotypes evaluated under field conditions 15 genotypes found resistant which were screened against diverse pathotypes (FPG-1 – FPG-19) and three genotypes *viz.,* Hissar Unnat, VRO-4 and SKBS-11 were identified as highly resistant against maximum 11 pathotypes. Relatively high activity of Phenols and enzymes; PPO and PO in a resistant genotype 'Hissar Unnat after inoculation revealed the biochemical basis of host resistance. Under *in vitro* conditions, thirty isolates of *Trichoderma* spp. isolated from okra rhizosphere were evaluated where *Trichoderma* sp.-29 was found best with 61.11 per cent mycelial inhibition, the potential bio-agents found effective for their efficacy of volatile metabolites and non-volatile metabolites of culture filtrates on mycelial growth of *F. solani*. Among different botanicals (*Azadirachta indica, Eucalyptus* sp*., Lantana camara, Eupatorium adenophorum, Dodonaea viscosa, Justicia adhatoda* and *Ageratum conyzoides)* and organic formulations (Jeevamrit, Beejamrit, Ghanjeevamrit, Vermicompost, Eupatorium ark, Neemastra, Darekastra and Brahamastra) evaluated against *F. solani*, *Dodonaea viscosa* with 53.66 per cent mycelial inhibition @ 25% concentration, Brahamastra (organic formulation) with 100 per cent mycelial inhibition @15, 20 and 25% concentrations were found best under *in vitro* conditions. Under *in vivo* conditions, seed treatment with potential bio-agent, botanical or organic formulation alone was proved better than soil and drenching application. An integrated treatment *viz*., seed treatment with Brahamastra (organic formulation) followed by soil drenching with *Trichoderma* sp-29 (bioagent @5kg/l) was found most effective giving 69.02 and 68.12 per cent disease control during *Kharif* 2021 and 2022, respectively for eco-friendly management of root rot of okra under field conditions.

5. RESEARCH

a) Survey and surveillance of the diseases of different crops

i) Cereals

Systematic surveys were conducted under survey and surveillance programme in maize growing areas like Badawan, Phandi bodiwala, Mallaon wala, Rukadi (Block Nahan), Nihalgarh, Sukh Chenpur, Girinagar (Paonta Block), of district Sirmour during Kharif, 2023 (Table1). The most common diseases of these areas were Bacterial stalk rot, Banded leaf and sheath blight (BLSB), TLB, Maydis leaf blight and Brown spot of maize. While Curvularia leaf spot was of minor importance.

During rabi season Survey and surveillance programme was undertaken to record diseases of field crops at farmers' field in Sirmour district. Different villages of the Nahan, Paonta, Shillai and Sangrah block of Distt. Sirmour *viz*., Ramdhon, Talon, Satiwala, Shambhuwala, Sainwala, Tokiyon, Bohliyon and Surajpur were visited to know the status of wheat yellow rust. The varieties grown by the farmers included HD 3086 and HD 2967. During the visit yellow rust infection was observed in both the varieties exhibiting up to 40(40S) to 60 (60S) per cent of yellow rust severity.

Table 1. Occurrence of diseases on different cereal crops in Sirmour district

Crops	Diseases Observed	Incidence/Severity
Maize	Turcicum leaf blight, Maydis leaf blight, Banded leaf & sheath blight	Moderate
	Brown spot, Curvularia leaf spot, common rust	Low
Wheat	Stripe rust	Moderate
	Loose smut, Hill Bunt	Low
Barley	Stripe rust	Moderate
	Covered Smut, Barley stripe	Low

ii) Fodder crops: During *Kharif* 2023, wilt/root rot complex, leaf spots and blight of cowpea, leaf bight of maize, zonate leaf spot of Sorghum and leaf blight and blast of bajra were observed the main diseases. In the *Rabi* 2023-24 season, oat powdery mildew and leaf blights of oats, root rot and leaf blight of berseem and leaf spot of lucerne were observed as the important diseases (Table 2).

Table 2. Diseases and Insect-pests of different *Kharif* & *Rabi* fodder crops

Crop	Diseases and insect pest	Incidence/ Severity (%)
***Kharif* 2023**		
Cowpea	Wilt/root rot (*Fusarium, Rhizoctonia*)	75
	Leaf spot and blight (*Phytophthora, Ascochyta, Phyllostricta*)	20
Maize	Blight (*Helminthosprium maydis* and *H. tercicum*)	40
Sorghum	Zonate leaf spot (*Gloeocercospora sorghi)*	60
Bajra	leaf blight *(Helminthosporium*)	10
	Blast (*Pyricularia grisea*)	40
***Rabi* 2023-24**		
Oats	Powdery mildew	80
	Leaf blights	70
Berseem	Root rot	15
	Leaf spot	70
Lucerne	Leaf spot	5

iii) Soyabean

Surveys were conducted in soybean growing areas of Himachal Pradesh during September 2023 to record data on the occurrence of different diseases (Table 3). Mainly four diseases *viz*., frog eye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*), bacterial pustule (*Xanthomonas campestris* pv. *glycines*) and yellow mosaic virus (YMV) were found to occur in areas surveyed in Kangra and Mandi districts. Diseases were scored on 0-9 scale. Location wise per cent disease index (PDI) is presented in table 3. Frog eye leaf spot (*Cercospora sojina*) and pod blight (*Colletotrichum truncatum*) were mainly observed on Hara Soya, Him Soya, Palam Soya and Bragg varieties of soybean and bacterial pustule (*Xanthomonas campestris* pv. *glycines*) was observed on Hara Soya in Himachal Pradesh. Low incidence 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 3: Occurrence of soybean diseases in major soybean areas in Himachal Pradesh

Location	**GPS location**		**Variety grown**	**Percent disease index**			
	Latitude	Longitude		Frogeye leaf spot (*Cercospora sojina*)	Pod blight (*Colletotrichum truncatum*)	YMV	Bacterial pustule (*Xanthomonas campestris* pv. *glycines*)
Kangra							
Baijnath	32°00' 88"N	76°65'43" E	Hara Soya	55.55	11.11	0.0	0.0
Matour	32°06' 00" N	76° 16' 12" E	Hara Soya	33.33	33.33	0.0	0.0
			Him Soya	33.33	33.33	11.11	0.0
Ghyana Khurd	32°15' 29" N	76° 32' 41" E	Him Soya	33.33	66.66	0.00	
Nagri	32°08' 21" N	76° 26' 56" E	Hara Soya	55.55	33.33	0.0	
Matour	32°11' 03" N	76° 29' 27" E	Palam Soy	33.33	11.11	33.33	0.0
Palampur	32°05' 53" N	76° 32' 07" E	Hara Soya	33.33	33.33	0.0	11.11
			Bragg	55.55	55.55	0.0	0.0
			Shivalik	77.77	11.11	0.0	0.0
			Him Soya	77.77	33.33	0.0	0.0
Mandi							
Fagoh	31°51' 60" N	76° 94' 63" E	Him Soya	33.33	11.11	0.0	0.0
Sunder Nagar	31°52' 23" N	76° 55' 67" E	Hara Soya	33.33	33.33	0.0	0.0
Lad Bharol	32°00' 76" N	76° 69' 86" E	Him Soya	33.33	11.11	0.0	0.0

iv) Oilseeds

An extensive survey in major linseed growing areas of Kangra, Shahpur, Darini, Palampur, Baijnath (Utrala) of Kangra district and Harabagh & Gumma of Mandi district was carried out during the cropping season for recording prevalence of major Linseed diseases (Table 4). In all the areas surveyed, the crop was grown either as relay crop or mono crop. The wilt and powdery mildew were the main diseases observed during survey. However, incidence of rust was also recorded this year at Kangra, Shahpur and Harabagh. The disease severity of wilt was ranged from 50-75%. Maximum disease severity was observed at Kangra and Shahpur locations (70-80%). On the other hand, powdery mildew severity was ranged from 10-50%. In this year, rust incidence was also recorded in Kangra, Shahpur,Darini, Palampur and Harabagh area of Mandi district. The rust severity score was ranged from 3 to 4 in lower belt however, the incidence in upper regions was 1-2. Late onset of winter rains in Feb-March created favourable conditions for rust infection in the region.

Table 4: Survey of linseed diseases prevailing across different districts

S. No.	Name of disease	Locations	Name of the variety	Final disease severity (%)
1.	Wilt	Kangra	Kangra local	50-70
		Shahpur	Boh (local)	60-75
		Palampur	local	50-60
		Baijnath (*Utrala*)	local	40-50
		Mandi (Harabagh, & Gumma)	local	50-60
2.	Powdery Mildew	Kangra	Kangra local	10-20
		Shahpur	Darini (local)	10-20
		Palampur	local	50
		Baijnath (Utrala)	local	40
		Mandi (Harabagh, &Gumma)	local	50
3.	Rust	Kangra	Kangra local	4
		Shahpur (Darini)	local	3
		Palampur	local	1
		Baijnath (Harer)	local	0
		Mandi (Harabagh)	local	3

v) Vegetable Crops

In dry temperate zone of Himachal Pradesh, incidence of lettuce rot was recorded in various villages and sclerotia were collected from 25 locations for further studies (Table 5). Survey of various areas to study the incidence and severity of black rot of crucifers, wilt/ drying of common bean and bacterial blight of common bean. Systematic surveys were conducted in and around of Hill Agricultural Research and Extension Centre Bajaura comprising areas of Kullu and Mandi districts. Incidence of various diseases varies from locality to locality. The incidence of garlic disease Stemphylium blight and purple blotch was also recorded 60-80% in all the garlic growing areas of the district Sirmour along with the garlic bulb rot complex with 40-60% incidence.

Table 5: Survey and Surveillance of Vegetable Crops

Crop	Disease	Disease Intensity
Tomato	Early Blight and Alternaria fruit Rot,	Moderate
	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
	bacterial wilt and virus diseases	Moderate
Cabbage and Cauliflower	Black rot	High
	Alternaria leaf spot	Low - Moderate
French Bean	Angular leaf spot	Low - Moderate
	Anthracnose	Moderate
	Rust	Low
Peas	Wilt & root rot, Powdery Mildew,	Low-Moderate
	Bacterial blight	Low
Cucumber	Powdery mildew, Downey mildew.	Moderate- High
	Wilt	Low
Garlic	Stemphylium blight & purple blotch in garlic.	Moderate
	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

b) Screening of germplasm

i. Cereals

i.)Rice: Screening for Leaf Blast Resistance

National Screening Nursery-1 (NSN-1) : The National Screening Nursery (NSN-1) comprised of 432 entries that included national regional and pathology checks. The nursery was evaluated at Rice and wheat Research Station, Malan . The screening against leaf blast was carried out under both natural and artificial inoculation conditions at malan. The disease pressure was moderate (3-6) and hence data from this centre was considered for the selection of promising entries. None of the entries found resistant (SI≤3.0) or performed better than resistant check Tetep (SI-2.9), however the entries that scored SI≤4.0 were considered as promising. The entries included IET Nos. 30593, 30561, 30573, 31054, 29694,30577, 32064, 29142, 29940, 30020, 31050, 30888, 29696, 29689, 30651, 30233, 28965, 30942, 30740, 29975, 30917, 30235, 30578, 31051 and 30579 .

National Screening Nursery-2 (NSN-2): The nursery consists of 643 lines drawn from initial variety trials (IVTs). These were evaluated at malan centre. The disease pressure was moderate (3-6) .None of the entries found resistant (<3.0) or performed better than resistant check Tetep (SI 2.9), but a few promising entries with low susceptibility index included IET # 31989, 31068, 31532, 31508, 31597, 31525, 31638, 31552, 3185-7, 31971, 31533, 31075, 31621, 31715, and 31528.

National Screening Nursery-Hills (NSN-Hills) : The National Screening Nursery -Hills (NSN-H) comprised of 86 entries, were evaluated at malan centre for their resistance to leaf blast. These entries were screened through natural infection condition. The disease pressure was moderate (LSI 3-6). None of the entries performed better over resistant check (Tetep SI 2.4); however, only one entry IET# 31420 (SI-3.0) was found resistant (SI≤3.0). The entries with SI ≤4.1 with high PI were considered promising and that included IET# 31422, 31409, 31389, 31403, 31405, 31429, and31388.

National Hybrid Screening Nursery (NHSN): One hundred and twenty hybrids that included checks were evaluated at malan against leaf blast disease under NHSN. The disease pressure was moderate (3-6). None of the hybrid entries found resistant (SI<3.0) against leaf blast in NHSN; however, entries found promising that included IET# 31435, 31433, 31480, 31469, 31447, 31473, 31442, 31459, 31437, 31438, 31455 and 31474

Donor Screening Nursery (DSN): The donor screening nursery comprised of 212 entries including checks were evaluated at RWRC Malan. The location severity index was moderate (LSI 3-6).None of the donors showed resistant reaction (SI<3.0), however the donors with severity index less than 4.1 were considered as promising and that included RP 6469-89, CB 18577, RBN-2, RNR 31581, RBN-1, RBN-6, CB 18586, NLR 3217, RBN-7, KNM 13525, KNM 13449, KNM 15361 and JGL 3889 .

ii.Screening for Neck Blast Resistance

NSN-1 : During *Kharif*2023, the National Screening Nursery-1 (NSN-1) for neck blast disease was evaluated at Malan centre with 432 entries. The entries were screened under natural conditions at the centre. The disease pressure was low (<3.2). The selection of promising entries was done based on the data and that included IET # 29560, 30252, 29808, 29820, 32065, 31120, 30918, 28965, 30021, 30772, 30907, 29696, 30830, 30757 and 29891.

NSN-2 :A total of 643 entries were evaluated under NSN-2 at malan location during *Kharif* 2023. The screening was done under natural infection condition. The location severity index and frequency distribution of scores was very low at malan. The entries that had shown low disease scores (≤3.5) included IET# 31924, 31681, 31683, 31710, 31835, 31820, 31616, 31821, 31836, 31974, 31719, 31827, 31868, 31525, 31987, 31595, 31521, 31754, 31774, 31895, 31505, 31507, 31509, 30684, 31676 and 31817.

NSN-H :A total of 86 entries were evaluated under NSN-hills nursery . The entries were screened under natural infection condition .The entries found resistant and which performed on par with resistant checkTetep (SI 3.0) were IET# 31420, 31423, 31412, 31416 and 31428.

