ANNUAL PROGRESS REPORT

(2020-21)

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Department of Plant Pathology

College of Agriculture

Chaudhary Sarwan Kumar

Himachal Pradesh Krishi Vishvavidyalaya

PALAMPUR-176062 (HP)

ACKNOWLEDGEMENT

The 35th 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 S. K. Rana, Dr Amar Singh and Dr Deepika Sud for compilation and editing of the report.

I express my deep sense of gratitude to the honorable Vice-Chancellor for the motivation and encouragement of the faculty of the department. The sincere advice and guidance provided by the 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.

Head of the Department
Dated: 07.01.2022

CONTENTS

1. INTRODUCTION

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

The research work on various ad-hoc projects & AICRPs is being carried out in the main department at Palampur, Hill Agriculture Research & Extension Centres (Bajaura, Dhaulakuan and Kukumseri), Shivalik Agriculture Research & Extension Centre (Kangra), Rice & Wheat Research Centre (Malan) and Research Stations (Berthin and Akrot). Research on wheat diseases is mainly carried out at Malan, Dhaulakuan and Bajaura, on rice diseases exclusively at Malan and on maize diseases at Bajaura and Dhaulakuan, whereas, the research on diseases of pulses is carried out at Palampur, Berthin and Dhaulakuan and on oilseed crops at Kangra and Palampur. Among diseases blast, yellow rust, banded leaf & sheath blight, bacterial stalk rot, anthracnose, powdery mildews, downy mildews, bacterial wilt and canker, late blight, fusarial wilt, white rot, root rot /wilt complex, fruit rots and viral diseases receive special attention.

The department is also conducting research on different aspects of cultivation of mushrooms including their diseases. The spawn laboratory at present is meeting the demand of Horticulture Department and private mushroom growers. Teachers/ scientists/ students of the department are actively participating in various seminars/ symposia/ conferences organized by different scientific societies and workshops held by AICRPs and University from time to time.

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

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

2. STAFF POSITION

a. Faculty

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

Name	Position/ Designation	E-mail
Dr S K Rana	Professor & Head	skrana62@gmail.com
Dr P N Sharma	Principal Scientist cum Librarian (Retired 31.10.20)	pns1960@gmail.com
Dr B R Thakur	Principal Scientist (Retired 31.03.21)	drbrthakur@rediffmail.com
Dr D K Banyal	Dr D K Banyal, Professor & Head (from 19.05.21)	dkbanyal@gmail.com
Dr Arun Sud,	Principal Extension Specialist & Programme Director CMRT	arunsud7217@gmail.com
Dr Amar Singh	Principal Scientist	singhamar008@gmail.com
Hill Agricultural Research & Extension Centre, Bajaura – 175125		
Dr R K Devlash Vacant	Principal Scientist Senior Scientist	devlashbajaura@rediffmail.com -
Hill Agricultural Research & Extension Centre, Dhaulakuan – 173031		
Dr V K Rathee	Scientist/ Principal Scientist & ADR (Retired 31.05.21)	vkrrathee@gmail.com
Dr Akhilesh Singh	Senior Scientist/ Principal Scientist	asingh1962@rediffmail.com
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		
Dr Sachin Upmanyu Vacant	Scientist Scientist	sachinupmanyu_mpp@rediffmail.com -
Research Sub-Station, Akrot – 177211		
Dr B K Sharma	Principal Scientist & Scientist Incharge	sharmabk63@yahoo.com
Research Sub-Station, Sunder Nagar - 175019		
Vacant	Scientist	-
Directorate of Extension Education, Palampur - 176062		
Dr Deepika Sood (From 13.09.19 AN)	Assistant Extension Specialist/ Subject Matter Specialist	deepika_agri@rediffmail.com
Krishi Vigyan Kendra, Dhaulakuan - 173031		
Dr Anand Singh	Assistant Extension Specialist/ Principal Extension Specialist & Programme	singhanandisi@yahoo.com

	Coordinator (Retired 31.07.20)	
Krishi Vigyan Kendra, Kukumseri – 175142		
Vacant	Subject Matter Specialist	-
Krishi Vigyan Kendra, Bara - 177044		
Dr Pardeep Kumar	Subject Matter Specialist/Programme Coordinator	pkdogra2007@rediffmail.com
Krishi Vigyan Kendra, Kangra - 176001		
Dr. Deepika Sud	Subject Matter Specialist (Salary from KVK kangra)	
Krishi Vigyan Kendra, Berthin - 174029		
Dr Suman Kumar	Subject Matter Specialist/ Principal Extension Specialist & Programme Coordinator	sumanhpkv@gmail.com
Krishi Vigyan Kendra, Una - 174303		
Vacant	Subject Matter Specialist	-

(b) Staff

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

Staff	**Name & Designation**
Ministerial Staff	
1	Smt Usha Rani, Section Officer (till 31.07.20)
2	Sh Ravi Kumar, Senior Assistant
Technical Staff	
1	Sh Naresh Kumar, Field Assistant G-I)
2	Sh Himat Ram, Junior Technician
3	Sh Balwant Singh (Tech Asstt Gr-II) (deputed at Salooni from 19.06.18)
4	Sh Subhash Chand, Lab Attendent (from 15.09.20)
Supporting Staff	
1	Sh Desh Raj, Beldar
2	Sh Subhash Chand, Beldar till 14.09.20

3. FINANCIAL OUTLAY AND STAFF POSITION IN DIFFERENT SCHEMES

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

Name of the Scheme	**Expdt (Lac Rs.)**	**Staff**
Creation of facilities for Postgraduate Studies in the Department (APL-001-17)	44.86	Sh Harbans Lal, Sr Asstt (Biotech) Sh Shakti Chand, Jr Technician (COBS)
Facilities for teaching in the Department/ College of Agriculture (APL-010-17)	76.08	Dr S K Rana, Professor & Head Dr A K Sud, Principal Extension Specialist Sh Ravi Kumar, Senior Assistant Sh Vijay Kumar (Security Cell) Sh Balwant Singh, Tech Asstt G-II (RRS Salooni)
Strengthening of facilities for research in the Department (APL-021-17)	17.34	Sh Ramesh Kumar, Beldar (Seed Tech) Sh Desh Raj, Beldar
Facilities for research in the Department (APL-059-17)	3.78	Sh Subhash Chand, Beldar
Funds of postgraduate research (APL-107-17)	0.90	-
All India Coordinated Research Project on Seed Technology Research under NSP (ICAR-017-17 Pt-II)	22.83	Dr P N Sharma, Professor (Retired on 31.10.2020) Sh Atul Kumar, Lab Attendant (Agri Biotech)
All India Coordinated Mushroom Improvement Project (ICAR-056-17)	7.69	-
Molecular mapping of anthracnose resistance gene in common bean land race KRC8 and identification of adult plant resistance components (DST- GOI-5042-17)	9.59	Ms Anila Badiyal, Research Associate
Fungicide testing (Ad Misc 626-17)	9.17	-
Evaluation of lentil and chickpea prebreeding material and germplasm against rust and Asochyta blight Ad Misc 4011-17	0.39	-
Up scaling Technical Support for Addressing Emerging Problems Vegetable crops under Protected Environment (Ad Misc 2239-17)	5.22	-
Eco Friendly Management strategies for powdery mildew of wheat in HP (Ad Misc 2241-17)	2.05	-
Protected Agriculture and Natural Farming (PANF) under NAHEP-CAAST Programme (NAHEP-ICAR-231-17)	6.99	Dr. Shiwali Dhiman, JRF
Self Finance Scheme (SFS-001-17)	1.56	-
Revolving Fund (RF-A-46-036-17)	4.58	-
Revolving Fund Scheme under SFS (Experiential Learning) (RF-B-61-142-17)	0.62	-
Central Assistance Development (CDA-004-17)	0.60	-
Total	**214.25**	