NHSN: The National Hybrid Screening Nursery (NHSN) was evaluated for their resistance to neck blast at RWRC, Malan. The entries were screened by natural infection conditions. Based on the performance of entries, entries *viz*., IET# 31490, 31489, 31475, 31469,31492, 31452, 31466, 31473, 31464 and 31496 were found promising

DSN: The Donor Screening Nursery (DSN) was evaluated for resistance to neck blast. Based on the performance of entries, the list of promising donors included VP-R262-SHB, VP-D6-SHB, VP-D8-SHB, VP-D9-SHB, CB 20166, VP-R45-SHB, NLRBL-8, VP-R243-SHB, WGL 14, VP-R107-SHB, VP-R109-SHB, 4857, VP-D5-SHB, 19451, RP-Patho-12, CR1014, NLRBL-5, and 4917.

ii) Barley

i. Screening of Barley Germplasm against fugal diseases: During the year 2023, thirty two germplasms/lines of barley were evaluated at experimental research farm of Research sub-station Lari, district Lahaul & Spiti-CSKHPKV Palampur for resistance source against various fungal diseases infecting barley crops. Of total 32, five germplasms *viz.* HB-2206, HB-2220, HB-2222, Dolma, HBL-113 were recorded resistant against barley leaf stripe, twenty eight *viz.* HB-2201, HB-2202, HB-2203, HB-2204, HB-2205, HB-2206, HB-2207, HB-2208, HB-2209, HB-2211, HB-2212, HB-2214, HB-2215, HB-2216, HB-2217, HB-2218, HB-2219, HB-2220, HB-2221, HB-2222, HBL-804,Dolma HBL-113, HBL-276, HBL-316, HBL-316, VLB-118 and Lapchal have shown resistant against powdery mildew whereas, twenty seven *viz.* HB-2201, HB-2202, HB-2203, HB-2204, HB-2205, HB-2206, HB-2207, HB-2208, HB-2209, HB-2213, HB-2214, HB-2215, HB-2216, HB-2218, HB-2219, HB-2220, HB-2221, HB-2222, HBL-804, Dolma HBL-113, HBL-276, HBL-316, HBL-316, VLB-118, Long Gharmo, Lapchal and Nainak were found to be resistant against covered smut disease. Overall, five germplasm *viz.* HB-2206, HB-2220, HB-2222, Dolma and HBL-113 were observed to show resistant against all the disease. The germplasms were also screened further for their yield attributes whereby maximum yield were recorded with HB-2213 (313g/plot) followed by HB-2208 (276g/plot) and HBL-113 (238g/plot).

Screening of Barley Germplasm against Stripe Rust: A total of 696 barley lines/ genotypes received from ICAR-IIWBR under IBDSN, NBDSN and EBDSN were screened against yellow rust during *rabi* 2023-24. A total of 346 genotypes were found resistant to Stripe rust.

iii) Maize

i. Evaluation of Maize Germplasm:A total of 60 normal maize (medium maturity, early maturity and OPV) and 30 specialty corn (QPM, Pop Corn, Sweet Corn and Baby Corn) genotypes were screened artificially against Turcicum leaf blight (TLB) during *kharif*, 2023. The details of promising genotypes under various maturity groups and speciality corn are as under:

- **Medium maturity:**A total of 8 genotypes showed resistant reaction to turcicum leaf blight out of 31 genotypes screened. Promising genotypes having resistance against TLB were AH 4672, DH 372, IBH 9-232, IMH 10-23K1, IMH 10-23K2, DKC 9256 (IX 8466), KGH 22-03 and LMH 1923.
- **Early maturity:**A total of 9 genotypes showed resistant reaction to turcicum leaf blight out of 18 genotypes screened. Promising genotypes having resistance against TLB were CP 418, DH 358, DH 371, IMH2-23K-2, JH 32783, KGH-22-35, LMH 2335, LMH 2342 (NIVT) and IX 7851 (AVT).
- **OPV(Open pollinated variety):**Two genotypes viz. APC 10, KDM 34, PFM 14 (NIVT) and ADC 4, ADC 3 (AVT) showed resistant reaction against TLB out of eleven genotypes screened.
- **QPM I-II-III:**A total of 9 genotypes viz. APH 7, FBH 101, FMH 66, LQPMH 7023, QH 2303 (NIVT) and FLPH 45, FMH 24, IQPMH 2102, IQPMH 2105 (AVT) were found resistant against TLB out of 15 genotypes evaluated.
- **Sweet Corn:**Genotypes FSCH 218, FSCH 266 (NIVT) and CP GOLDEN, FSCH 131 (AVT) were found resistant to TLB out of six genotypes screened for resistance.
- **Baby Corn:**Genotypes IBH 9-231 (NIVT) and IBH 11-223, IMHSB 19B-2, JH 32484 (AVT) were found resistant against TLB.

- **Pop Corn:**Genotype IBH IPH7-205 was found resistant against TLB.

ii. Maize Disease trap nursery: Maize disease trap nursery consisting of 12 lines was planted to determine the prevalence of different diseases of maize. Highest TLB score was observed in Early Composite (8.0) followed by CM 400 and CM 600.

iii.Screening of maize hybrids of public and private sector: Twenty eight maize hybrids of public and private sectors along with three checks (Bio-605, Palam sankar Makka-2 and Bioseed-9544) were screened against Turcicum leaf blight (TLB) under artificial epiphytotic conditions during *kharif* 2023. All the maize hybrids were found resistant/ moderately resistant against TLB. Maize hybrids 1024 A 384-01, HYM 333, PL-1515 Gold, 2745, KMH-8333, DKC-7240, DKC-8174, NK-6110 and 1028 B 450-01 were found promising.

iv. Screening of AICRP Maize germplasm: During kharif 2023, 284 entries received from IIMR, Ludhiana including QPM-I-II-III, Early and Late Maturity, OPV and Speciality Corn, TPN nursery. But due to the heavy rainfall after 2-3 days of sowing, only 5-10 percent germination of maize seed has been observed. This heavy rain continued in the region during the month of June and July where water remain stagnated in the entire farm. During this season, the screening of maize entries against BSR and BLSB is almost unsuccessful. Among the tested 31 MH lines under natural epiphytotic conditions for the occurrence of BLSB and BSR diseases of maize, 26 lines showed resistant type reaction against the BSR whereas all the enteries were found resistant against BLSB.

iv) Wheat

i. Screening of wheat germplasm against Stripe Rust: A total of 1761 Wheat lines/ genotypes (IPPSN 1212, PPSN 469 & EMDSN 80) received from ICAR-IIWBR under PPSN AVT and PPSN NIVT/ Special Trials were screened against yellow rust during Rabi 2023-24. A total of 886 genotypes were found free from Stripe rust.

ii. Wheat Disease Trap Plot Nursery: Trap nursery comprising of 20 lines of wheat and one line of barley was received from Regional Station, Directorate of Wheat Research (ICAR), Flowerdale, Shimla to monitor the appearance and progress of yellow rust during Rabi 2023-24. Yellow rust appeared in 12 lines of wheat. Disease samples were sent to Flowerdale, Shimla as soon as the disease appeared for pathotype analysis.

iii. Evaluation of advanced breeding material against yellow rust and powdery mildew: Wheat germplasm consisting of 1997 entries from various screening nurseries viz. SAARC-20, TPN-20, IPPSN (Initial Plant Pathological Screening Nurseries-1212), PPSN (AVT, Plant pathological Screening Nursery- 146), NIVT-323, EMDSN (Rust)-80, were evaluated against yellow rust at Dhaulakuan under natural epiphytotic conditions with disease augmentation by following artificial inoculation procedure. For powdery mildew of wheat entries of PMSN (Powdery Mildew Screening Nurseries-148) and EMDSN (PM)-48 (Ellite Multiple Diseases Screening Nurseries-48) were screened. Out of these nurseries, 6 entries from SAARC, 6 entries from TPN, 949 entries from IPPSN, 108 entries from AVT, 145 from NIVTs, 67 entries from MDSN were found highly promising (0-20S) against yellow rust. However, out of these 3 entries from MDSN, 25 from PMSN, were found highly promising (0-2) against Powdery mildew of wheat, whereas, among SAARC and TPN nurseries none of entries were found resistant.

v) Pulses

i.) Urdhbean

i. Screening for Yellow mosaic disease of Urdbean germplasm: During Kharif 2023 screening of germplasm of Urdbean designated for North Hill Zone rainfed was performed at KVK Berthin. A total of 27 entries were evaluated at RSS Berthin location during *Kharif* 2023(Table 6). The screening was done under natural infection condition. The location severity index and frequency distribution of scores was variable at Berthin centre and disease was also not uniform and at desired level of LSI (Localized severity index), hence no conclusions were dawn on the results recorded.

Table 6: Screening of Urdbean germplasm for Yellow mosaic disease

Sr. No.	Variety / Code	Seed Yield (Kg/ha)	100-Seed weight (g)	50% Flowering (Days)	Maturity (Days)	Plant Stand (%)	Plant height (cm)	No. of branches / plant	No. of Pods / Plant	Yellow mosaic incidence (%)
1.	KU-23-1	974.54	3.33	48	76	89.25	47.00	4	51	16.50
2.	KU-23-2	564.81	4.58	51	79	81.25	48.75	5	36	5.83
3.	KU-23-3	437.50	4.08	52	83	70.75	54.50	4	32	1033
4.	KU-23-4	250.00	2.20	51	83	70.00	50.50	5	27	9.67
5.	KU-23-6	939.81	3.93	49	81	83.75	51.25	4	49	14.98
6.	KU-23-7	601.85	4.35	50	79	72.50	53.00	4	37	12.61
7.	KU-23-8	1203.70	3.70	47	78	88.75	48.75	4	66	31.07
8.	KU-23-9	664.35	4.10	53	82	83.25	61.25	4	39	18.50
9.	KU-23-10	1064.81	3.80	48	77	86.25	47.75	4	55	16.93
10.	KU-23-11	685.19	4.58	49	72	80.00	36.50	4	41	11.66
11.	KU-23-12	342.59	4.00	54	84	88.25	64.50	5	30	8.13
12.	KU-23-13	965.28	3.73	48	78	88.25	50.25	5	50	12.42
13.	KU-23-14	912.04	3.50	48	80	78.75	45.25	4	48	7.83
14.	KU-23-15	949.07	4.13	48	74	77.50	48.25	4	50	6.92
15.	KU-23-16	319.44	3.15	53	84	87.00	61.00	6	29	11.42
16.	KU-23-17	483.80	4.20	47	76	75.75	53.25	4	31	21.70
17.	KU-23-18	740.74	3.78	51	81	76.25	52.00	6	42	12.93
18.	KU-23-19	314.81	4.18	52	81	75.00	71.75	4	29	18.91
19.	KU-23-20	854.17	4.15	50	81	77.00	57.25	4	46	33.67
20.	KU-23-23	803.24	4.13	50	79	82.50	47.00	4	45	12.13
21.	KU-23-25	731.48	4.03	51	82	83.75	58.25	4	41	18.01
22.	KU-23-26	787.04	3.58	47	75	73.75	38.00	4	44	9.83
23.	KU-23-27	715.28	3.63	47	76	80.00	51.75	5	41	10.00
24.	KU-23-28	671.30	3.73	49	79	80.00	59.75	5	40	16.78
25.	KU-23-29	680.56	3.53	47	74	74.50	49.00	5	40	12.41
26.	KU-23-30	995.37	3.83	47	77	77.50	42.50	4	50	11.90
27.	KU-23-31	775.46	5.43	48	80	81.25	59.00	4	43	16.22
	GM	719.56								
	SE(m)±	33.72								
	CD(P=0.05)	95.12								
	CV (%)	9.37								

i. Evaluation of advanced breeding material against MYMV, Anthracnose and Powdery Mildew

MYMV: Dhaulakuan is a hot spot for MYMV of urdbean. The disease development was very good as was evident from the disease reaction of 9 i.e. 100% incidence and severity on genotypes RVSU 22-11, -12, TPU 4 and BU 2021-3 Genotypes IPU 13-3, IPU 18-02, IPU 2-43, IPU 94-1, IUF 311, IUF 312, KU 21-10, KU 96-3, KUG 1027, KUG 1069, KUG 941, LBG 1002, LBG 787, LBG 1001, MBG 1123, PU 10, PU 12, PU 1920, PU 1921, PU 2018, PU 2021 and RUB 15-02 were free from MYMV. Genotypes DBG 90, KUG 479, PU 31, VBG 20-008, VBG 20-100 with disease reaction 1 were highly resistant whereas, genotypes Azad Urd 1, KPU 22-1 and KPU 40 were resistant among all the tested 39 urdbean entries.

Anthracnose- Dhaulakuan is also hot spot for anthracnose of urdbean. The disease development was very good as clear from the data out of screened thirty nine genotypes 3 (BU 2021, DBG-90, IUF 312) were found highly susceptible resulted the disease score of 9 whereas 6 genotypes (JLPU 813-12, KU 96-3, LUG1069, PU 12, RVSU 22-11 and VBG 20-100) resulted susceptible reaction with the disease score of 5. However none of the genotype were free from anthracnose whereas five genotypes viz., Kota Urd 4, LBG 787, PU 1921, VBN 11 and RUB 15-02 showed resistant reaction.

Powdery Mildew-Among the tested genotypes viz., IPU 13-3, IPU 2-43, IPU 94-1, IUF-311, IUF 312, KU 96-3, LBG 787, LBg 1002, LBG 1001, MBG 1134, MBG 1123, PU 10, PU12, PU 1920, Pu 1921, RVSU 22-11, VBG 20-008, VBN 11 were free from powdery mildew where as seven genotypes viz., KU 21-10, KUG 1027, KUG 479, KUG 941, PU 2021 and PU 31 showed the moderately susceptible reaction.

ii) Mungbean: During Kharif 2023 screening of germplasm of Mungbean designated for North Hill Zone rainfed was performed at KVK Berthin (Table7) . A total of 8 entries were evaluated at RSS Berthin location during *Kharif* 2023. The screening was done under natural infection condition. The location severity index and frequency distribution of scores was variable at Berthin centre and disease was also not uniform and at desired level of LSI (Localized severity index), hence no conclusions were dawn on the results recorded.

Table 7: Screening of germplasm for Yellow mosaic disease of Mungbean

S. No.	Variety / Code	eed Yield (Kg/ha)	100-Seed weight (g)	50% Flowering (Days)	laturity (Days)	Plant Stand (%)	Plant height (cm)	No. of branches / plant	No. of Pods / Plant	Yellow mosaic severity
1.	KM-23-1	972.22	3.5	54	85	89	79.75	2	32	12.03
2.	KM-23-2	581.02	3.9	53	86	91	83.25	2	20	9.11
3.	KM-23-3	543.98	3.7	45	70	72	53.75	2	18	4.08
4.	KM-23-4	643.52	4.1	44	71	72	59.75	3	25	9.55
5.	KM-23-5	766.20	3.5	43	67	73	51.00	2	29	11.18
6.	KM-23-6	611.11	3.6	45	67	72	51.00	2	21	33.54
7.	KM-23-7	1034.72	3.5	47	75	88	58.00	3	35	18.19
8.	KM-23-8	638.89	3.4	43	67	73	53.00	2	22	16.47
	GM	723.96	-	-	-	-	-	-	-	-
	SE(m)±	30.00	-	-	-	-	-	-	-	-
	CD(P=0.05)	88.82	-	-	-	-	-	-	-	-
	CV (%)	8.29	-	-	-	-	-	-	-	-

vi) Oilseeds -Soybean

1. Evaluation of breeding materials for resistant donor(s): IVT trial

Twenty eight entries of IVT- trial were sown in two replications on 29.06.2023 in RBD. Each line was sown in two rows of 3m each. Two susceptible checks i.e JS 335 and Shivalik were sown after every five entries. Data were recorded on 0-9 scale and disease reaction to the diseases is presented in table 8. The entry; VLS 106, TS 101, KDSIS 1394 and ASb 101 were found resistant to highly resistant against FLS (*Cercospora sojina*). The test entries having code AMS 22-16, and THPS 6 were found resistant to highly resistance against anthracnose (*Colletotrichum truncatum*).

Table 8: Disease reaction of IVT entries to the various diseases

Sr. No.	Entry	Frogeye leaf spot (*Cercospora sojina*)				Anthracnose (*Colletotrichum truncatum*)			
		R1	R2	Max Score	Disease reaction	R1	R2	Max Score	Disease reaction
1	NRC 270	5	5	5	MS	5	3	5	MS
2	AMS 22-16	0	3	3	MR	1	0	1	R
3	VLS 89	5	5	5	MS	1	1	1	R
4	MAUS 816	3	1	3	MR	5	5	5	MS
5	Pusa Sipani BS 8	3	5	5	MR	7	7	7	S
6	VLS 99	0	0	0	HR	1	3	3	MR
7	DS 1589	3	3	3	MR	7	5	7	S
8	RSC 11-95	7	7	7	S	1	3	3	MR
9	VLS 63 (c)	3	5	5	MS	5	3	5	MS
10	BAUS (M) 6	5	5	5	MS	3	5	5	MS
11	NRC 142 (c)	5	5	5	MS	3	3	3	MR
12	KBSL 23-36	5	5	5	MS	5	7	7	S
13	VLS 106	0	0	0	HR	3	0	3	MR
14	VLS 99(RC)	0	0	0	HR	5	5	5	MS
15	SL 1315	3	1	3	MR	5	5	5	MS
16	TS 101	1	1	1	R	5	5	5	MS
17	THPS 6	1	1	1	R	1	1	1	R
18	KDSIS 1394	0	0	0	HR	7	7	7	S
19	NRC 271	3	3	3	MR	5	5	5	MS
20	Lok-Soya 03	3	1	3	MR	5	7	7	S
21	KSS 225	1	5	5	MS	9	5	9	HS
22	DS 1547	7	7	7	S	1	3	3	MR
23	MACS 1810	5	7	7	S	5	5	5	MS
24	JS 25-08	3	3	3	MR	3	3	3	MR
25	ASb 101	1	0	1	R	7	5	7	S
26	NRC 268	5	3	5	MS	7	5	7	S
27	DLSb 5	3	5	5	MS	5	5	5	MS
28	NRC 269	5	5	5	MS	3	3	3	MR
	JS 335 Check	5	7	7	S	7	7	7	S
	Shivalik Check	7	9	9	HS	5	5	5	MS

HR= Highly resistant, R= Resistant, MR= Moderately Resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

2. Performance of the previous year's resistant entries (Frogeye leaf spot and Pod blight (Ct)

Twenty six lines found resistant in IVT, AVT, AVT-II, PP4 trials and germplasm evaluation during 2022, *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) on 29.06.2023. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS) and anthracnose (pod blight) and each entry was categorised into different disease reaction as presented in table 9. Twenty lines maintained their high resistance status against frogeye leaf spot (*Cercospora sojina*). Thirteen lines maintained their high resistance status against pod blight (*Colletotrichum truncatum*). Eight lines have shown highly resistance against both the diseases. Himso 1685 and JS 20-116 have shown constantly resistance reaction against FLS for seventh years

Table 9: Disease reaction of previous resistant entries against various diseases

S. No.	Entry	Year of testing	Frogeye leaf spot (*Cercospora sojina*)		Pod blight (*Colletotrichum truncatum*)	
			Score	Reaction	Score	Reaction
		1st	**5**	**MS**	**0**	**HR**
2	DS 1510	1st	3	MR	0	HR
3	NRCSL 5	1st	0	HR	5	MS
4	VLS 104	1st	0	HR	3	MR
5	PS 1693	1st	7	S	0	HR
6	KDS 1169	2nd	0	HR	5	MS
7	KDS 1201	2nd	0	HR	7	S
8	EC 350664	2nd	0	HR	1	R
9	EC 280129	2nd	1	R	0	HR
10	EC 308312	2nd	0	HR	0	HR
11	EC 291401	2nd	0	HR	3	MR
12	EC 393153 (late)	2nd	0	HR	0	HR
13	EC 393153	2nd	0	HR	0	HR
14	EC 390981A	2nd	1	R	0	HR
15	PK 25	3rd	0	HR	0	HR
16	UGM 77	3rd	0	HR	0	HR
17	EC 391181	3rd	0	HR	1	R
18	Harder	3rd	0	HR	0	HR
19	ASb 50	4th	0	HR	1	R
20	ASb 51	4th	3	R	1	R
21	EC 241778	4th	0	HR	0	HR
22	Cat 411A	4th	0	HR	0	HR
23	SKF 6029	4th	0	HR	1	R
24	MACS 1566	4th	0	HR	5	MS
25	Himso 1685	7th	0	HR	1	R
26	JS 20-116	7th	0	HR	3	MR
	JS 335 (Check)	-	5	MS	7	S
	Shivalik (Check)	-	9	HS	5	MS

HR= Highly resistant, R= Resistant, MR= Moderately Resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible

3. Evaluation of germplasm lines for identification of multiple disease resistant sources

Forty soybean germplasm lines received from ICAR IISR, Indore were sown on 29.06.2023. in augmented design. After every 5 entries two susceptible checks were sown. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS), anthracnose (pod blight) and brown spot (BS) and each entry was categorised into different disease reaction as presented in table 10. The germplasm lines; EC 0528663, IC 0242857, EC 0528651, IC 0501941, IC 0128988, EC 114570 and IC 0128992 were observed having multiple disease resistance against frogeye leaf spot (*Cercospora sojina*), anthracnose (*Colletotrichum truncatum*) and brown spot (*Septoria glycines*).

d) Biological management of major diseases of soybean

An experiment comprising eight treatments of seed and two foliar sprays with bioagents along with one check was conducted with three replications in RBD. Experiment was planted on 29.06.2023. Six rows at 45cm of 3 m were kept in each plot (2.7m X 3 m). Data on % field stand, % disease severity at 45 DAS, 60 DAS, 75 DAS 3, AUDPC, plant ht (cm), No. of branches per plant, No. of pods per plant, 100 seed weight (g) and Seed yield (q/ha) were recorded and presented in table 11.

f) Estimation of avoidable losses soybean diseases

The experiment was planted on 19.06.2023 comprising two main treatments ie. Variety VLS 59 and JS 335 and six sub-treatments in split plot design .Different sprays ie. one, two, three and four sprays were applied on 28.07.23, 14.08.23, 30.08.21 and 14.09. 23 were applied. Data on frogeye leaf spot (FLS) and anthracnose (pod blight) was recorded at 15 days intervals on 0-9 scale on 10 randomly

selected plants. Per cent disease index (PDI) was calculated and AUDPC was also calculated. Avoidable yield loss also calculated and presented in table 12. Frogeye leaf spot start appearing after first week of August while pod blight start appearing after first week of September. 4.78 to 27.63% avoidable losses have been observed in moderately resistant variety VLS 59 due to frogeye leaf spot and anthracnose diseases. While 11.67 to 33.35% avoidable losses have been observed in susceptible variety JS 335 due to frogeye leaf spot and anthracnose.

Table 10: Evaluation of germplasm for multiple disease resistant sources

Code	Entry	Disease reaction					
		Frogeye leaf spot (*Cercospora sojina*)		Pod blight (*Colletotrichum truncatum*)		Brown spot (*Septoria glycines*)	
		Score	Reaction	Score	Reaction	Score	Reaction
1	IC 0419798	3	MR	5	MS	5	MS
2	IC 27150	3	MR	1	R	3	MR
3	IC 107903	7	S	1	R	1	R
4	IC 0548724	3	MR	1	R	1	R
5	EC 0528663	0	HR	0	HR	1	R
6	IC 13005	7	S	1	R	3	MR
7	EC 341825	5	MS	1	R	3	MR
8	IC 0129014	3	MR	1	R	3	MR
9	IC 0501894	3	MR	1	R	3	MR
10	EC 57048	5	MS	3	MR	3	MR
11	IC 0241857	0	HR	1	R	3	MR
12	EC 14674	3	MR	1	R	3	MR
13	EC 76750	5	MS	1	R	3	MR
14	EC 39743	7	S	1	R	3	MR
15	EC 0528651 (late)	0	MS	1	R	1	R
16	EC 99552	1	R	5	MS	5	MS
17	EC 76757 (late)	5	MS	1	R	1	R
18	IC 0548721	5	MS	1	R	1	R
19	EC 0241711	3	MR	3	MR	3	MR
20	IC 0501941	1	R	1	MS	1	M
21	EC 50057	3	MR	1	R	3	MR
22	IC 419847	3	MR	1	R	3	MR
23	EC 0097789	1	R	1	R	3	MR
24	EC 76752 (late)	7	MR	1	R	3	MR
25	IC 0574382	3	MR	3	MR	3	MR
26	EC 58526	5	MS	1	R	3	MR
27	IC 0316142	7	S	1	R	3	MR
28	IC 0128988	0	HR	1	R	3	MR
29	EC 0257977	9	HS	1	R	3	MR
30	IC 0281845	7	S	1	R	1	R
31	EC 114570	0	HR	1	R	3	MR
32	IC 0118431	3	MR	1	R	3	MR
33	EC 0039494	5	MS	1	R	3	MR
34	IC 0118409	7	S	3	MR	3	MR
35	EC 39766 (late)	7	S	3	MR	3	MR
36	IC 0128992	0	HR	1	R	1	R
37	IC 0538013	7	S	1	R	3	MR
38	IC 0501867	3	MR	1	R	3	MR
39	EC 0251874	1	R	1	R	3	MR
40	IC 0574362	5	MS	1	R	3	MR
	JS 335 (Check)	7	S	9	HS	3	MR
	Shivalik (Check)	9	HS	3	MR	5	MS

HR= Highly resistant, R= Resistant, MR= Moderately Resistant, MS= Moderately susceptible, S= Susceptible, HS= Highly susceptible, Late= late maturing (so may be escape in pod blight), NG= Line not germinated, - = lines not received

.

Table 11: Biological management of major diseases of soybean

Treatment	Frogeye leaf spot (*Cercospora sojina*)					Pod blight/Anthracnose (*Colletotrichum truncatum*)			Pl. Height(cm)	No. of branches /pl	Pods /Pl	100 seed wt(g)	Yield q/h
		PDI (%)			AUDPC	PDI(%)		AUDPC					
	Field stand (%)	31th Aug.	15th Sept.	30th Sept		15th Sept	30th Sept.						
T1= Seed application of *Bacillus amyloliquefaciens* (5g/kg)	96.37	5.18	13.33	34.81	499.88	9.18	23.80	247.38	84.5	3.2	41.1	12.67	16.71
T2= Seed application of *B. subtilus* (5g/kg)	96.50	4.81	14.44	35.55	519.30	9.99	22.54	244.00	83.5	3.4	42.7	12.83	16.83
T3= Foliar application of *B. amyloliquefaciens* (10g/l)	95.37	4.81	14.07	30.74	477.65	10.29	25.14	265.70	90.2	3.3	45.0	12.67	16.30
T4= Foliar application of *B. subtilis* (10g/l)	95.60	4.44	13.33	36.29	505.45	6.29	21.25	206.58	85.2	3.0	44.7	13.00	17.28
T5= Seed application of local strain of *Trichoderma sp.* (5g/kg)	96.03	4.44	13.33	40.00	533.23	8.25	25.17	250.65	80.9	3.7	42.9	12.17	16.26
T6= Foliar application of local strain of *Trichoderma sp.* (10g/l)	96.23	5.92	13.70	37.77	533.15	8.03	23.96	239.95	83.1	3.2	39.4	12.33	17.00
T7= Seed application of local strain of *Pseudomonas fluorescence* (5g/kg)	90.90	5.55	15.92	40.74	585.98	10.29	31.21	311.25	82.1	2.9	40.1	12.50	16.05
T8= Foliar application of local strain of *Pseudomonas fluorescence* (10g/l)	96.03	5.92	16.66	38.51	583.15	9.99	22.54	244.00	81.5	3.0	42.9	12.33	16.46
T9 =Control	94.77	6.29	15.51	39.92	579.30	9.36	30.03	295.43	79.6	3.3	44.0	12.33	14.40
CD	NS	-	-	NS	NS	-	NS	NS	NS	NS	NS	NS	1.108

Seed treatment @ 5g/ kg seed, Two foliar sprays @ 10g/L were applied after 40 DAS and 55 DAS