4. TEACHING

a. Courses offered/ taught:

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

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

b. Students admitted:

S. No.	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Anshul Kumar Sharma	Dr. Amar Singh	Biology of *Colletotrichum truncatum* causing anthracnose of soybean and identification of resistant sources
2	Nidhi	Dr. Deepika Sud	Fortification of substrates to produce bio-enriched oyster mushrooms
3	Nikhil Rana	Dr. B. K. Sharma	Studies on black point of wheat in Himachal Pradesh
4	Preeti	Dr. Sachin Upmanyau	Management of false smut of rice caused by Ustilaginoidea virens (Cke.) Tak.
5	Parul Upadhyay	Dr. D. K. Banyal	Etiology ad epidemiology of Ascochyta leaf spot of Urdbean
6	Sachin Sharma	Dr. Pradeep Kumar	Eco-friendly management of bacterial wilt of tomato

c. Ongoing students:

S No	Name of student	Major advisor	Title of research problem
M Sc Programme			
1	Ms Ayushi Sharma (A-2019-30-067)	Dr B R Thakur	Biological control of pea root rot caused by *Fusarium solani* f. sp. *pisi*
2	Ms Kajal (A-2019-30-068)	Dr Rakesh Devlash	Epidemiology of Turcicum leaf blight in maize and identification of resistance sources
3	Ms Monika Rathi (A-2019-30-069)	Dr Sachin Upmanyu	Virulence analysis of *Rhizoctonia Solani* Kuhn and evaluation of resistance in rice
4	Ms Ridhima Gupta (A-2019-30-070)	Dr S K Rana	Biology of *Xanthomonas axonopodis* pv *glycines* causing bacterial pustule of soybean and identification of resistance sources
5	Ms Sakshi Sharma (A-2019-30-071)	Dr B K Sharma	Studies on epidemiodogy of lentil wilt and host resistance
6	Ms Tarushi (A-2019-30-072)	Dr Deepika Sud	Studies on synthetic log cultivation of Shitake mushroom *Lentinula edodes*
Ph D Programme			
1	Ms Diksha Sinha (A-2019-40-024)	Dr D K Banyal	Biology and management of early blight of tomato caused by *Alternaria Solani*
2	Ms Khushwinder Kaur (A-2019-40-025)	Dr Amar Singh	Diversity analysis of *Pseudocercospora griseola* populations causing angular leaf spot of common bean and identification of resistant sources
3	Vakul Sood (A-2019-40-026)	Dr A K Sud	Studies on variability in pathogen(s) causing root rot of okra and its integrated disease management
4	Ms Ashima Thakur (A-2017-40-019)	Dr D K Banyal	Epidemiology and management of Stemphylium blight of onion
5	Ms Priya Bhargava (A-2017-40-021)	Dr S K Rana	Epidemiology and management of flag smut *(Urocystis agropyri* (Preuss) Schroet) of wheat
6	Ms Abhilasha Sharma (A-2018-40-023)	Dr Amar Singh	Characterization of variability in *Cercospora sojina* Hara causing frogeye leaf spot and identification of resistant sources in soybean
7	Ms Gurpreet Kaur (A-2018-40-024)	Dr S K Rana	Epidemiology and management of Fusarium head blight of wheat

d. Students completed M Sc / Ph D programme:

S. No.	Name of student	Major advisor	Title of thesis
	M Sc programme		
1	Ms Aanchal Titaria (A-2018-30-061)	Dr S Upmanyu	Studies on sheath rot of rice caused by *Sarocladium oryzae*
2	Ms Ankita Chauhan (A-2018-30-062)	Dr Pardeep Kumar	Variability of *Ralstonia solanacearum* and eco-friendly management of bacterial wilt of tomato
3	Ms Divya Bhandari (A-2018-30-063)	Dr Amar Singh	Biology of *Phytophthora colocasiae* Raci. causing blight of colocasia and its eco-friendly management
4	Ms Nikita (A-2018-30-064)	Dr A K Sud	Management of wet bubble of white button mushroom caused by *Mycogone perniciosa* (Megnus)
5	Ms Pratibha Sharma (A-2018-30-065)	Dr P N Sharma	Analysis of virulence shift in *Colletotrichum lindemuthianum* causing bean anthracnose and its eco-friendly management
6	Mr Raghav alias Bantu (A-2018-30-066)	Dr Rakesh Devlash	Management of Turcicum leaf blight of maize in Himachal Pradesh
7	Ms Shiney Chatak (A-2018-30-067)	Dr D K Banyal	Integrated disease management of urdbean anthracnose caused by *Colletotrichum truncatum*
8	Ms Sunidhi (A-2018-30-068)	Dr B R Thakur	Epidemiology and management of Ascochyta blight of chickpea (*Cicer arietinum*)
	Ph D programme		
1	Ms Shabnam (A-2015-40-020)	Dr S K Rana	High resolution mapping of *Co-Ind* gene from common bean landrace KRC-5 possessing resistance to *Colletotrichum lindemuthianum* races
2	Ms Shiwali Dhiman (A-2015-40-021)	Dr P N Sharma	Molecular mapping of anthracnose resistance gene in common bean landrace KRC-8 and identification of adult plant resistance components
3	Mr Anudeep B M (A-2016-40-017)	Dr D K Banyal	Studies on virulence and host resistance in oat-*Blumeria graminis* f *sp avenae* pathosystem
4	Ms Dimple Rana (A-2017-40-020)	Dr B R Thakur	Studies on variability and management of Fusarium wilt of chickpea

e. Students' placement

Name of Student & Admission No.	Name of Major Advisor	Nature of Placement along with Details
Mr. Anudeep B M (A-2016-40-017)	Dr D. K. Banyal	Plant Protection officer, Govt of India
Ms Shabnam Katoch A-2015-40-020	Dr S K Rana	SRF, Division of Plant Pathology, IARI New Delhi
Ms Shiwali Dhiman A-2015-40-021	Dr P N Sharma	JRF, Deptt Plant pathology, CSKHPKV Palampur

f. Salient achievements of students' research

a. M Sc students:

1. **Aanchal Titaria (A-2018-30-061) Majaor Guide: Dr Sachin Upmanyu**
   "Studies on Sheath Rot of Rice caused by Sarocladium oryzae"

- Among different *Trichoderma* spp. evaluated by dual culture technique, *Trichoderma harzianum* (T-5) gave maximum (77.89 %) inhibition of *Sarocladium oryzae* followed by *T. harzianum* (TH-11).
- Among fungicides, barring Indofil M-45 (mancozeb), all other fungicides namely Nativo 75 WG (trifloxystrobin 50% + tebuconazole 25 % WG), Companion (mancozeb 63 % + carbendazim 12 % WP), Bavistin (carbendazim 50 WP) and Folicur (tebuconazole 250 EC) completely arrested the mycelial growth of *Sarocladium oryzae* at all the concentrations under study.
- In field, application of carbendazim (0.1%) proved to be the most effective with least disease index of 126 and maximum per cent reduction in disease index by 57.85 per cent followed by Nativo 75 WG which recorded disease index of 138 with disease index reduction by 53.85 per cent for the control of sheath rot of rice.

2. **Ankita Chauhan (A-2018-30-062) Majaor Guide: Dr Pardeep Kumar**
   "Variability in Ralstonia solanacearum and ecofriendly management of bacterial wilt of tomato"

- The *in vitro* evaluation of different varieties against *R. solanacearum* showed that 4 tomato varieties (LS-89, Hawaii 7996, Hawaii 7998, Palam Pride), 2 brinjal varieties (Arka Keshav, Arka Nidhi) and 2 chilli varieties (PI201232, VI-037556) were resistant to bacterial wilt.
- Among six bioagents, *Pseudomonas fluorescens* and *Trichoderma koningii* (DMA-8) showed maximum inhibition zones of 21.67mm and 12.33mm against *R. solanacearum*, respectively with paper disc method whereas, In case of botanicals, eucalyptus (*Eucalyptus spp.*) showed highest inhibition zone (6.73mm) followed by neem (*Azadirachta indica*) with 6.56mm at 20% conc.
- Among the organic inputs tamar lassi at 5% concentration showed maximum growth inhibition (99.21%) followed by Himsol (93.01%) through poison food technique whereas, Agniastra, Beejamrit and Lantana Ark were found ineffective in inhibiting the growth of *R. solanacearum.*

3. **Divya Bhandari (A-2018-30-063) Majaor Guide: Dr Amar Singh**
   "Biology of *Phytophthora colocasiae* Raci. causing blight of colocasia and its eco-friendly management"

- On the basis of morpho-cultural and pathogenic variability, 20 isolates of *Phytophthora colocasiae* were categorised into 6 and 5 groups, respectively and of these only 4 isolates formed chlamydospores which were formed abundantly under dark condition at pH 6.0 in carrot broth incubated at 18°C. Out of twenty isolates of *Phytophthora colocasiae* 18 were of A_1 mating type and 2 were of mating type A_2.
- Out of 14 isolates of *Trichoderma* spp. (9 isolated from colocasia rhizosphere and 5 standard ones), 6 unidentified bacterial isolates (from colocasia phylloplane) and one standard *Pseudomonas fluorescens* isolate, *Trichoderma* sp.-6 was found significantly superior bio-agent as it resulted in 72.9 per cent mycelial growth inhibition of *P. colocasiae* followed by *Trichoderma* sp.-5 (63.2%), *Trichoderma* sp.-4 (60.1%) and *Trichoderma* sp.-1 (54.5%) and *Pseudomonas fluorescens* (50.5%).
- *Trichoderma* sp.-6 as corm treatment and drenching was found superior in managing colocasia blight than other bioagents while *Trichoderma* sp.-5 was found best as soil application under net house conditions.

4. **Nikita (A-2018-30-064) Majaor Guide: Dr A K Sud**
   "Management of wet bubble of white button mushroom caused by *Mycogone perniciosa* (Magnus)"

- Under *in vitro* conditions propiconazole and trifloxystrobin 25% + tebuconazole 50% (Nativo 75 WG) at 20 ppm and carbendazim 12% + mancozeb 63% (Saaf) fungicide at 200 ppm, provided 100 per cent mycelial inhibition and the organic formulation, himsol and jeevamrit at 50 per cent were found most effective.

- Under *in-vivo* conditions, fungicide trifloxystrobin 25% + tebuconazole 50% (Nativo 75 WG) was found to be the best for quality parameters and wet bubble disease control (87.5%) with yield of 22.2 kg per 100Kg compost.
- Among organic formulations, jeevamrit was the best for quality parameters followed by himsol but for wet bubble disease control himsol was more effective (87.9%) with the highest yield of 20.3 kg per 100 kg compost.

5. Pratibha Sharma (A-2018-30-065) Majaor Guide: Dr P N Sharma

"Analysis of virulence shift in *Colletotrichum lindemuthianum* causing bean anthracnose and its eco-friendly management"

- Twenty five isolates of *Colletotrichum lindemuthianum* were categorized into 23 physiological races on the CIAT bean differential cultivars out of which, five races *viz.*, 3, 87, 211, 503 and 631 resembled the previously known races in the respective areas of their occurrence, while the remaining eighteen races were novel to various production areas explored in this study.
- Evaluation of 214 common bean accessions against three new races (437, 198 and 1015) of *C. lindemuthianum* revealed that 5 common bean accessions namely EC 500364, EC 500821, EC 400454, EC 400408, and IC 423433 were resistant to all the three races while, three exotic varieties viz., Cornell 49242 (*Co-2*), AB 136 (*Co-6* and *co-8*) and G 2333 (Co^4, Co^5 and Co^7) were resistant to all the 23 races.
- Under greenhouse conditions, seed treatment of the infected seeds with Jeevamrit (@4%) was found most effective in controlling seed borne infection (75.60%) whereas same formulation when applied after inoculation of the pathogen resulted in almost equal control (75.34%). However, Bavistin as a check showed 100% disease control in both cases.

6. Raghav Alias Bantu (A-2018-30-066) Majaor Guide: Dr Rakesh Devlash

"Management of Turcicum Leaf Blight of Maize in Himachal Pradesh"

- Out of 144 maize inbreed lines screened against *Exserohilum turcicum* under artificially inoculated conditions, 57 medium maturing, 11 early maturing and 50 QPM inbreds were found resistant to TLB.
- *In vitro* evaluation of fungicides revealed that Propiconazole (Tilt 25EC) and Tabuconazole (Folicur) at the lowest dose of 50 ppm gave cent per cent inhibition of mycelial growth while, Propiconazole, Zineb and Mancozeb + carbendazim at 500 ppm exhibited cent per cent inhibition of spore germination.
- Field evaluation of fungicides revealed that two sprays of Trifloxystrobin + Tebuconazole (Nativo) were most effective resulting in 80.3% disease control with 54.7 percent increase in yield. However, two sprays of Propiconazole) were economical and cost effective as compared to Trifloxystrobin + Tebuconazole (Nativo).

7. Shiney Chatak (Admission No. A-2018-30-067) Majaor Guide: Dr D K Banyal

"Integrated disease management of urdbean anthracnose caused by *Colletotrichum truncatum*"

- Out of 202 diverse germplasm lines of urdbean, evaluated under field conditions for anthracnose resistance, only three lines (93-259, HBU1-2-4 & DKU-94) were found resistant while nine *i.e.* 341, DKU-411, PU-13-33, 26-332, 175-T94-2, DKU 99, 598, 557 and 1142 were moderately resistant.
- Among five fungicides evaluated *in vitro*, trifloxystrobin 25% + tebuconazole 50% at 50 ppm, carbendazim 50WP at 100 ppm, propiconazole 25EC at 250 ppm, tebuconazole 25EC at 250 ppm and mancozeb 75WP at 500 ppm showed complete mycelial inhibition of the pathogen.
- In integrated disease management, seed treatment with carbendazim 50WP followed by three sprays of trifloxystrobin 25% + tebuconazole 50% gave highest disease control of 85.44 per cent with 49.58 per cent increase in yield over check.

8. Sunidhi (A-2016-30-068) Majaor Guide: Dr B R Thakur

"Epidemiology and management of Ascochyta blight of Chickpea (*Cicer arietinum* L.)"