Table.12: Assessment of avoidable losses due to FLS and pod blight

Variety/Treatment	PDI of Frogeye leaf spot					PDI of Pod blight			Yield (q/ha)	Avoidable yield loss (%)
	16th Aug	1st Sept	16th Sept	30th Sept	AUDPC	15th Sept.	30th Sept.	AUDPC		
Variety 1: VLS 59										
Sub T 1= Seed treatment + one spray	4.44	10.15	18.88	34.43	726.85	8.14	23.94	240.65	16.05	22.66
Sub T 2= Seed treatment + two sprays	3.70	5.18	14.06	27.95	526.05	6.66	17.77	183.25	17.78	14.27
Sub T 3= Seed treatment + three sprays	3.03	5.18	5.92	18.51	328.05	4.07	12.22	122.15	19.75	4.78
Sub T 4= Seed treatment + four sprays	2.96	5.18	5.18	11.84	266.43	3.70	6.66	77.70	20.74	-
Sub T 5= Seed treatment + water spray	3.70	10.37	22.95	38.85	818.93	9.99	22.95	247.10	16.15	22.13
Sub T 6= No seed treatment and no spray	4.81	14.07	30.36	39.24	996.80	12.22	26.66	291.55	15.01	27.63
Variety-2 (JS 335)										
Sub T 1= Seed treatment + one spray	5.92	15.17	28.87	42.45	1023.48	21.00	41.62	469.63	13.33	25.03
Sub T 2= Seed treatment + two sprays	5.92	8.14	21.47	37.02	766.23	14.81	26.45	309.45	14.86	16.42
Sub T 3= Seed treatment + three sprays	6.29	7.40	10.37	22.21	480.23	10.37	17.39	208.20	15.65	11.67
Sub T 4= Seed treatment + four sprays	6.29	6.66	8.51	16.28	396.85	6.29	10.36	124.90	17.78	-
Sub T 5= Seed treatment + water spray	7.77	23.69	37.02	45.54	1310.40	28.28	45.55	553.75	12.35	30.54
Sub T 6= No seed treatment and no spray	7.77	28.14	46.26	50.72	1554.70	33.69	46.29	599.85	11.85	33.35
CD (P=0.05)				A=2.662 B=4.611 A x B= NS	A=54.685 B=94.717 A x B= 133.95		A=1.93 B=3.342 A x B= 4.727	A=22.539 B=39.039 A x B= 55.209	A= 1.293 B= 2.240 AxB=NS	-

Figures in parentheses are angular transformation value, A = main factor (variety), B = Sub-factor (Fungicide treatments)

Seed treatment: Thiophanate methyl + Pyraclostrobin @ 2ml/kg of seed Foliar spray: Tebuconazole @ 625ml/ha

vii) Linseed

Different foliar pathogens infecting linseed at Kangra and Palampur regions were isolated and maintained as pure cultures in refrigerator. They were identified tentatively as *Alternaria* spp. based on their morpho-cultural characteristics. Further, the cultures will be identified on molecular basis. The molecular identification work is under progress.

iviii) Vegetables

A total of 51 endophytic fungi were isolated from healthy pea roots samples collected from sub-tropical and dry temperate zones of Himachal Pradesh. Of total, three promising strains *viz. Schizophyllum* sp. isolate JPE19, *Epicoccum* sp. isolate JPE2 and *Talaromyces purpureogenus* isolate JPE38 displayed remarkable plant growth and disease control potential against pea root rot complex therefore could be used as the eco-friendly alternatives for tackling pea root rot complex in future.A total of 34 pathogens associated with root rot of pea has been isolated from different locations of Kangra, Mandi, Hamirpur and Lahaul Spiti districts of Himachal Pradesh. Out of 34 pathogen cultures, *Fusarium oxysporum* was recorded the most prevalent pathogen associated with pea root rot/wilt disease in Himachal Pradesh. Screening of 186 pea cultivars for evaluation against powdery mildew and root rot complex has been conducted at research farm of Research Sub –Station Lari-CSKHPKV. The data analysis work is under progress.

ix) Forage crops

1. Evaluation of breeding material: During *Kharif*, 57 entries of maize were evaluated against leaf blight and all the entries except fifteen found either resistant or moderately resistant Table 13). However, in cowpea 18 entries were evaluated and all the entries except four were found moderately susceptible, susceptible and highly susceptible. During *Rabi,* 65 entries were evaluated and 13 entries were found resistant, under different experiments of oats against powdery mildew. Berseem having 11 entries were evaluated and 1 entry was found resistant, under different experiments of berseem against root rot and 3 entries were found moderately resistant to leaf blight of berseem.

Table 13 - Field screening of *Kharif* & *Rabi* breeding material

Crop and disease	**Name of the trial**	**Entries**	**Resistant entries**		**Moderate Resistant**	
Maize (Leaf blights)	AVTM-2 (Seed)	07	AVTM-2 (Seed)- 1, 2, 7		AVTM-2 (Seed)- 4, 6	
	AVTM-2 (FM)	07	AVTM-2 (FM)- 6		AVTM-2 (FM)- 2, 4, 5	
	AVTM-1	16	AVTM-1- 3, 10		AVTM-1- 1, 2, 4, 6, 7, 8, 9,	
	IVTM-2 (FM)	27	IVTM-2 (FM)- 11, 20, 21, 23, 24, 25		IVTM-2 (FM)- 2, 4-10, 12-14, 16-19, 22, 26, 27	
Cowpea (Root rots)	IVTC	11	Nil		IVTC- 5, 7	
	AVTC	07	Nil		AVTC- 1, 4	
Oats (Powdery mildew)	IVTO (SC)	15	IVTO (SC)- 4-7, 9-12		IVTO (SC)-8	
	IVTO (MC)	13	IVTO (MC)- 2, 8, 12		IVTO (MC) - 1, 13	
	AVTO-2 (MC)	11	-		AVTO-2 (MC)- 6, 10	
	AVTO-1 (SC)	10	AVTO-1 (SC)- 7		AVTO-1 (SC)- 4, 10	
	AVTO-2 (MC) Seed	11	AVTO-2 (MC) Seed- 3		AVTO-2 (MC) Seed- 4	
	AVTO-1 (MC)	05	Nil		Nil	
Beseem (Root rot)			Root rot	Leaf blight	Root rot	Leaf blight
	IVTB	7	IVTB- 7	Nil	IVTB- 2, 6	Nil
	AVTB	4	Nil	Nil	AVTB- 3, 4	AVTB- 2, 3, 4

2: Germplasm evaluation programme against diseases in *Kharif* and *Rabi* forages

i. ***Kharif,* 2023:** In maize 44 entries were evaluated and 3 entries were found resistant, 13 entries were found moderately resistant, 5 entries were found susceptible and 8 entries were found moderately susceptible, under different experiments of maize against leaf blight, However, in cowpea 130 entries were evaluated, none was found resistant, 21 entries were found moderately resistant, 38 entries were found susceptible, 48 entries were found moderately susceptible and 23 entries were found highly susceptible, under different experiments of cowpea against root rot

***Rabi*:** In oats 71 entries were evaluated against diseases and insect-pests and 1 entry *i.e.,* GETO-66 was found resistant, 5 entries *i.e.,* GETO-5, 7, 8, 9 and 65 were found moderately resistant against powdery mildew. Rest all entries were recorded as susceptible and highly susceptible. However, in berseem 29 entries were evaluated and 7 entries *i.e.,* GETB- 4, 7, 11, 18, 22, 26 and 29 were found moderately resistant against root rot. Rest all entries were recorded as moderately susceptible and susceptible

3. Eco friendly management of zonate leaf spot of Sorghum

The experiment was conducted with 9 treatments having 3 replications in RBD design at Palampur for the management of zonate leaf spot (*Gloeocercospora sorghi*) of Sorghum using non chemical methods (Table 14). Among all the treatments three foliar spray of propiconazole @ 0.1% (Chemical check) was found most effective which gave 51.22 % disease control with 68.26 % increase in the green fodder yield over check. Among the non-chemical methods three foliar sprays of extract of eupatorium ark @ 10% giving 41.87 % disease control with 41.59 % increase in the yield over check, was found best which was followed with non-significant differences by three foliar spray of Tamarlassi @ 10% with 39.02 % disease control with 23.81 % increase in the yield over check. Three foliar spray of Azadirachtin @ 0.3 % also found effective with 32.93 % disease control and 12.38 % increase in the yield. Three foliar spray of Panchgavya @ 10% also found effective with 30.89 % disease control and 7.62 % increase in the yield. The values of r/day and AUDPC were also observed minimum *i.e.,* 0.03 and 505.17, respectively in chemical check. Among non-chemical treatments minimum r and AUDPC were observed least in treatment having three foliar spray of extract of eupatorium ark @ 10% *i.e.,* 0.05 and 546, respectively. This was followed by three foliar spray of Tamarlassi @ 10% having r 0.07 and AUDPC 578.67, respectively. The relative infection rate and AUDPC values also show the effect of the treatment in the management of the disease. In control the disease severity was observed 82 per cent with maximum r (0.17) per day and AUDPC (847) and minimum GFY (102.22 q/ha).

4: Estimation of yield losses due to foliar diseases (anthracnose, gray leaf spot and zonate leaf spot) in fodder sorghum

The experiment was conducted with 8 treatments having 3 replications in RBD design at Palampur for the management of zonate leaf spot (*Gloeocercospora sorghi*) of Sorghum (Table 15). Among all the treatments, seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 20 and 35 DAE was found most effective which gave 42.86 % disease control with 68.57 % increase in the green fodder yield over check. This was followed with non-significant difference by seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 35 DAE with 41.90 % disease control and 52.38 % increase in the yield over check. The values of r/day and AUDPC were also observed as 0.04 and 606.67, respectively in treatment having seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 20 and 35 DAE. This was followed by seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 35 DAE having r 0.05 and AUDPC 637.00, respectively. The

relative infection rate and AUDPC values also show the effect of the treatment in the management of disease. In control the disease severity was observed 70 per cent with maximum r (0.12) per day and AUDPC (941.50) and minimum GFY (105 q/ha).

Table 14: Eco friendly management of zonate leaf spot of Sorghum
Treatments:

Treatment	Zonate leaf spot of Sorghum						GFY	
	Zonate leaf spot		r (per day)		AUDPC			
	Severity (%)	Control (%)	Rate (r)	Relative infection rate (%)	AUDPC	Relative AUDPC (%)	(q/h)	Increase over check (%)
T1	63.33 (52.72)*	22.76	0.09	58.82	704.67	83.2	125.68	19.69
T2	66.67 (54.73)	18.70	0.12	70.59	701.17	82.78	121.68	15.89
T3	58.33 (49.78)	28.86	0.09	52.94	660.33	77.96	116.68	11.12
T4	50.00 (44.98)	39.02	0.07	41.18	578.67	68.32	130.00	23.81
T5	47.67 (43.64)	41.87	0.05	35.29	546.00	64.46	148.67	41.59
T6	55.00 (47.86)	32.93	0.07	41.18	634.67	74.93	118.00	12.38
T7	56.67 (48.82)	30.89	0.08	47.06	627.67	74.11	113.00	7.62
T8	40.00 (39.21)	51.22	0.03	17.65	505.17	59.64	176.67	68.26
T9	82.00 (64.89)	-	0.17	-	847.00	-	105.00	-
CD (5%)	3.51		0.03		44.99		26.02	
CV	4.06		20.25		3.99		11.61	
SE (M)±	1.16		0.10		14.88		8.61	

T1: Three foliar spray of *Trichoderma viride* @ 0.5%
T2: Three foliar spray of *Psuedomonas flourescens* @ 0.5%
T3: Three foliar spray of Jeevamrit @ 10%
T4: Three foliar spray of Tamarlassi @ 10%
T5: Three foliar spray of extract of eupatorium ark @ 10%
T6: Three foliar spray of Azadirachtin 3000 ppm @ 0.3%
T7: Three foliar spray of Panchgavya @ 10%
T8: Three foliar spray of propiconazole @ 0.1% (Chemical control)
T9: Control

Table-15: Estimation of yield losses due to foliar diseases (anthracnose, gray leaf spot and zonate leaf spot) in fodder sorghum

*Figures in parentheses are arc sine transformed values

Treatment	Zonate leaf spot of Sorghum						Quality Characters						GFY	
	Zonate leaf spot		r (per day)		AUDPC		Crude protein		ADF		NDF			
	Severity (%)	Control (%)	Rate (r)	Relative infection rate (%)	AUDPC	Relative AUDPC (%)	Crude protein (%)	% decrease	ADF (%)	% decrease	NDF (%)	% decrease	(q/h)	Increase over check (%)
T1	40.00 (39.22)*	42.86	0.04	35.69	606.67	64.43	9.33	-8.11	57.00	4.04	68.00	4.76	177.00	68.57
T2	46.00 (42.69)	34.29	0.06	72.53	688.33	73.10	9.33	-8.11	57.80	2.69	69.00	3.36	159.00	51.43
T3	40.67 (39.60)	41.90	0.05	55.99	637.00	67.66	9.10	-5.45	58.00	2.36	69.00	3.36	160.00	52.38
T4	46.00 (42.69)	34.29	0.06	72.53	698.83	74.23	8.87	-2.78	58.40	1.68	70.40	1.40	121.00	15.24
T5	47.67 (43.65)	31.90	0.06	46.77	691.83	73.48	9.22	-6.84	58.60	1.35	70.80	0.84	144.00	37.14
T6	43.00 (40.96)	38.57	0.06	72.53	647.50	68.77	9.22	-6.84	59.00	0.67	71.00	0.56	151.00	43.81
T7	43.33 (41.15)	38.10	0.07	72.53	651.00	69.14	8.75	-1.39	59.40	0.00	71.40	0.00	133.00	26.67
T8	70.00 (56.82)	-	0.12	-	941.50	-	8.63	-	59.40	-	71.40		105.00	-
CD (5%)	2.74		0.02		46.32		0.25		-		-		24.27	
CV	3.58		18.96		3.77		1.55		-		-		9.55	
SE (M)±	0.90		0.01		15.13		0.08		-		-		7.93	

T1: Seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 20 and 35 days after emergence (DAE)
T2: Seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 20 DAE
T3: Seed treatment with carbendazim (2g/kg) + foliar spray of propiconazole @ 1ml/l at 35 DAE
T4: Foliar spray of propiconazole @ 1ml/l at 20 and 35 DAE
T5: Foliar spray of propiconazole @ 1ml/l at 20 DAE
T6: Foliar spray of propiconazole @ 1ml/l at 35 DAE
T7: Seed treatment with carbendazim (2g/kg)
T8: Control

5: Development of *Trichoderma* mediated biocontrol strategy for managing leaf blight (*Drechslera avenae*) disease in Oat: Ten isolates of *Drechslera avenae* causing leaf blight in oat have been isolated from disease samples collected from locations in and around Palampur center (Table16). These isolates have been identified based on morpho-cultural characteristics and are being maintained under suitable laboratory conditions. Fifteen isolates of *Trichoderma* species have been isolated from rhizospheric soil of oat collected from different oat growing area of Himachal Pradesh. During this year these *Trichoderma* isolates were evaluated against four isolates i.e. OLB-1, OLB-2, OLB-3, OLB-4 of *Dreschlera avenae* under *in vitro* in dual culture. Out of these, *Trichoderma* isolate OTS-12 was found most effective against Palampur isolate of *Drechslera avenae* with 88.89 per cent mycelial inhibition of the pathogen over control in dual culture assay followed by OTS-5 which showed 85.56 per cent mycelial inhibition of the pathogen over control.