- *In vitro* evaluation of organic inputs and botanicals against *Ascochyta rabiei* revealed that Jeevamritat at 10 % concentration gave maximum 89.16 % inhibition of spore germination while Vermicompost at 25 % concentration exhibited 67.29 % inhibition of spore germination. Both the aqueous and alcoholic

extracts of *Eucalyptus* sp**.** were found to be the best among all the test botanicals at 25 % test concentration giving more than 50 % spore germination inhibition.

- Thiram 75DS and Vitavax power (2.5%) were found most effective seed dressers to inhibit 90 % spore germination of *Ascochyta rabiei.*
- Among 50 germplasm lines of chickpea, 15 lines viz., ICWA 1904, FLIP13-145C, FLIP13-164C, FLIP13-244C, FLIP13-269C, FLIP13-299C and FLIP13-309C, ICWA 1909, ICWA 1926, HC 1, FLIP13-27C, FLIP13-137C, FLIP13-156C, FLIP13-242 and FLIP13-256 (with disease score of 2 & 3) were rated resistant against *A. rabiei*.

Ph D students:

1. **Shabnam (A-2015-40-020) Majaor Guide: Dr S k Rana**
   "High resolution mapping of *Co-Ind* gene from common bean landrace KRC 5 possessing resistance to *Colletotrichum lindemuthianum* races"

- The segregation studies on F_2 and $F_{2:9}$ mapping populations obtained from *Jawala* x KRC-5 cross against races 3 and 211 of *Colletotrichum lindemuthianum* showed a good fit of 3R:1S and 1R:1S ratio, thus confirmed the presence of a single dominant gene in landrace KRC-5.
- The genotyping of 219 $F_{2:9}$ RIL individuals with SCAR marker $ScOPR15_{408}$ and previously developed SCAR ($ScOPF6_{522}$) showed their linkage with R-gene at 2 cM distance on the opposite sides of R-locus.
- The tentative position of R-gene (*Co-Ind*) present in landrace KRC-5 was marked on chromosome 10 along with two SCAR markers flanking the target gene and other SNP markers however, the exact position of R-gene can only be established after genotyping the whole population with associated SNPs.
- In gene strength analysis, the landrace KRC-5 was found resistant to 17 races of *C. lindemuthianum* and hence could be effectively used in molecular breeding programmes.

2. **Shiwali Dhiman (A-2015-40-021) Majaor Guide: Dr P N sharma**
   "Molecular mapping of anthracnose resistance gene in common bean landrace KRC-8 and identification of adult plant resistance components"

- The segregation ratios in F2 and F2:9 mapping populations of cross Jawala x KRC-8 against race 87 of *Colletotrichum lindemuthianum* fitted good to 1R:3S and 1R:1S ratios respectively, thus confirming the presence of single recessive gene in landrace KRC-8.
- After screening of 172 F2:9 RIL mapping population with IAC-238 marker, segregation ratio of 1:1 with no recombinant was observed showing no linkage distortion with resistance gene.
- R-gene was located on chromosome 1 at position 44472100 – 44472139 (41b) with the transcript - Phuvl. 001G186600.1- K141510- Serine / Threonine- protein kinase CTR1, tentatively named as coB-Ind and found to be different from the earlier identified R-genes located on chromosome 1.
- The APR components studied by artificially inoculating the parental genotypes (Jawala and KRC-8) at five plant growth stages against three races (race 3, 87 and 211) of *C. lindemuthianum* revealed the presence of a novel phenomenon of APR in common bean which can be utilized further in resistance breeding programmes.

3. **Anudeep B Mallannavara (A-2016-40-017) Majaor Guide: Dr D K Banyal**
   "Studies on virulence and host resistance in Oat- *Blumeria graminis f. sp. avenae* pathosystem"

- A total of 303 oat germplasm lines were evaluated under field conditions for 3 consecutive years against *Blumeria graminis* f. sp. *avenae* and 11 lines *viz.*, JPO-40, OS-10, OG-77, PLP-1, OL-1847, OL-1869, OL-1689, OL-1689-AVTSC, HFO-864, HFO-125 and OL-6 were found resistant.
- The cultivars IG-03-203, JPO-20 and KRR-AK-06 were identified as slow mildewers on the basis of low values of AUDPC, high incubation and latent period, smaller size of colonies, less sporulation as represented by number of 'conidiophores bearing conidia' per colony as compared to highly susceptible check HJ-8.

- Study of pathogenic variability on developed differential set grouped 24 isolates into 14 pathotypes (OMP-1 to OMP-14) out of which OMP-2, OMP-7 and OMP-13 were highly virulent among all the pathotypes, and gave susceptible reaction on 9 out of 11 differential lines.
- The inheritance of resistance was studied by makig crosses of 3 resistant lines i.e. OL-1847, OG-77 and OL-1689 with highly susceptible cv. HJ-8 and F_1 population of all the three crosses was found resistant to powdery mildew whereas, F_2 generation segregated into three resistant and one susceptible plant ratio, which confirmed that the resistance to oat powdery mildew was controlled by single dominant gene.

4. Dimple Rana (A-2017-40-020) Majaor Guide: Dr B R Thakur
"Studies on variability and management of Fusarium wilt of chickpea"

- A total of 35 isolates of *Fusarium oxysporum* f. sp. *ciceris* were categorized into eight groups on the basis of virulence spectra on differential lines and the prevalence of four known races 1, 2, 5, 6 and four new reactions were found in chickpea growing areas of Himachal Pradesh and northern parts of India.
- Based on molecular characterization, *F. oxysporum* f. sp *ciceris* isolates were clustered into eight groups at 55 per cent similarity coefficient.
- Among all the test fungicides, Carbendazim 50WP (Bavistin) and Carboxin 37.5% + Thiram 37.5% (Vitavax power) gave cent per cent mycelial inhibition at 500 ppm.
- The integrated disease management treatment of soil amendment with himcompost @ 10t/ha followed by seed treatment with E. adenophorum @ 5ml/kg of seed and further seed dressing with *T. viride* @ 5g/kg of seed managed the average wilt incidence up to 49.55 per cent at Palampur and 71.91 per cent at Akrot.

5. RESEARCH

A. Survey and surveillance

I. Rice:

Surveys in major rice growing areas of district Kangra and a few locations of tehsil Sandhol of district Mandi were conducted during *kharif* 2020.

Kangra: More than forty locations from nine blocks of district Kangra viz., Nagrota Bagwan, Baijnath, Rait, Bhawarna, Bhedu Mahadev, Panchrukhi, Dharamshala, Indora and Fatehpur were covered under survey during *kharif* 2020 at different crop stages. Diseases such as leaf blast, neck blast and false smut were observed as moderate while sheath rot, grain discolouration, brown spot, sheath blight and narrow brown leaf spot were recorded as low. False smut was more prevalent of hybrids like Arize 6129, Sawa 200, PAC 807 plus etc.

Mandi: Suvey was mainly conducted in Sandhol area. Very high intensity of diseases like brown spot and narrow brown leaf spot was observed on a few cultivars in Sandhol area.

In rice, the severity of **brown spot** varied from 10-20% and **leaf blast** from 10-30% recorded at few locations. The incidence of **false smut** varied from 5-30%.

II. Maize:

In Kangra district the disease severity of **Maydis leaf blight** in maize ranged from 30-70%, incidence of turcicum leaf blight 10-30%, incidence of **brown spot** ranged from 40-80% and incidence of **BLSB** varied from 10-50%.

In Kullu district, the occurrence of Turcicum leaf blight, Maydis leaf blight, Banded leaf & sheath blight disease was modrate in different surved locations such as Nahalach, Pirdi, Khokhan, Garsa, Mohan, Dhaman, Shalouri, Ratwa, Targali, Banjar, Panarsa, Nagwain and Jia.

III. Wheat and barley:

Stripe Rust: Severe outbreak (80-100 S) of stripe (yellow) rust of wheat was observed in a farmers' field in Lahasan area of Dehra block of district Kangra on a local variety.

Flag Smut: Incidence of flag smut (10-15%) was also observed in HD 2967 and HD 3086 grown in Dhanot area of Dehra block at heading stage of the crop.

Powdery Mildew: Sporadic appearance of powdery mildew with disease intensity 3-5 (on 0-9 scale) was observed in locations surveyed.

Karnal bunt: Karnal bunt incidence on HS542, HPW368, WH1080, DBW88, HD-2967, HD-2380, WH-1105, WH-1184, HS-562,VL-907, VL-953, HPW-373, HPW349 and local varieties was observed in the range of 0-0.23 per cent in Sirmour district.

Although very less rains were received during *rabi* 2020-21 however, **Yellow rust** in wheat was reported at some locations and severity varied from 20-60S depending upon the varieties cultivated by farmers, intensity of **powdery mildew** ranged from 3-7 on 0-9 scale and incidence of **flag smut** ranged from 5-15%. In Kullu district, the occurrence of yellow rust severity was modrate while losesmut and hill bunt was low in surveyed locations such as Bhekhali, Nahalach, Pirdi, Khokhan, Garsa, Mohan of Kullu Block, Dhaman, Shalouri, Ratwa, Targali, Sai Ropa, Banjar of Banjar block. In case of barley main disease was stripe rust with modrate severity while coverd smut and brown stripe were in low intensity.

IV. Vegetable and pulse crops:

Systematic surveys were conducted in the command area of Hill Agricultural Research and Extension Centre Bajaura. The diseases observed in different crops are given in Table 1. Incidence of various diseases varied from locality to locality.

Table 1: Survey and Surveillance Bajuara.

Crop	Disease	Disease Intensity	Area Surveyed
Tomato	Early Blight and Alternaria fruit Rot,	Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Late Blight and fruit Rot, Buck Eye Rot	Moderate - High	
	Septoria Blight, Bacterial Spots, Bacterial wilt,	Low - Moderate	
	Virus diseases and Disorders.	Low	
Capsicum	Blight and Fruit Rot, Anthracnose	Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	bacterial wilt and virus diseases	Low	
Cabbage and Cauliflower	Black rot	High	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Alternaria leaf spot	Low - Moderate	
French Bean	Angular leaf spot	Low - Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
Peas	Wilt & root rot, Powdery Mildew,	Low-Moderate	Kelhali, Garsa, Jia, Ruaru, Bhuntar, Nagwain, Panarsa, Aut, Haat, Jhiri, Jwalapur, Manikaran, Katrain, Seobagh
	Bacterial blight	Moderate	
Cucumber	Powdery mildew, Downey mildew.	Moderate-High	Kelhali, Garsa, Jia, Ruaru, Nagwain, Panarsa, Aut, Haat, Piridi, Mohal, Khokhan
Garlic	Stemphylium blight & purple blotch in garlic.	Moderate	Nahalach, Pirdi, Khokhan, Chheol, Garsa, Mohan, Dhaman, Shalouri, Ratwa, Targali, Sai Ropa, Banjar
	Rust	Low	
	Bulb rot	Low	
Onion	Purple blotch, downy Mildew.	Moderate	-
	Bulb rot	Low	
Urd Bean	cercospora leaf spot,	Low - Moderate	-
	Leaf crinkle virus	Low	

In capsicum the **powdery mildew** severity varied from 10-30% and Phytophthora blight severity ranged from 10-40%. In tomato very high severity of Phytophthora blight (50-70%) was recorded in a polyhouse at Palampur.

In Mash the **anthracnose** severity was very high at Palampur and ranged from 40-70% whereas, the **Ascochyta blight/ leaf spot** severity varied from 30-50%. In **chickpea** the Fusarial wilt and root rot complex was recorded at Palampur and incidence ranged from 5-20%.

V. Oilseeds/ Soybean

Surveys were conducted in main soybean growing areas of Himachal Pradesh during September 2020 to record data on the occurrence of different diseases. Mainly four diseases *viz*.,

frog eye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*), bacterial pustule (*Xanthomona scampestris* pv. *glycines*) and yellow mosaic virus (YMV) were found to occur in areas surveyed in Kangra and Mandi districts. Location wise per cent disease index (PDI) is presented in table 2. 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 2: Occurrence of soybean diseases in major soybean areas in Himachal Pradesh

District/village	**Variety grown**	**Percent disease index**			
		Frogeye leaf spot (*Cercospora sojina*)	Pod blight (*Colletotrichum truncatum*)	YMV	Bacterial pustule (*Xanthomonas campestris* pv. *glycines*)
Kangra district					
Utrala	Hara Soya	33.33	11.11	0.0	11.11
	Him Soya	55.55	33.33	0.0	0.0
Paprola	Him Soya	55.55	11.11	0.0	0.0
Mahakal	Hara Soya	55.55	33.33	0.0	11.11
Pantehar	Hara Soya	55.55	33.33	0.0	0.0
Nagri	Hara Soya	55.55	33.33	0.0	11.11
Kachyari	Hara Soya	11.11	11.11	11.1	0.0
Kangra	Hara Soya	33.33	11.11	33.3	0.0
	Shivalik	77.77	33.33	00	0.0
Palampur	Hara Soya	55.55	33.33	0.0	11.11
	Bragg	55.55	55.55	0.0	0.0
	Shivalik	77.77	33.33	0.0	0.0
	Him Soya	77.77	33.33	0.0	0.0
Mandi district					
Jogindernagar	Hara soya	33.3	11.11	0.0	0.0
Chauntra	Hara soya	55.55	11.1	0.0	0.0
	Palam soya	11.11	33.3	0.0	0.0

VI. Fodder crops:

During *Kharif* 2020, wilt/root rot, leaf spot and blights of cowpea, blight and BLSB of maize, zonate leaf spot sorghum and blast of bajra were observed to be the main diseases. In the *Rabi* 2020-21 season oat powdery mildew and leaf blights of oats, root rot and powdery mildew of clovers was observed as important diseases (Table 3).

Table 3: Diseases and Insect-pests of different *Kharif* & *Rabi* fodder crops

Crop	Diseases and insect pest	Incidence/ Severity (%)
***Kharif* 2018**		
Cowpea	Wilt/root rot (*Fusarium, Rhizoctonia*)	59
	Leaf spot and blight (*Phytophthora Ascochyta, Phyllostricta*)	35
Maize	Blight (*Helminthosprium maydis* and *H. Tercecium*)	30
	Banded leaf & sheath blight (*Rhizoctonia*)	4
Sorghum	Zonate leaf spot (*Gloeocercospora sorghi)*	70
Bajra	leaf blight *(Helminthosporium*)	25
	Blast (*Pyricularia grisea*)	45
***Rabi* 18-19**		
Oats	Powdery mildew	49
	Leaf blights	15
Berseem	Root rot	5
	Leaf spot	15
Lucerne	Leaf spot	10

VII. Status of diseases under protected cultivation:

Capsicum: Powdery mildew was the most prevalent disease occurring with average disease severity ranging from 10 to 50% followed by root rot i.e. up to 5-25%. Third important disease was Cercospora leaf spot (5-100 % incidence and average disease severity ranged from 10 to 25 per cent). Bacterial wilt was observed 5-15% in Kangra district (Table 4).