Table 16: Development of *Trichoderma* mediated biocontrol strategy for managing leaf blight (*Drechslera avenae*) of Oat

***Trichoderma* isolate**	***Dreschlera avenae* isolate**							
	OLB-1		**OLB-2**		**OLB-3**		**OLB-4**	
	Mycelial growth (mm)	% Mycelial inhibition	Mycelial growth (mm)	% Mycelial inhibition	Mycelial growth (mm)	% Mycelial inhibition	Mycelial growth (mm)	% Mycelial inhibition
OTS-1	30	66.67	43	52.22	50	44.44	40	55.56
OTS-2	40	55.56	37	58.89	47	47.78	35	61.11
OTS-3	53	41.11	52	42.22	37	58.89	50	44.44
OTS-4	54	40.00	53	41.11	51	43.33	52	42.22
OTS-5	13	85.56	18	80.00	17	81.11	20	77.78
OTS-6	50	44.44	38	57.78	45	50.00	43	52.22
OTS-7	20	77.78	25	72.22	18	80.00	23	74.44
OTS-8	40	55.56	50	44.44	38	57.78	46	48.89
OTS-9	50	44.44	45	50	42	53.33	47	47.78
OTS-10	45	50.00	35	61.11	35	61.11	39	56.67
OTS-11	30	66.67	50	44.44	45	50.00	46	48.89
OTS-12	10	88.89	12	86.67	13	85.56	15	83.33
OTS-13	18	80.00	15	83.33	20	77.78	20	77.78
OTS-14	30	66.67	40	55.56	50	44.44	40	55.56
OTS-15	50	44.44	47	47.78	30	66.67	50	44.44
Control	90	-	90	-	90	-	90	-

*Figures in parentheses are arc sign transformed

Details of *Dreschlera avenae* isolates		**Details of *Trichoderma* isolates**	
Isolate	**Location**	**Isolate**	**Location**
OLB-1	Palampur, Experimental field	OTS-1	Arla, Kangra
OLB-2	Malan, Kangra	OTS-2	NagrotaBhagwan, Kangra
OLB-3	Nehran Pukhar, Kangra	OTS-3	Nadaun, Hamirpur
OLB-4	Nadaun, Hamirpur	OTS-4	Bagoda, Kangra
OLB-5	Yol Cantt, Kangra	OTS-5	Nagri, Kangra
OLB-6	Bhota, Kangra	OTS-6	Hatwas, Kangra
OLB-7	Dhaliara, Kangra	OTS-7	Bharmoti, Hamirpur
OLB-8	Dehra, Kangra	OTS-8	Rangarh, Hamirpur
OLB-9	Nagrota Bhagwan, Kangra	OTS-9	Patohla, Kangra
OLB-10	Bajuri, Hamirpur	OTS-10	Dharmshala, Kangra
		OTS-11	Khoala, Kangra
		OTS-12	Yol Cantt, Kangra
		OTS-13	Kangra
		OTS-14	Pragpur, Kangra
		OTS-15	Samloti, Kangra

6: Eco friendly management of powdery mildew of white clover caused by *Erysiphe trifoliorum:* The experiment was conducted for the management of powdery mildew of white clover with ten different non-chemical treatments (Table 17). The experiment was having 10 treatment including untreated check and chemical check (three foliar spray of hexaconazole @ 0.1%). Out of ten treatments, T9 (three foliar spray of hexaconazole @ 0.1%) was found most effective with 5.14 per cent disease severity, 82.78 per cent disease control, 253.8 AUDPC, 0.03 rate of infection and 1.56 q/ha yield against powdery mildew in white clover. Among ecofriendly treatments T6 *i.e.,* three foliar spray of dashparni @ 2% was found best with 7.32 per cent disease severity with 75.45 per cent disease control, 292.45 AUDPC, 0.07 rate of infection and 1.41q/ha yield against powdery mildew in white clover.

Table-17: Eco friendly management of powdery mildew of white clover caused by *Erysiphe trifoliorum*

Sr. No	Treatments	Severity (%)	Control (%)	AUDPC	Relative AUDPC (%)	r	Relative infection rate (%)	Yield (q/ha)	Increase over check (%)
T1	Three foliar spray of *Trichoderma viride* @0.5%	12.13 (3.62)*	59.31	445.35	63.48	0.22	62.86	1.27	11.40
T2	Three foliar spray of *Pseudomonas flourescens* @ 0.5%	14.53 (3.94)	51.26	458.35	65.34	0.27	77.14	1.22	7.02
T3	Three foliar spray of Chitosan @ 0.05%	9.53 (3.24)	68.03	346.98	49.46	0.12	34.29	1.38	21.05
T4	Three foliar spray of Jeevamrit @ 10%	13.17 (3.76)	55.85	424.34	60.49	0.17	48.57	1.24	8.77
T5	Three foliar spray of Tamarlassi @ 10%	17.70 (4.32)	40.64	521.34	74.32	0.29	82.86	1.20	5.26
T6	Three foliar spray of Dashparni @ 2%	7.32 (2.88)	75.45	292.45	41.69	0.07	20	1.41	23.68
T7	Three foliar spray of Eupatorium ark @ 10%	10.94 (3.45)	63.30	363.83	51.86	0.13	37.14	1.30	14.04
T8	Three foliar spray of Vitex extract @ 10%	19.83 (4.57)	33.52	568.08	80.98	0.29	82.86	1.17	2.63
T9	Three foliar spray of Hexaconazole @ 0.1%	5.14 (2.47)	82.78	253.80	36.18	0.03	8.57	1.56	36.84
T10	Untreated Control	29.82 (5.54)	--	701.51	--	0.35	--	1.14	--
C.D.		3.65		75.51				0.10	
SE(d)		1.72		35.66				0.05	
SE (m)		1.22		25.22				0.03	
C.V.		15.06		9.98				4.34	

7: Yield loss assessment due to leaf blight in fodder oats: The experiment was conducted to assess the crop losses due to leaf blight in oats (JHO 99) with two treatments i.e. artificially inoculated plot and Control (uninoculated + fungicide treated plot). In Artificially inoculated plot treatment 70 per cent

leaf blight disease severity was found with 323 q/ha yield. In the Control (uninoculated + fungicide treated plot) treatment, 42 per cent leaf blight disease severity was found with 40 per cent control and 370 q/ha yield with 14.55 per cent increase over artificially inoculated plot treatment in oat (Table18). Hence by using foliar spray of propiconazole @ 1ml/l at 15 days interval for disease management 14.55 per cent losses of GFY can be avoided in oats at Palampur.

Table 18: Yield loss assessment due to leaf blight in fodder oats

Sr. No	Treatments	Disease Severity (%)	Control (%)	Green fodder Yield (q/ha)	Increase over check (%)
T1	Artificially inoculated plot	70 (56.79)*	--	323.00	--
T2	Control (uninoculated + fungicide treated plot)	42 (40.38)	40.00	370.00	14.55
CD (P=0.05)		2.42		12.32	
SE(m)		0.69		3.49	
SE (d)		0.97		4.94	
CV		3.24		2.67	

*Figures in parentheses are arc sine transformed values

Different foliar and soil borne pathogen (s) infecting Lucerne grass has been collected from Research Farm of Research Sub-Station Lari and the laboratory work on isolation of these pathogen (s) is under progress.

x) Molecular Plant Pathology

Eight fungal root endophytes *viz.* *Epicoccum* sp. isolate JPE2, *Fusarium oxysporum* isolate JPE6, *Aspergillus* sp. isolate JPE7, *Epicoccum sorghinum* isolate JPE13, *Schizophyllum* sp.isolateJPE19, *Fusarium solani* isolate JPE20, *Fusarium* sp. isolate JPE23 and *Talaromyces purpureogenus* isolate JPE38 associated with pea were identified by ITS sequence analysis using the primer pair ITS 1 and ITS 4. The severe attack of dieback pathogen was observed on Seabucthorn plants at adjoining areas of Research Sub-Station Lari-CSK HPKV Palampur. The pathogen was isolated, purified and maintained at 4^{o}C temperature under refrigerator for further studies. The molecular identification work of pathogen is under progress.

xi) Seed Pathology

Rice: Various Rice diseases, including False smut, Bacterial leaf blight, Neck blast, Sheath rot, Sheath blight, Brown spot, and leaf scald, were surveyed across different districts of Himachal Pradesh (Table 19). In Hamirpur district, the incidence of brown spot was low (1-2%), while a high incidence of false smut disease (5%) was observed in Dimmi on variety LG No. 1. In Mandi district, the incidence of brown spot was low (1-3%), with a high incidence of false smut disease (5%) observed in Chaang for Star 795 and a low incidence (1%) in Balh for Byala. In Kangra district, the incidence of brown spot was low (1-3%), with a comparative high incidence of false smut disease (5%) observed in Palampur, Yol, and Malan for GBW 343, Sawa 200, and 234 No., varieties respectively. In Chamba district, the incidence of false smut (3%), brown spot (2%), and Sheath rot (2%) was low in Vijeta 700. In Una district, the incidence of false smut (1-10%) and brown spot (10-20%) was high in variety PR 126. In Sirmour district, the incidence of false smut

(5%), Bacterial leaf blight (5-10%), Neck Blast (5%), Sheath rot (5-10%), and Brown spot (10-15%) were recorded.

Wheat: Among seed borne diseases of wheat, Loose smut and Common Bunt were observed in districts *viz.,* Mandi, Bilaspur, Sirmour and Hamirpur districts of Himachal Pradesh to the extent of 0-2 per cent. Both the diseases were observed on variety HPW 368.

Table-19: Status of seed borne diseases in rice hybrids/ improved rice varieties cultivated by farmers in Himachal Pradesh during *kharif* 2023

Location District/ Blocks	Location	Variety	False Smut Incidence (%)	False Smut Incidence (Scale 0-9)	BLB Severity (%)	Neck Blast	Sheath Rot	Sheath Blight Incidence	Brown Spot (BS)/ Narrow Brown Leaf Spot (NBLS)	Leaf Scald
Hamirpur										
Hamirpur	Bhira	Sawa 200	4						1	
	Kehdru	Local	2						1	
Bhoranj	Khad Bazar	Star 795	4						2	
Bhoranj	Dimmi	LG No. 1	5						1	
	Bhareri	Local	1						1	
Mandi										
Baldwada	Bahi	Tanatan	3						3	
Jogindernagar	Bharnahu	Star795, Sawa 200	4						1	
Jogindernagar	Narla	Sawa 200	2						1	
Jogindernagar	Harabhag	Tanatan	4						1	
Jogindernagar	Chhang	Star 795	5						1	
	Baldwada	LV	2						-	
	Barot	LV	2						1	
	Ghatasani	Chaina (LLR)	5						2	
	Chauntra	Chaina (LLR)	3-4						1	
	Ropapadhar	Chaina (LLR)	3						2	
Sundernagar	Balh	Byala	1						-	
Kangra										
Palampur	Gadiyara	HD 3086	4						1	
Palampur	Sihotu	HS 562, 5258	4						2	
Palampur	Panchrukhi	GBW 343	5						1	
Dharamshala	Tang	6129, Tanatan	4						3	
Dharamshala	Sheelan	Star795, Sawa 200	3						1	
Yol	Narwana	Sawa	5						1	

		200								
Baijanath	Mahakaal	Tanatan	3						1	
	Shahpur	LV	3							
	Paraur	LV	4-5							
	Gaggal	LV	3							
	Chamunda	LV	4-5							
	Malan	234No.	5		1-5					1-2
	Lahla	200 No.	1-2							
	Icchi	Shriram	4-5		1-2			1-2		
	Birta	234 No.	3							
	Baijnath	-	1-2							
Chamba										
Bhatiyat	Sihunta	Vijeta 700	3		-	-	2		2	
Chowari	Ladi		3				1		2	
Una										
	Haroli		3						1-5	
	Jankaur	PR 126	1-10						10-20	
	Bangana		2					-		
Sirmour (Block Paonta Sahib)										
	Parduni	Arize 6444	2	1	5-10	2	5-10	5-10	10-15	-
	Surajpur	Pusa 1509	5	3	5-10	5	5-10	5-10	5	-
	Majra	HPR 2795	2	1	T	5	5-10	5	5-10	-
	Kotri vyas	HPR 2795	5	3	T	5	5-10	5	5-10	-
	Kedarpur	PR 130	5	3	T	5	1-5	5-10	10-15	-
	Bhoopur	PR126	5	3	5-10	5	1-5	5-10	10-15	-
	Navada	Lal Killa	-	-	T	-	-	T	-	-
	Kansipur	Pusa 1121	5	3	-	2	5-10	5-10	5-10	-
	Shivpur	Pusa 1121	5	3	-	2	5-10	5-10	5-10	-
	Manpur Deora	Pusa 1121	-	-	-	2	5-10	5	5-10	--
	Jamniwala	PR126	5	3	T	5	1-5	5-10	10-15	-
	Sainwala	PR 130	5	3	T	5	1-5	5-10	10-15	-
	Chandpur	Sarvati	-	-	T	-	5	-	-	-
	Puruwala	Lal Killa	-	-	T	-	T	T	-	-
	Khara	Arize 6444	2	1	5-10	2	1-5	5-10	10-15	-
	Dhaulakaun	Arize 6444	2	1	-	2	1-5	5-10	10-15	-

xii) Mushrooms

Survey was conducted in two districts of H.P i.e Kangra and Mandi for collection, identification and conservation of wild edible and medicinal mushrooms. 27 samples were collected in total and 8 were deposited in DMR for obtaining Accession Numbers (Table 20). P-23-2 was identified as *Gymnopus* sp. and was allotted accession number (DMRX-2263)

Table 20. Collection, identification and conservation of wild edible and medicinal mushrooms from Palampur and nearby areas

Centre	No. of Mushroom specimen collected	No. of specimen deposited	Accession no. obtained
Mandi	23	8	1
Palampur	4	0	-
Total	**27**	**8**	**1**

Sample No	DMR Accession No.	Habitat	GPS data (Longitude Latitude)	Tentative identification
P-23-02	DMRX-2263	Jhatingri, Mandi	31.4405° N 77.30287°E	*Gymnopus* sp.