Tomato: Complex leaf spotting was observed due to target spot, early blight and gray leaf spot diseases as major problem while powdery mildew was observed second important disease. Incidence of Fruit rot and Fusarium wilt was sporadic with low intensity. A new mold disease is also emergind under protected condition.

Cucumber: Powdery mildew was the most prevalent disease with disease severity of 20-30% while downy mildew was also found at with moderate intensity with disease severity of 20-30% particularly after rainy season (Oct.-Nov.) crop. A new disease sowing target spot symptoms was also emerging as new threat to the cucumber cultivation in the polyhouses.

Table 4: Prevalence of diseases under protected cultivation

Crop	Disease(s)	Poly-houses infested (%)	Disease Severity (%)
Tomato	Blights (Early, gray and target spots)	20	10-25 (20)
	Fruit rots (target, gray mould and sunscald)	24	5-20 (15)
	Powdery mildew	20	20-30 (25)
	Fusarium wilt	7.5	5-10 (7.5)
	Bacterial wilt	5	5-20 (7.5)
	Leaf mold	5	5-25 (12.5)
Capsicum	Root/collar rot	15	5-25 (15)
	Bacterial wilt	6	5-15 (7.5)
	Blights (Cercospora leaf spot)	20	10-25 (15)
	Viruses	25	5-25 (10)
	Powdery mildew	35	10-50 (20)
Cucumber	Powdery mildew	15	20-30 (25)
	Downy mildew (Aug.-Nov)	50	10-50 (25)
	Target leaf spot	50	5-75 (40)

Mapping of geographical distribution and identification of new invasive species of insect pests and diseases simulated futuristic crop water footprint scenarios for major crops, in Himachal Pradesh: To study the impact of climate on the development of important diseases and emergence of new diseases of important crops in Himachal Pradesh, data were collected from different places on different diseases. The major diseases already reported from different parts of the state were yellow rust & Karnal bunt of wheat, blast of rice, powdery mildew, white rot & root rot/wilt of pea, fruit rot of tomato, black rot of cauliflower, downy mildew of cucurbits, bacterial wilt of solanaceous crops, bean yellow mosaic, wilt & anthracnose of gram, rhizome rot of ginger, downy mildew of onion etc are being observed regularly but the intensity of these diseases increasing or decreasing in different years/seasons and depended on weather conditions. However, some very important observations on the change in scenario of the disease intensity or emergence of diseases at new locations were observed in last few years from different parts of the state. It was observed that in wheat along with yellow rust, Helminthosporium leaf spot and head scab severity is increasing and also these diseases are reported from new locations. In maize BSLB which was a minor disease is becoming major disease in all the maize growing area of the state. In rice, false smut which was considered as a minor disease is becoming major disease in most of parts of state, however the incidence of blast is decreased and sheath rot, head scab and brown spot of rice are new emerging diseases. In garlic bulb rot & rust has been report as new important disease along with increasing severity of Stemphylim blight on garlic as well as on onion. Tomato bacterial canker & bacterial spot and pea bacterial blight is also becoming as important diseases in recent time in Zone III of the state. In the lower parts of the state wilt of cucurbit is now became most important disease from last 4-5 years instead of downy mildew. So a regular data on these diseases and also on change on the disease intensity or insurgence of new disease or pathogen will be collected regularly and analyzed for any impact of climate change.

B. Cereals

I. Rice

1. Screening of germplasm:

I. Screening for leaf and neck blast resistance:

Rice germplasm consisting of 706 entries from various screening nurseries viz. National Screening Nursery 1 (NSN1=323), National Screening Nursery-Hills (NSN-H=128), National Hybrid Screening Nursery (NHSN=105) and Donor Screening Nursery (DSN=150) were screened under natural epiphytotic conditions at RWRC, Malan for leaf blast resistance under Uniform Blast Nursery Pattern and for neck blast resistance under transplanted conditions. The test entries were scored based on leaf blast severity following Standard Evaluation System for Rice (SES) scale as per the technical programme of All India Coordinated Plant Pathology Trials (2020-21).

Out of these nurseries, 56 entries from NSN-1, 67 from NSN-H, 46 from NHSN and 41 entries from DSN were found promising against leaf blast. However, 44 entries from NSN-H and 23 from NHSN were found promising against neck blast.

II. Monitoring of field virulences in *Pyricularia oryzae*:

To characterize the virulence spectrum in the population of *Pyricularia oryzae* in different rice ecosystems, a set of 35 differentials consisting of international differentials, donors and commercial cultivars was planted across 23 locations across the country adopting UBN pattern including Malan. The observations revealed that C101 A51, C104 PKT, RIL 10, CO 39 and RP Patho-3 showed susceptible reaction while rest of the differentials were found resistant to leaf blast. The difference in disease reaction score of susceptible and resistant checks revealed a shift in pathogen population. The reaction pattern of genotypes at all test locations was grouped into six major groups wherein reaction pattern of Malan was included in group four.

III. Disease Observation Nursery:

To observe the time of occurrence and intensity of leaf blast a trial was conducted during *kharif* 2020 at RWRC, Malan. A susceptible variety, HPU 2216 was selected and the crop was sown on dated 21.05.20 (early), 05.06.20 (normal) and 20.06.20 (late). The early sown crop was found to be relatively disease free (1.2% PDI) when compared to the normal (7.2 to 25.6% PDI) and late sown (4.3 to 37.8% PDI) crop (Table 5). Excess moisture during the early stages of the crop under the late sown conditions led to the more incidence of the disease, when compared to the relatively dry season during early sown conditions and as a result the initial stage of the crop was relatively dry and the crop matured when the humidity starts building up during late stages of the crop.

Table 5: Occurrence of leaf blast of rice in disease observation nursery at Malan during *kharif*-2020

DAT*	Per cent Disease (Leaf blast) Severity		
	Early	Normal	Late
30 DAT	0.0	0.0	4.3
40 DAT	0.0	0.0	14.9
50 DAT	0.0	7.2	22.1
60 DAT	0.0	15.4	31.5
70 DAT	1.2	25.6	37.8

DAT = Days after transplanting

2. Disease Management:

i) Evaluation of new fungicides against location specific diseases:

A field trial was conducted during *kharif* 2020 in randomized block design to evaluate the efficacy of some new fungicide formulations against blast using a susceptible variety 'HPU 2216'.

Fungicides namely, difenconazole 25% EC, isoprothiolane 40% EC, kasugamycin 3% SL, kitazin 48% EC, propineb 70% WP, tebuconazole 25.9% EC, thifluzamide 24% SC including untreated control were evaluated for their efficacy against neck blast. In all, two sprays were applied first on September 9, 2020 and second spray was applied on September 24, 2020 at the time of booting and flowering stages, respectively.

Observations on neck blast incidence were recorded a week before harvest by counting the infected over total panicles from 3 sampling units of 1 x 1 m area in each plot in case of neck blast following 0-9 scale of Standard Evaluation System for Rice, Philippines (2013). The grain yield was recorded on plot basis and was converted to q/ha.