Exp -1: Performance of selected white accessions of *Agaricus bisporus* in Initial Varietal trial

Initial Varietal trial for selected white accessions (IVTB 23-01-10) of *Agaricus bisporus* were conducted and following recommendations were made (Table21). Maximum yielders were IVTB-23-05 (28.09 Kg) followed by IVTB-23-07 and 06 (27.63 Kg and 26.96 kg) and minimum yielder was IVTB-23-04 (23.98 kg). Time taken for first harvest (post casing) between 21-22 days and average fruit body weight ranged between 17-19 gms.

Table 21. Initial Varietal trial for selected white accessions (IVTB 23-01-10) of *Agaricus bisporus*

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
IVTB-23-01	25.80	21	18.48
IVTB-23-02	26.13	21	17.50
IVTB-23-03	25.10	21	18.62
IVTB-23-04	23.98	21	17.79
IVTB-23-05	28.09	21	17.72
IVTB-23-06	26.96	22	17.99
IVTB-23-07	27.63	22	18.48
IVTB-23-08	24.07	22	17.30
IVTB-23-09	26.85	22	18.82
IVTB-23-10	24.46	22	17.57
CD (0.05)	**1.77**		**0.80**

Compost parameters				
Centre	**pH**	**Nitrogen (%)**	**Moisture (%)**	**Colour**
Palampur	7.6	1.8	68%	Brownish-Blackish

Exp-2: Advance Varietal Trial- 2 for selected white accessions of *Agaricus bisporus*

Advance Varietal Trial- 2 for selected white accessions of *Agaricus bisporus (*AVTB-23-201-206) were conducted and following recommendations were made (Table 22). Maximum yielder was AVTB-23-201 (24.52 Kg) followed by AVTB-23-202 and 206 (23.07Kg and 22.42 kg) and minimum yielder was AVTB-23-205 (19.41kg). Time taken for first harvest (post casing) was between 21-24 days and average fruit body weight ranged between 16-19gms.

Table 22. Performance of selected white accessions of *Agaricus bisporus* in Advance Varietal Trial- 2

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
AVTB-23-201	24.52	21.50	18.28
AVTB-23-202	23.07	22.34	17.32
AVTB-23-203	20.70	22.25	16.57
AVTB-23-204	21.76	23.25	17.79
AVTB-23-205	19.41	24.00	16.90
AVTB-23-206	22.42	23.50	18.62
CD(0.05)	2.21		0.01

Compost parameters				
Centre	**pH**	**Nitrogen (%)**	**Moisture (%)**	**Colour**
Palampur	7.6	1.8	68%	Brownish-Blackish

Exp-3: AVT-2 of high yielding varieties/strains of Oyster Mushroom (*Pleurotus pulmonarius)*

AVT-2 of high yielding varieties/strains of Oyster Mushroom (*Pleurotus pulmonarius*) was conducted and following recommendations were made (Table 23).Maximum yielder was PP23-206 (87.23 Kg) and PP 23-203 and 205 (79.29 Kg and 75.71 kg) and minimum yielders were PP-23-201 (70.51 kg).Time taken for first harvest was between 25-29 days and average fruit body weight ranged between 8-11 gms.

Table 23. Performance of of high yielding varieties/strains of Oyster Mushroom (*Pleurotus pulmonarius)*in AVT-2

Strains	Yield kg/100kg dry straw	Time take for first harvest	Average fruit body weight (g)
PP-23-201	70.51	29.00	10.86
PP-23-202	74.67	27.25	10.25
PP-23-203	79.29	26.33	9.12
PP-23-204	75.32	28.00	8.98
PP-23-205	75.71	28.33	9.60
PP-23-206	87.23	25.25	8.49
CD (0.05)	**6.18**		**0.83**

Expt 4: AVTL-2 of Shiitake mushroom on Saw Dust

AVTL on Shiitake mushroom 23-201-206 on sawdust was conducted and following recommendations were made (Table 24).Maximum yielder was AVTL 23-205 (49.83 Kg) followed by AVTL 23-206 (43.22 Kg and 34.54 kg) minimum yielder was AVTL-23-203 (20.28 kg). Time taken for first harvest was between 90-95 days and average fruit bodyweight ranged between 15-18gms.

Table 24. AVTL on Shiitake mushroom 23-201-206 on sawdust

Strains	Yield kg/100kg saw dust	Time take for first harvest	Average fruit body weight (g)
AVTL-23-201	34.54	91.50	16.67
AVTL-23-202	26.34	92.75	15.67
AVTL-23-203	20.28	94.30	17.33
AVTL-23-204	28.29	92.33	17.28
AVTL-23-205	49.83	90.20	17.67
AVTL-23-206	43.22	91.33	16.33
CD (0.05)	**4.52**		**1.75**

Expt 5.: AVTL-2 of Shiitake mushrooms 23-201-206 on Paddy straw

AVTL on Shiitake mushroom 23-201-206 on Paddy straw was conducted and following recommendations were made (Table 25).Maximum yielder was AVTL 23-205 (20.33 Kg) followed by AVTL 23-206 (18.23 kg) and AVTL 23-201 (12.74 kg) minimum yielder was AVTL-23-203 (9.98 kg). Time taken for first harvest was between 90-95 days and average fruit bodyweight ranged between 16-19gms.

Table 25. AVTL on Shiitake mushroom 23-201-206 on Paddy straw

Strains	Yield kg/100kg dry straw	Time take for first harvest	Average fruit body weight (g)
AVTL-23-201	12.74	93.25	16.00
AVTL-23-202	11.69	94.33	16.90
AVTL-23-203	9.98	95.00	17.32
AVTL-23-204	10.99	94.33	17.79
AVTL-23-205	20.33	91.25	18.62
AVTL-23-206	18.23	92.25	17.57
CD (0.05)	**2.12**		**0.01**

Expt 6: Evaluation of packaging materials for button, oyster and Shiitake mushrooms

Polyethylene bag (100 guage with 0.5% perforations), Polypropylene bags (100 guage with 0.5% perforations) and Punnet bags were evaluated for PLW (%), Whiteness, Spoilage (%) and Veil Opening (%) characters of all the three mushrooms for 2, 4and 6 days respectively and punnet bags were found to be best packaging material for all the mushrooms (Table 26.27 & 28).

Table 26 Evaluation of packaging material for button mushroom storag

Treatment	PLW (%) (days)				Whiteness (days)				Spoilage (%) (days)				Veil Opening (%) (days)			
	0	2	4	6	0	2	4	6	0	2	4	6	0	2	4	6
Control	0	6.10	10.75	14.67	++++	++	+	+	0	28.78	55.10	89.20	0	83.45	100	100
PE	0	2.9	6.89	12.76	++++	++	++	+	0	19.50	42.75	63.87	0	54.5	86.09	100
PP	0	2.02	4.43	8.66	++++	+++	++	+	0	13.20	26.25	58.34	0	44.95	80.98	100
Punnet	0	1.53	2.34	5.62	++++	+++	+++	++	0	2.32	10.39	25.86	0	25.21	73.91	100

Table 27 Evaluation of packaging material oyster mushroom storage

Treatment	PLW(%)				Colour retention				Spoilage (%)			
	0d	2d	4d	6d	0 d	2d	4d	6d	0d	2d	4d	6d
Control	0	5.67	9.04	16.99	++++	++++	++	+	0	22.23	46.24	77.92
PE	0	4.56	9.89	14.98	++++	++++	+++	++	0	15.52	38.25	68.29
PP	0	2.43	4.01	13.75	++++	++++	+++	++	0	13.84	30.24	55.39
Punnet	0	1.37	2.35	6.02	++++	++++	+++	+++	0	10.30	18.98	42.21

Table 28 Evaluation of packaging material for shiitake mushroom

Treatment	PLW (%) (days)				Whiteness (days)				Spoilage (%) (days)				Veil Opening (%) (days)			
	0	2	4	6	0	2	4	6	0	2	4	6	0	2	4	6
Control	-	-	-	-	++++	++++	++++	++++	0	5.52	10.38	15.92	-	-	-	-
PE	-	-	-	-	++++	++++	++++	++++	0	5.21	10.25	15.29	-	-	-	-
PP	-	-	-	-	++++	++++	++++	++++	0	2.62	8.68	12.39	-	-	-	-
Punnet	-	-	-	-	++++	++++	++++	++++	0	1.05	4.28	6.11	-	-	-	-

xiv) Bio-control

During the year 2023-24, talc based formulations of eight fungal endophytes *viz.* *Epicoccum* sp. isolate JPE2, *Fusarium oxysporum* isolate JPE6, *Aspergillus* sp. isolate JPE7, *Epicoccum sorghinum* isolate JPE13, *Schizophyllum* sp.isolateJPE19, *Fusarium solani* isolate JPE20, *Fusarium* sp. isolate JPE23 and *Talaromyces purpureogenus* isolate JPE38 were evaluated against pea root rot/wilt disease under field conditions at Experimental Research Farm Department of Plant Pathology and Research Farm Research Sub-Station Lari-CSKHPKV. All the formulation tested were found effective in controlling the disease however, three endophytic formulations *viz.* *Schizophyllum* sp. isolate JPE19, *Epicoccum* sp. isolate JPE2 and *Talaromyces purpureogenus* isolate JPE38 has displayed remarkable plant growth and disease control potential against pea root rot complex disease under both the conditions. Fourty one fungal root endophytes were isolated from healthy root samples of okra collected from localities of Kangra, mandi and Hamirpur districts of HP. Out of 41 isolates, seven endophytes have showed good antagonistic activity against *Rhizoctonia solani* (incitant of damping-off of okra) under laboratory conditions. Effect of liquid formulations of these fungal endophytes has been carried out for the management of damping-off of okra under pot and field conditions. The impact of these formulations will also be recorded on growth and yield parameters of these crops. The research trials are under progress at Experimental Research Farm, Department of Plant Pathology, CSKHPKV Palampur.

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 3025 farmers
Advisory through news papers	16
Liaison/ collaboration with National/ International bodies/agencies	Liaison was established with various agencies like ICARDA, AVRDC, ICRISAT, NBPGR, MYMV, RKVY, ATMA, JICA etc.
Trainings conducted	130trainingprogrammesondifferent topicswereconducted at headquarter(DEE)andoutstations/KVKsandmorethan3250 farmersweretrained
Participation in Extension Training Programmes	252numbersoflectureswereredeliveredtofarmersinvarious trainingprogrammesconductedatheadquarterandoutstations/ KVKs/otheragencies
Front Line Demonstrations	47numbersofDemonstrationswereconducted(KVKs)
On farm trials	36numbersofonfarmtrialswereconducted
Field demonstrations	Demonstration:60 demonstrationson Setaria (20) NXB hhybrid (20), Oat (20) and Rye grass (10). EstablishmentofNewDemonstrationunitonIFS-1no
Adaptive trials	2numbersofadaptivetrialswereconducted
Kisan melas/ divas/field days/SpecialCelebrations	32numbersofkisanmelas/divaswereorganized(KVKs)
Workshops organized/ attended	Facultyparticipatedin57numbersofworkshops
Radio & TVtalks	Thefacultydelivered7radio/TVtalks
Mushroom cultivation	Produced and Solds pawn of 1. *Agaricus*and*Pleurotus*mushroom:2021.94kgworth Rs 2,22.413.40 /- 2. Compostofbuttonmushroom:6356kgworthRs95350/- 3. Fresh mushroom :273.33kg worth Rs. 41,050.0/- Total economic activity- 3,58,813.40/-
Disease samples analyzed	316numbers
Diagnosti cvisits	66
Telephonic Consultation	112
Monitoring and joint visits With other departments	52

7. MISCELLANEOUS ACTIVITIES

i) Honour & Awards:

1. Dr. D.K. Banyal received appreciation letter from Egyptian Journal of Biological Pest Control as Reviewer for 2023
2. Best Poster Presentation Award for the paper entitled "The mapping of the anthracnose resistance gene on Pv10 in the common bean landrace KRC-5" authored by Irtifa Lateef, Bilal A. Padder, M.D. Shah, Shabnam Katoch, Abhishek Katoch, P.N. Sharma and Adfar Bashir, in the IPS National Conference 2024 on Plant Health for Food Security: Threats and Promises organized at ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow, U.P., India from February 1-3, 2024.
3. Prof. MJ Narsimhan Academic Merit Award (Commendation certificate) for presentation of paper entitled “Unveiling the biocontrol and plant growth potential of endophytic fungi against pea root rot complex in Himachal Pradesh, India” authored by Kushwaha,Kavita and Pal Joginder in the 76th annual meeting of Indian Phytopathological Society on “Plant Health for Food Security Threats and Promises” held at ICAR-Indian Institute of Sugarcane Research, Lucknow Uttar Pradesh, February 1-3, 2024.
4. Dr. Pardeep Kumar elected as Zonal Zonal President of Indian Phytopathological Society, North Zone for the Year 2024-25.
5. Dr. Shikha Sharma erlected as Zonal Councillor of Indian Phytopathological Society, North Zone for the Year 2024-25.
6. Dr. Pardeep Kumar received certificate of Excellence In Peer-Reviewing in recognition of an outstanding contribution of the quality of work from B P International, 27 Old Gloucester Street London WC1N 3AX, UK.
7. Dr. Shiwali Dhiman received Dr YS Parmar National Builders Award facilitated by Youngwarta Media Group at Diet (JBT) Nahan (HP) March 2024.
8. Ph.D. student Ms Tavi Ph. D received Jawahar Lala Nehru Memorial Scholarship.