A perusal of the data (Table 6) revealed that all the fungicides significantly reduced the neck blast incidence as compared to control during *kharif* 2020. Application of isoprothiolane 40% EC proved to be highly effective in reducing neck blast incidence to 12.5% as compared to 75.4 per cent in untreated control and was statistically at par with kasugamycin 3% SL (15.0%) resulting in 83 and 80 per cent reduction in neck blast incidence over control. Kitazin 48% EC was next best fungicide in order of efficacy resulting in 70 per cent (22.5% neck blast incidence) reduction in neck blast incidence over control. However, rest of the fungicides were not very effective but caused significant reduction (up to 50%) in disease incidence over control.

All the fungicides significantly enhanced the grain yield over control but highest mean grain yield was obtained from plots where isoprothiolane 40% EC and kasugamycin 3% SL were sprayed being statistically at par with each other and both resulted in about 95 per cent (26.9 q/ ha grain yield) increase in grain yield over control. Treatments of isoprothiolane 40% EC and kasugamycin 3% SL didn't differ significantly with kitazin 48% EC (25.4 q/ ha) also which provided 84 per cent increase in grain yield followed by tebuconazole 25.9% EC (24.0 q/ ha).

Table 6: Evaluation of new fungicides for the management of rice blast during *kharif* 2020

Fungicide	Dose / L	Neck blast incidence (%)	Per cent reduction in neck blast	Grain yield (q/ ha)	Per cent increase over control
T1- Difenconazole 25% EC	0.5 ml	40.5 (39.5)	46.3	22.5	63.0
T2- Isoprothiolane 40% EC	1.5 ml	12.5 (20.7)	83.4	26.9	94.9
T3- Kasugamycin 3% SL	2.0 ml	15.0 (22.7)	80.1	26.9	94.9
T4- Kitazin 48% EC	1.0 ml	22.5 (28.3)	70.2	25.4	84.1
T5- Propineb 70% WP	3.0 g	38.1 (38.1)	49.5	21.1	52.9
T6- Tebuconazole 25.9% EC	1.5 ml	35.1 (36.3)	53.4	24.0	73.9
T7- Thifluzamide 24% SC	0.8 g	39.6 (39.0)	47.5	21.1	52.9
T8- Control	-	75.4 (60.3)	-	13.8	-
CD (*P = 0.05*)	-	3.5		2.8	

Figures in parentheses are arcsine transformed values

ii) Integrated disease management:

To test the effect of Integrated Disease Management practices against major diseases like blast, a trial was laid out in RBD design with three replications during *kharif* 2020. A highly susceptible variety, HPU 2216 with 6 treatments of IDM was planted. Seedlings (25 days old) of HPU 2216 were transplanted and the application of fertilizer was done as per the requirement of the treatments. Treatment-wise sprays were applied, first of bioagent (*Trichoderma viride*) between 15-20 DAT on August 13, 2020 and second spray of fungicides was applied on September 11, 2020 at the time of booting stage of the crop.

Treatment Details

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

Observations on leaf blast severity were recorded from 10 hills/ plot following 0-9 scale of Standard Evaluation System for Rice, Philippines (2013) at flowering and that on neck blast incidence were recorded a week before harvest by counting the infected over total panicles. The grain yield was recorded on plot basis and was converted to q/ha.

The perusal of data (Table 7) revealed that among different treatments, TS i.e. treatment combination of seed treatment with carbendazim (2 g/kg) + one blanket application of combination fungicide Nativo 75 WG (trifloxystrobin 25% + tebuconazole 50%) @ 0.4 g/l at booting stage proved to be highly promising resulting in about 50 per cent reduction in neck blast incidence and increased the grain yield by 89% over control followed by treatment T4 i.e. combination of Seed treatment with bio-control agent + one application of bio-control agent at 15-20 DAT (10 g/litre) + One blanket application of propiconazole (1 g/litre) at booting stage registering an increase of about 57 per cent in grain yield.

Table 7: Integrated management of neck blast of rice during *kharif*-2020

Treatment	Neck blast incidence (%)	Reduction in disease incidence (%)	Grain yield (q/ ha)	Per cent increase over control
T1 = ST with Bio-control agent @ (10 g/kg)	46.7 (43.1)	23.4	15.2	28.6
T2 = T1 + bio1control agent at 15-20 DAT	46.5 (43.0)	23.8	16.0	35.7
T3 = T1 + one spray of propiconazole at booting stage	44.6 (41.9)	26.9	16.0	35.7
T4 = T2 + one spray of propiconazole at booting stage	33.8 (35.5)	44.6	18.5	57.1
T5 = ST with carbendazim (2 g/kg) + spray of Nativo 75 WG @ 0.4 g/l at booting stage	30.6 (33.6)	49.8	22.3	89.3
T6 = Control	61.0 (51.3)	-	11.8	-
CD (*P = 0.05*)	4.1	-	3.6	-

Figures in parentheses are arcsine transformed values

iii) Special trial on yield loss assessment due to rice blast:

A special trial on yield loss assessment due to leaf blast was laid out during *kharif* 2020 in a randomized block design with five replications and four treatments, viz., Inoculum sprayed thrice at an interval of 2 days (T1); Inoculum sprayed twice at an interval of 2 days (T2); Inoculum sprayed once (T3) and uninoculated/ fungicide treated plot served as control (T4). Leaf blast susceptible variety HPU 2216 was used for yield loss assessment. The pathogen was artificially inoculated by spraying conidial suspension or supplementing with spreading of diseased leaves and disease was recorded as percent disease index (PDI). The grain yield was recorded on plot basis and was converted to q/ha.

The perusal of data presented in Table 8 revealed that the highest disease severity (92.8%) was observed where the plots received pathogen inoculum thrice as compared to plots with two times (67.9%) and one time inoculated (55.3%). The highest yield was recorded in control plot (26.60 q/ha) and lowest in plot with more disease severity (T1- 10.60 q/ha). The grain yield was decreased by 60.2%, 47.4% and 31.6%, respectively in T1, T2 and T3 over control plot.

Table 8: Leaf blast disease severity on rice grain yield during *kharif*-2020

Treatment	Leaf blast severity (%)	Grain yield (q/ ha)	Per cent increase over control
T1	92.8 (74.7)	10.60	60.2
T2	67.7 (55.6)	14.00	47.4
T3	55.3 (48.0)	18.20	31.6
T4	17.8 (25.0)	26.60	
CD (*P = 0.05*)	4.01	1.89	-

Figures in parentheses are arcsine transformed values

Treatment details:

T1- Inoculum sprayed thrice at an interval of 2 days (Randomly select 5 one sq m area where disease intensity is more than 50%)
T2- Inoculum sprayed twice at an interval of 2 days (Randomly select 5 one sq m area where disease intensity is 30-50%)
T3- Inoculum sprayed once (Randomly select 5 one sq m area where disease intensity is below 30%)
T4- Un-inoculated + fungicide/antibiotic treated control plot

II. Maize

I. Evaluation of Maize Germplasm

A total of 106 normal maize (medium maturity, early maturity and OPV) and 43 specialty corn (QPM, Pop Corn, Sweet Corn and Baby Corn) genotypes were evaluated against Turcicum leaf blight (TLB) during *kharif*, 2020. The screenings of these genotypes were carried out under artificial epiphytotic conditions. The details of promising genotypes under various maturity groups and speciality corn are presented in Table 9.