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

The faculty of Plant Pathology participated in 19 Workshops/ Conferences/ Symposia/ Trainings etc. during 2022-23 as enlisted below:

Sr. No.	Date	Details of programme	Name of participants
1	1-3.2.2023	IPS National Conference 2024 on Plant Health for Food Security: Threats and Promises organized at ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow, U.P., India.	Dr. Shabnam Katoch
2	23.2.2023	online NIPHM 3rd workshop on ‘National Network of Plant Health Experts’	Dr. D.K. Banyal
3	14.08.2023	Work plan meeting for crop protection, AICRP wheat and Barley in virtual mode.	Dr. Rakesh Devlash
4	18-19.9.2023	NAHEP-CAAST sponsored Training Programme on "'Genomic Tools In Plant Genetic Resource Management'" at ICAR-NBPGR, New Delhi.	Dr. Shabnam Katoch

5	23.9.2023	Brain storming Session at KVK Kullu on agricultural Challenges and coping strategies concerning weather vagaries in Himachal Pradesh	Dr. Shiwali Dhiman
6	7.10.2023	Agriculture Officers workshop on Rabi crops at CSKHPKV, Palampur	All Scientist
7	22-24.11.2023	National Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security" held at ICAR-Central Coastal Agricultural Research Institute, Ela, Goa, India.	Dr. Shabnam Katoch
8	11.12.2023	Group discussion and meeting on Viksit Bharat at Raj Bhawan Shimla.	Dr. D.K. Banyal
9	11- 15.12.2023	Training Course on Mushroom production Technology for Scientist/SMSs of KVKs from at ICAR-DMR Campus Chambaghat Solan (HP)	Dr. Shiwali Dhiman
10	19.01.2024	Online training on Krishi Mapper for Natural Farming Organized by ICAR ATARI Ludhiana	Dr. Shiwali Dhiman
11	31.01.2024	Mid-Term Review Workshop of Cereals, Millets and Forages on at ICAR-Indian Institute of Millet Research, Hyderabad	Dr. Rakesh Devlash
12	11-15.3.2024	Training cum Exposure visit on Natural Farming for Master Trainer's Organized by National Institute of agricultural Extension Management Hyderabad at SAMETI, Mashobra Shimla	Dr. Shiwali Dhiman
13	22.04.2024	Pre-workshop meeting of AICRP Seed Crops on	Dr. Shoha Sharma
14	04.5.2024	Agriculture Officers workshop on Vegetable crops CSKHPKV, Palampur	All Scientist
15	8-10.5.2024	67th Annual Maize Workshop (AICRP, Maize at PJTSAU, Hyderabad (Telangana).	Dr. Rakesh Devlash
16	12.5.2024	Attended International Day of Plant Health "Plant Health, Safe Trade and Digital Technology" organized by ICAR-National Rice Research Institute, Cuttack Odisha (Virtual mode)	Dr. Joginder Pal
17	27-29.5.2024	Annual Group Meet on Kharif Pulses, 2023-24	Dr. Suman Kumar
18	08.6.2024	On line AICRP (FC) workshop	Dr. D.K. Banyal
19	13-14.6.2024	AICRP-Mushroom Review Meeting at IIHR Bengaluru	Dr. Deepika Sud

8. PUBLICATIONS

a) Research papers

1. Aggarwal S. K., Hooda K. S., Bagaria P. K. Debnath Srabani, Mallikarjuna N., Gogoi Robin, Sharma S. S., Jadesha G., Kaur Harleen., Singh R. P., Devlash R., Harlapur S. I., Mallaiah B. and Kaur Harman Jot. (2022). Surveillance of major maize diseases and their distribution scenario in different agro-climatic zones of India. *Maize Journal* (October 2022) 11(2): 88-94. (Published 2023).
2. Arora, M., Sharma, S., Sood, V., Singh, A. and Banyal, D.K. 2024. Viral diseases incidence and Symptomatology spectrum associated with Capsicum under protected cultivation. Himachal Pradesh. *Himachal Journal of Agricultural Research* 50(1): 96-101.
3. Badiyal A, Dhiman S, Singh A, Rathour R, Pathania A, Katoch S, Padder BA, Sharma PN. 2024. Mapping of adult plant recessive resistance to anthracnose in Indian common bean landrace Baspa/KRC 8. *Molecular Biology Reports*. 1;51(1):254. doi: 10.1007/s11033-023-09160-3.
4. Badiyal A, Dhiman S, Singh A, Rathour R, Pathania A, Katoch S, Padder BA, Sharma PN. 2024. Mapping of adult plant recessive resistance to anthracnose in Indian common bean landrace Baspa/KRC 8. *Molecular Biology Reports*. 51(1):254
5. Banyal D. K., Thakur A., Parwan, S. and Singh, A. and. 2023. Effect of weather variables on banded leaf and sheath blight (*Rhizoctonia solani* f. sp. *sasakii)* of fodder maize and its integrated management. *Plant Disease Research 38(1): 64-70.*
6. Bhardwaj Neelam , Bhardwaj Kajal, Sud Deepika, Bhatia Shivani , Singh Vivek .2024.Genetic Analysis of Variation in Rice (*Oryza Sativa* L.) For Yield and Yield Components under Organic *Vis-a-vis* Chemical Input Conditions. *Himachal Journal of Agricultural Research* 50(1): 38-44 (2024) (NASS 4.3
7. Chauhan A, Katoch S, Padder B.A. *et al.* 2024. Bean anthracnose: a regional overview in Himachal Pradesh. *Indian Phytopathology* . https://doi.org/10.1007/s42360-024-00766-6.
8. Duo, H., Muthusamy, V., Mishra, S. J., Chhabra, R., Chand, G., Mehta, B. K., Devlash, R., Guleria, S. K., Pal, D., Kumar, R., Zunjare, R. U., & Hossain, F. (2023). Composition of methionine and association with lysine and tryptophan in subtropically adapted maize breeding lines. *Cereal Chemistry*, 1–11. https://doi.org/10.1002/cche.10716.
9. Gopinath Ikkurti, Hossain Firoz, Selvakumar Thambiyannan, Sharma Neha, Duo Hriipulou, Kasana Ravindra K, Katral Ashvinkumar, Devlash Rakesh, Sathya Sheela K.R. Veluchamy, Zunjare Rajkumar U., Sekhar Javaji C., Guleria Satish K., Rajasekaran Ravikesavan, Muthusamy Vignesh (2024). Unraveling popping quality through insights on kernel physical, agro-morphological, and quality traits of diverse popcorn (*Zea mays* var. *everta*) inbreds from indigenous and exotic germplasm. *Food Research International* 191 (2024) 114676. https://doi.org/10.1016/j.foodres.2024.114676.
10. Katoch A, Katoch S, Padder BA *et al.* 2023. Assessing anthracnose resistance in common bean accessions: identification of resistance genes using SCAR markers against *Colletotrichum lindemuthianum*. *Indian Phytopathology* 76, 835–844. https://doi.org/10.1007/s42360-023-00656-3.
11. Katoch S, Banyal D, Sinha D. *et al.* 2024. Report of sea buckthorn wilt caused by *Fusarium sporotrichioides* from dry temperate zone of Himachal Pradesh, India. *Indian Phytopathology* 77, 207–209. https://doi.org/10.1007/s42360-023-00699-6.
12. Katoch S., Banyal DK., Sinha D., Sharma S., Singh A. and Rana R K. 2023. Report of sea buckthorn wilt caused by *Fusarium sporotrichioides* from dry temperate zone of Himachal Pradesh, India. *Indian Phytopathology* (2023). https://doi.org/10.1007/s42360-023-00699-6.
13. Kaur K. and Singh Amar. 2024. Occurrence of angular leaf spot of common bean in major growing areas of Himachal Pradesh and effect of leaf wetness durations on its development. *Himachal Journal of Agricultural Research*. 50: 82-87
14. Khushwaha, K., Pal, J. and Banyal, D.K. 2024. Endophytic and pathogenic fungal root communities associated with pea in sub-humid and dry temperate regions of Himachal Pradesh. *Himachal Journal of Agricultural Research* 50(1): 88-95 (2024).
15. Kumar, S. and Hallan, S., 2023. Characterization and etiolgy of pathogen (S) associated with wilt complex disease of *Lagenaria siceraria* in Himachal Pradesh. *Indian Journal of Ecology*, *50*(6), pp.2081-2087.
16. Lateef I, Katoch S, Katoch A, Badiyal A, Pathania A, Dhiman S, Nisa Q, Bashir A, Nabi A, Nabi N, Fayaz T. 2024. Fine mapping of a new common bean anthracnose resistance gene (Co-18) to the proximal end of Pv10 in Indian landrace KRC-5. *Theoretical and Applied Genetics*. 137(1):32

17. Lateef I, Katoch S, Katoch A, et al. 2024. Fine mapping of a new common bean anthracnose resistance gene (*Co-18*) to the proximal end of *Pv10* in Indian landrace KRC-5. *Theoretical and Applied Genetics*. 25,137(1):32. doi: 10.1007/s00122-023-04539-z.
18. Nidhi and Sud, Deepika 2023. Cultural studies on mycelia of *Pleurotus ostreatus* (Oyster mushroom). *Mushroom Research* 32 (1): 81-85. DOI: https://doi.org/10.36036/MR.32.1.2023.126319.
19. Nidhi, Sud, Deepika,Bhardwaj, Neelam and Riya.2023. Effect of variable light intensities on the mycelial growth of *Pleurotus ostreatus*. *Himachal Journal of Agricultural Research* 49(2): 261-263.
20. Pawar, T., Sharma, S., Arora, R.K. et al. 2024. Distribution of cotton leaf curl virus species/strain and characterization of associated satellite molecules in Gossypium hirsutum. *Indian Phytopathology*. https://doi.org/10.1007/s42360-024-00758-6
21. Preeti, Upmanyu S., Banyal D.K. and Bhardwaj N.2023 Screening of rice genotypes against *Ustilaginoidea virens*, an incitant of false smut. *Himachal Journal of Agricultural Research* 49(2): 257-260
22. Sahrma S, Katoch S, Dhiman S, Banyal DK, and Sharma PN. 2023. Bioefficacy and phytotoxicity of coordinated fungicide (fluopyram 200 + tebuconazole 200-400 SC) against anthracnose and angular leaf spot disease of common bean under wet temperate conditions of Himachal Pradesh. *Plant Disease Report* Volume 37, Issue 2, p110-117
23. Sharma A., Singh Amar, Sharma S. and Kumari V. 2023. Screening of soybean germplasm against frogeye leaf spot of soybean caused by *Cercospora sojina* Hara in Himachal Pradesh. *Himachal Journal of Agricultural Research* 49(1): 107-112
24. Sharma, Shilpa and Kumar, Pardeep. 2024. Biochemical and physiological characterization of *Ralstonia solanacearum* causing bacterial wilt of tomato. *Himachal Journal of Agricultural Research* 50(1):102-107.
25. Sinha D., Banyal D K. and Singh Amar. 2024. Studies on factors affecting the pathogenesis of *Alternaria solani* (Ell. and Mart.) Jones and Grout on tomato (*Solanum lycopersicum* Mill.). *Himachal Journal of Agricultural Research*. 50: 108-114.
26. Sood, V., Singh, A., Sood, S., Sood, V. K., Banyal, D. K., Sharma, S. and Sood, T. 2024. Morpho-cultural variability of Fusarium solani isolates causing root rot of okra in low and mid hills of Himachal Pradesh. *Himachal Journal of Agricultural Research* 50(1): 115-123.
27. Sud Deepika and Riya. 2023. Production potential, technology gap and economic analysis of cultivated mushrooms in Kangra district of Himachal Pradesh. *Mushroom Research* 32 (2): 165-167. DOI: https://doi.org/10.36036/MR.29.1.2020.134517 DEE.
28. Thakur D., Sud D., Riya, Banyal D. K., and Bhardwaj N.2023 Influence of different organic additives on spawn growth of *Pleurotus ostreatus*. *Mushroom Research* 32 (2): 149-152, 2023 DOI: https://doi.org/10.36036/MR.29.1.2020.137141
29. Thakur Dipanshi, Sud Deepika, Riya and Kumar Pardeep. 2023. Biofortification of wheat straw with organic additives and its effect on morphological parameters and biological efficiency of *Pleurotus ostreatus* (Jacq.) P. Kumm. *Himachal Journal of Agricultural Research* 49(2): 212-218.
30. Thakur Dipanshi, Sud Deepika, Riya, Banyal D.K. and Bhardwaj Neelam. 2023.Influence of different organic additives on spawn growth of *Pleurotus ostreatus. Mushroom Research* 32 (2): 165-167. DOI: https://doi.org/10.36036/MR.29.1.2020.134517 DEE.
31. Thakur Dipanshi, Sud Deepika, Riya, Banyal D.K. and Bhardwaj Neelam. 2023. Influence of different organic additives on spawn growth of *Pleurotus ostreatus. Mushroom Research* 32 (2): 149-152. DOI: https://doi.org/10.36036/MR.29.1.2020.137141.
32. Twinkle, Singh Amar and Banyal, D. K. 2024. Impact of storage conditions on seed-borne mycoflora and seed health parameters of soybean. *Himachal Journal of Agricultural Research*. 50: 76-81.

b) Book/ Book Chapters

1. Kumar, Pardeep and Riya. 2023. Mass production of high value medicinal mushroom. Chapter in Compendium on "Natural farming- Present status and future prospectus" Compendium: 131-142 pp.
2. Sud Deepika and Riya. 2023.Mushrooms in Traditional Medicine. In: Entrepreneurship through high tech mushroom cultivation and spawn production. Eds. Sachin Gupta, Moni Gupta, Amreesh Ved and Upasna Dutta. 40-45 pp.

3. Sud Deepika and Riya. 2023.Exploaring entrepreneurial prospects in specialty mushroom cultivation. In: Entrepreneurship through high tech mushroom cultivation and spawn production. Eds. Sachin Gupta, Moni Gupta, Amreesh Ved and Upasna Dutta. 58-64 pp.
4. Rakesh Devlash, Neha Sharma, Vinod Sharma and Surender Thakur .2024. Himachal Pradesh mein gehun v jau ki unnat kheti. Pages 10. Published by CHKHPKV, Pahari Krishi Anusandhan evm parser kinder, Bajaura, Jila Kullu, Himachal Pradesh. (In Hindi)

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

1. Katoch, S.attended online training on “Lectures on Biodiversity Conservation” 11:00 to 01:00 PM on 31.07.2023.
2. Katoch, S. attended NAHEP-CAAST sponsored Training Programme on "'GENOMIC TOOLS IN PLANT GENETIC RESOURCE MANAGEMENT"' from September 18-29, 2023 at ICAR-NBPGR, New Delhi.
3. Best Poster Presentation Award for the paper entitled "*The mapping of the anthracnose resistance gene on Pv10 in the common bean landrace KRC-5*" authored by Irtifa Lateef, Bilal A. Padder, M.D. Shah, Shabnam Katoch, Abhishek Katoch, P.N. Sharma and Adfar Bashir, in the IPS National Conference 2024 on Plant Health for Food Security: Threats and Promises organized at ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow, U.P., India from February 1-3, 2024.
4. Pankaj Chopra, Vinod Sharma, Ashita Bisht, Kanika Baghla and Shabnam Katoch 2023. Performance of Rajmash (Phaseolus vulgaris L.) varieties under different nutrient management practices in dry temperate region of Himachal Pradesh. In: Extended summaries of XXII Biennial National Symposium on “Climate Smart Agronomy for Resilient Production Systems and Livelihood Security” held at ICAR-Central Coastal Agricultural Research Institute, Ela, Goa, India w.e.f. November 22–24, 2023.
5. Riya, **Sud, Deepika** Nidhi and Banyal, D K. 2023. Fortification of substrate with zinc and selenium to produce bio enriched mushroom. National conference on Natural and organic farming for ecological, economical and nutritional security organized by Organic agriculture society of India, Department of organic agriculture and natural farming and PANF-CAAST-NAHEP (ICAR) at CSKHPKV, Palampur. P. 349-350.

d. Popular articles

1. Arora, Mansi and Sharma, Shikha. 2023. ‘Shimla mirch ke rog evm Prabandhan” Giriraj Weekly,18-24 October, (5).
2. Banyal, D. K. and Parwan, S. 2023. Mote anajo mai lagane bale permukh rog aibam unki roktham. Parvatia Kheti Bari . April –June, 2023. 15-16.
3. Dhiman Shivali.2024. Dudharoo pashuon ka garvkal avam prashav ke dauran vagyanik roop se pravandhan.
4. Kumar, Naveen, Sood V K, Banyal D K, Katoch Rajan and Kumar Sanjay (2023). Sources of fodder in Himachal Pradesh (Hindi). Kheti 75:43-45
5. Naveen Kumar, V K Sood, D K Banyal, Rajan Katoch and Sanjay Kumar (2023). Sources of fodder in Himachal Pradesh (Hindi). Kheti 75:43-45
6. Pal J and Bisht A. 2024. Mulyavardhak Fasal Seabuckthorn. Giriraj 46 (24): 5p
7. Pal J, Sharma SK and Sharma A. 2023. Interruption of Quorum sensing: A new paradigm for combating phytopathogenic bacteria. Agrobios Newsletter 22(4):45-48.
8. Pal, J., Sud, D., Katoch, S., Kushwah, K. and Banyal D. K. 2024. Mater ke jade shadhan ba wilt rog ka jaivic niyantran (Hindi). Parvatia Kheti Bari. October- December 2023: 16-17.
9. Riya and Sud Deepika .2023. Mushroom cultivation – a solution to combat burning problem of paddy straw utilization. Krishi Science. 04(2)5-7. KS-2442
10. Riya and Sud Deepika .2023. Mycotoxins: types, effect and management practices. Krishi Science 04(12)9-13. KS-2984.
11. Sud, Deepika and Pal J. 2024. Aalu main jhulsa rog ka prabandhan. Giriraj 46(19): 5p
12. Tarushi and Sud Deepika.2023. Aahariye fiber ka utkrisht strot- Shiitake mushroom. Giriraj Weekly,45(50) (5)
13. Thakur, Dipanshi, Sud, Deepika and Riya.2023. Nutraceutical properties of mushroom. Krishi Science 04(10)1-4. KS-2902. eMagazine for Agricultural Sciences 4 (10) 2023. 1-4.

e. Pamphlets

1. Attri S, Dhiman S, Sood H, Chaand S, and Mittal P. 2024. Postikta ka bhandaar shri Ann, KVK-Sirmour.

2. Devi R, Chopra P, Bisht A, Thakur A, Pal J and Katoch S. 2024. Ucch Sushq shitoshan khsetron main gobhi fasal ki vibheen avsthaon main rogon aur kiton ke prakop hetu anukulmausamparisthityaantathaunkeprabandhankeupaaye.GraminKrishimausamseva, UcchbhumiKrishianusandhanyevamprasaar Kendra, KukumserijilaLahualvaSpiti pp.1-4.
3. Dhiman S, Chaand S, Sood H and Mittal P. 2024. Dhiman S,. Gaon Ka Paisa Gaon Mein-Adhunik yug ka naya vikalp. ICAR ATARI Zone-1, KVK-Sirmour/Pamphlet/2024/11.
4. Dhiman S, Chaand S, Sood H and Mittal P. 2024. Prakritik kheti aur uske ghatak. ICAR ATARI Zone-1, KVK-Sirmour/Pamphlet/2024/13.
5. Dhiman S, Sood H, Chaand S and Mittal P. 2024. Prakritik Kheti mein Fasal Suraksha-Jaivik Fafondnashak. ICAR ATARI Zone-1, KVK-Sirmour/Pamphlet/2024/15.
6. Dhiman S, Sood H, Chaand S and Mittal P. 2024. Prakritik Kheti mein desi gaye ka mahatav. ICAR ATARI Zone-1, KVK-Sirmour/Pamphlet/2024/12.
7. Dhiman S, Sood H, Chaand S and Mittal P. 2024. Prakritik Kheti mein Fasal Suraksha-Jaivik Keetnashak. ICAR ATARI Zone-1, KVK-Sirmour/Pamphlet/2024/14.
8. Katoch, Shabnam, Kumar, Pardeep Pal, Joginder Chopra Pankaj, Banyal D,K. 2024 See buckthorn (Charma) mein Rog Prabandhan.
9. Pal, Joginder, Katoch, Shabnam, Banyal, D,K, Twinkle and Sharma S.K.2024 .Lahul-spiti ghati mein Aalu fasal ke pramukh rog tatha unka niyantran.
10. Sud Deepika Banyal, D.K, Singh Amar, Kumar Pardeep and Riya.2024. Shiitake Khumb ki utpadan takniki.
11. Sud Deepika Banyal, D.K, Singh Amar, Kumar Pardeep and Riya.2023. Dhingri Khumb ki utpadan takniki.
12. Sud Deepika Banyal, D.K, Singh Amar, Kumar Pardeep and Riya.2023. Varshbhar rituaadharit Khum bkikheti se sudrud aarthiki..

f. Extension folders in Hindi

1. Gaon Ka Paisa Gaon Mein-Adhunik yug ka naya vikalp, KVK-Sirmour/Pamphlet/2024/11
2. Prakritik Kheti mein desi gaye ka mahatav, KVK-Sirmour/Pamphlet/2024/12
3. Prakritik kheti aur uske ghatak, VK-Sirmour/Pamphlet/2024/13
4. Prakritik Kheti mein Fasal Suraksha-Jaivik Keetnashak, KVK-Sirmour/Pamphlet/2024/14
5. Prakritik Kheti mein Fasal Suraksha-Jaivik Fafondnashak, KVK-Sirmour/Pamphlet/2024/15
6. Postikta ka bhandaar shri Ann, KVK-Sirmour

g. Technical bulletin/Booklets

1. Kumar, P., Sud, D., Riya, Sharma, S., Singh, A. and Banyal D K 2024. Practical Manual on Experiential Learning programme (Mushroom Cultivation). Department of Plant Pathology, CSK HPKV Palampur. 76p.

h). Lead Lectures

1. Dr. Pardeep Kumar delivered Lecture on “Mass production of high value medicinal mushroom” in training programme on Natural Farming –Present and Future prospectus organized by Protedcted agriculture and Organic faming at CSKHPKV, Palasmpur w.e.f.14-27 September, 2023.

9. OTHER ACTIVITIES

a). Visits of Dignitaries

Sr. No.	Date	Dignitary visited
1	29.9.2023	Hon'ble Agriculture minister, Hon'ble Vice Chancellor and all Statutory officers of CSKHPKV
2.	22.11.2023	Director DMR, Solan

b. 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 3025 farmers
Advisory through news papers	16
Liaison/ collaboration with National/ International bodies/agencies	Liaison was established with various agencies like ICARDA, AVRDC, ICRISAT, NBPGR, MYMV, RKVY, ATMA, JICA etc.
Trainings conducted	130trainingprogrammesondifferent topicswereconducted at headquarter(DEE)andoutstations/KVKsandmorethan3250 farmersweretrained
Participation in Extension Training Programmes	252numbersoflectureswereredeliveredtofarmersinvarious trainingprogrammesconductedatheadquarterandoutstations/ KVKs/otheragencies
Front Line Demonstrations	47numbersofDemonstrationswereconducted(KVKs)
On farm trials	36numbersofonfarmtrialswereconducted
Field demonstrations	Demonstration:60 demonstrationson Setaria (20) NXB hhybrid (20), Oat (20) and Rye grass (10). EstablishmentofNewDemonstrationunitonIFS-1no
Adaptive trials	2numbersofadaptivetrialswereconducted
Kisan melas/ divas/field days/SpecialCelebrations	32numbersofkisanmelas/divaswereorganized(KVKs)
Workshops organized/ attended	Facultyparticipatedin57numbersofworkshops
Radio & TVtalks	Thefacultydelivered7radio/TVtalks
Mushroom cultivation	Produced and Solds pawn of 4. *Agaricus*and*Pleurotus*mushroom:2021.94kgworth Rs 2,22.413.40 /- 5. Compostofbuttonmushroom:6356kgworthRs95350/- 6. Fresh mushroom :273.33kg worth Rs. 41,050.0/- Total economic activity- 3,58,813.40/-
Disease samples analyzed	316 numbers
Diagnosti cvisits	66
Telephonic Consultation	112
Monitoring and joint visits With other departments	52

10. SALIENT FINDINGS

1. Three foliar sprays of extract of eupatorium ark @ 10% giving 41.87 % disease control with 41.59 % increase in the yield over check, was found best against zonate leaf spot of sorghum. However, three foliar spray of propiconazole @ 0.1% (Chemical check) was found most effective which gave 51.22 % disease control with 68.26 % increase in the green fodder yield over check.
2. Rhizome treatment with fungicide i.e. Metalaxyl – M 31.8% ES @ 250 ml/1000 kg of rhizome was found highly effective for the management of rhizome rot of ginger.
3. Out of 40 soybean germplasm line screened for having multiple disease resistance, the germplasm lines; EC 0528663, IC 0242857, EC 0528651, IC 0501941, IC 0128988, EC 114570 and IC 0128992 were observed having multiple disease resistance against frogeye leaf spot (*Cercospora sojina*), anthracnose (*Colletotrichum truncatum*) and brown spot (*Septoria glycines*).
4. Three foliar spray of dashparni @ 2% was found most effective with 75.45 per cent white clover powdery mildew control and minimum disease severity (7.32%), white clover. However, three foliar spray of hexaconazole @ 0.1% (chemical check) provided maximum disease control (82.78%) with minimum white clover powdery mildew severity (5.14%) as compared to control (29.82%).
5. Characterization of Cucumber mosaic virus, Potato virus Y, Tomato Spotted wilt virus and Pepper mottle virus on molecular and microscopy bases causing varied viral diseases in bell pepper under protected cultivation was done.
6. Bio fortification of wheat substrate with organic additives had a positive effect on morphological parameters and biological efficiency of *Pleurotus ostreatus*. By fortification with cereal brans it was concluded that wheat bran resulted in better morphological characters and biological efficiency as compared to control where no additives were added.

7. Recommendation: (Five plant protection recommendations were accepted for POP in Vegetable Workshop on 04.05.24):

i. Recommendation for the management of late blight of Tomato caused by *Phytophthora infestans*:

- Two sprays with Cymoxanil 8% + Mancozeb 64% WP @ 20 gm per 10 litres water/ Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC @ 10 gm per 10 litres water or two -three sprays with Zineb 75%WP @ 25 gm per 10 litres of water at 10-15 days intervals

ii. Management of Early blight of tomato caused by *Alternaria solani*:

- Two sprays with Azoxystrobin 23% SC@10 gm per 10 litres of water at fortnight interval or 2-3 sprays with Zineb 75%WP @25 gm per 10 litres of water at 10 -15 days intervals.

iii. Management of Buckeye rot of tomato caused by *Phytophthora nicotianae* var. *parasitica*:

- Two-three sprays with Propineb 70 WP% @ 25 gm per litres of water at an intervalof 10-15 days.

iv. Management of Purple blotch of onion caused by *Alternaria porri*:

- Two sprays with Difenoconazole 25% EC or Tebuconazole 25.9% EC or Azoxystrobin 18.2%+ Difenconazole 11.4% w/w SC or Azoxystrobin 11% + Tebuconazole18 .3% w/w SC@10 gm per 10 litres water at fortnight intervals.

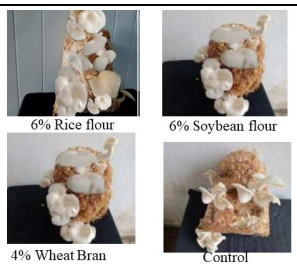
v. Management of Stemphylium blight caused by *Stemphylium vasicarium*of onion:

- Two sprays of crop with Azoxystrobin 18.2%+ Difenconazole 11.4% w/w SC or Azoxystrobin 11% + Tebuconazole 18.3% w/w SC@10 gm per 10 litres water at fortnight intervals.

11. PHOTO GALLERY

Evaluation of Soybean germplasm for disease resistance

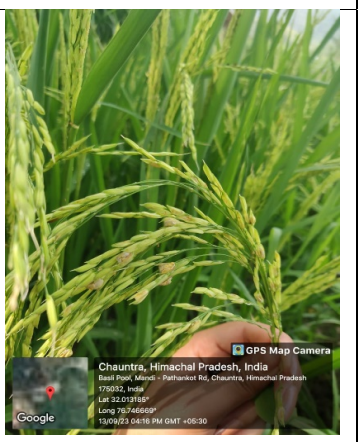
Management of zonate leaf spot of sorghum



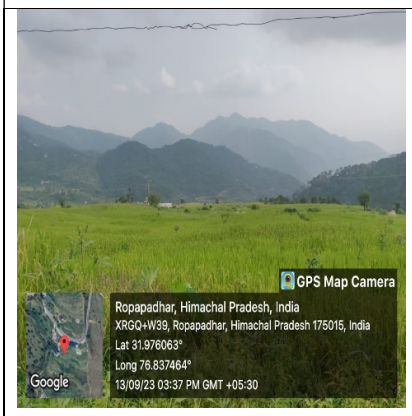
Bio fortification of substrate fot *Pleurotus ostreatus*

Narrow leaf spot of rice on leaves

Shealth blight of rice



False smut of rice



Local variety Chaina covering large scale area in Mandi district

Leaf scald disease of rice

Brown spot of rice on panicle