Table 9: Screening of maize genotypes against Turcicum leaf blight (TLB)

Maturity Group	Total entries screened	No. of Resistant entries	Promising genotpes
NIVT medium maturity	62	8	AH 3001, HM 20105, HT 520015, IMHSB 20K-3, KMH-1, OMH 19-14, PM20101M and PM20104M
NIVT early maturity	27	4	EH3573, FH3947, FSMH-2001 and H- 120
AVT Medium Maturity	5	4	DKC-8205, DKC9190 and DKC-8191
AVT Early Maturity	3	2	KMH 18-13 and KMH17-89
QPM I-II-III	23	4	DQH113, IQPMH 2002, LQPMH1920 and FQH 160
Sweet Corn	-	9	BSCH 417160, CSCH15005, FSCH 131, DSCH- 340, FSCH 128, CP Sweet 2, CPSC 301, Top Sweet and Super sweet
Pop Corn	-	1	DPCH-311
Baby Corn	-	4	IMHSB-19KB-1, IMHSB-19KB-2, MBC-20-2 and ABHS4-1
OPV(Open pollinated)	14	4	SKMC-03, KDM30, M- 11 and L316

II. Maize Disease trap nursery

Maize disease trap nursery consisting of 12 lines was planted to monitored the prevalence of different diseases of maize. Maximum disease incidence of TLB was recorded on early composite, Surya and CM400.

III. Screening of maize hybrids of public and private sector

Eighteen maize hybrids of public and private sectors along with three checks (Bio 605, Palam sankar Makka 2 and Bio 9544) were screened against Turcicum leaf blight (TLB) and Maydis leaf blight (MLB) under artificial epiphytotic conditions during *kharif* 2020. All the maize hybrids were found resistant/ moderately resistant against both the diseases. Maize hybrids P3378, K-25 Super, M9366, CP555, DKC7204, M9333, LG36607 and CP333 were found promising (Table 10).

Table 10: Evaluation of maize hybrids

Hybrids	TLB Score (1.9 Scale)	Reaction Type	MLB Score (1-9 Scale)	Reaction Type	Yield (q/ha)
LG36607	2.0	R	2.0	R	85.0
Bioseed 9220	2.0	R	2.0	R	71.2
CP 555	2.0	R	2.0	R	86.9
CP 333	2.0	R	3.0	R	84.8
B-52AGold	2.0	R	2.0	R	65.9
K-25	3.0	R	2.0	R	89.1
Bioseed 9784	4.0	MR	2.0	R	76.9
VNR-4343	2.0	R	2.0	R	84.2
Nutra Early	3.0	R	3.0	R	73.3
DKC 7204	4.0	MR	3.0	R	86.8
M-9333	3.0	R	2.0	R	85.3
DKC8209	3.0	R	2.0	R	86.6
Bio 605 (Check)	2.0	R	2.0	R	73.1
M9344	3.0	R	3.0	R	73.9
Palam Sankar Makka 2 (Check)	4.0	MR	2.0	R	69.9
M9366	2.0	R	2.0	R	87.6
P3378	2.0	R	2.0	R	95.2
Bio 9544 (Check)	3.0	R	3.0	R	71.6
VNR-Y3099	3.0	R	2.0	R	77.3
SAMBA GOLD	3.0	R	2.0	R	71.7
P-3302	3.0	R	3.0	R	51.3

IV. Efficacy of fungicides in control of Turcicum leaf blight (TLB)

A field trial consisting of eight treatments was conducted for the management of Turcicum leaf blight (TLB) of maize with variety Early Composite in RBD having 3 replications during *kharif*, 2020. Plot size was 2.5 x 2.4 m**.** Two sprays at 15 days interval were given. First spray was given 3 days after inoculation with the pathogen. All the treatments were found superior over the control treatment. Two sprays of Azoxystrobin 7.5% +Propiconazole 12.5% SE @ 0.2 % or Kresoxim methyl 44.3%SC @ 0.1 % or Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.1 %

at were found most effective in controlling TLB giving 74 to 76 per cent disease control with 33 to 59 per cent increase in yield (Table 11).

Table 11: Efficacy of fungicides in control of Turcicum leaf blight (TLB)

Treatments	Dose (%)	Percent Disease Index	Average Disease Score	Disease Control (%)	Yield (q/ha)	Increase in Yield (%)
T1: Kresoxim methyl 44.3%SC	0.10	21.5 (27.6)	1.9	74.2	41.0	33.0
T2: Zineb75% WP	0.20	41.9 (40.3)	3.8	49.8	37.0	20.2
T3: Thiram 75% WS (seed treatment)	0.20	66.7 (54.7)	6.0	20.0	38.4	24.6
T4: Azoxystrobin 18.2 w/w +Difenoconozole11.4% w/w SC	0.10	23.7 (29.1)	2.1	71.5	36.7	19.2
T5: Tebuconazole 50% + Trifloxystrobin 25% WG	0.10	21.1 (27.3)	1.9	74.7	44.5	44.4
T6: Azoxystrobin 7.5% +Propiconazole 12.5% SE	0.20	20.0 (26.5)	1.8	76.0	49.2	59.9
T7: Protected check (Mancozeb 75%WP	0.20	43.3 (41.1)	3.9	48.0	37.2	20.9
T8: Untreated Control (Water spray)	-	83.3 (65.9)	7.5	-	30.8	-
CD (0.05)		1.9	0.3	-	1.9	-
CV (%)		5.8	4.3	-	7.8	-

III. Wheat

Evaluation of advanced breeding material against yellow rust and powdery mildew:

In all, 1939 wheat entries comprising Initial Plant Pathological Screening Nursery (IPPSN = 1362), Plant Pathological Screening Nursery (AVT 1st Year = 200; NIVT = 271), Elite Plant Pathological Screening Nursery (EPPSN = 56) and Multiple Disease Screening Nursery (MDSN = 50) were evaluated against yellow rust at Malan under natural epiphytotic conditions with disease augmentation by following artificial inoculation procedure. Entries from Powdery mildew Screening Nursery (PMSN = 200) were screened against powdery mildew separately while MDSN entries were screened against both yellow rust as well as powdery mildew. It was observed that out of 1939 entries from various screening nurseries, 30 entries from EPPSN, 104 from AVT 1st Year, 136 from NIVT, 26 from MDSN and 704 from IPPSN were free from yellow rust infection. However, out of 200 entries from PMSN and 50 entries from MDSN, 24 and 21 entries were found were found promising against powdery mildew, respectively. The information is given in table 12.

Table 12: Stripe rust resistant entries in stable wheat breeding material received from IIW&BR, Karnal under AICRP on wheat.

Nursery	No. of entries	Resistant entries with reaction to yellow rust		
		Free	Severity≤ 5	Promising entries
EPPSN	56	30	9	39
IPPSN	1362	704	124	828
PPSN (NIVT)	271	136	16	152
AVT 1st Year	200	104	13	117
MDSN	50	26	2	28
Total	1939	1000	164	1164

iii) Evaluation of fungicides for the management of wheat powdery mildew:

A field trial was conducted during 2020-21 season in randomized block design to evaluate the efficacy of some new fungicide formulations against powdery mildew of wheat using a susceptible variety 'HPW 155'. Fungicides namely, azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC, azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC, tebuconazole 50% + trifloxystrobin 25% WG, propiconezole and tebuconazole including untreated control were evaluated for their efficacy against powdery mildew. In all, two sprays were applied first on the initiation of disease on March 3, 2021 and second spray was applied 15 days after 1st spray on April 6, 2021.

Observations on powdery mildew were recorded following 0-9 scale (Leath and Heun, 1990). The grain yield was recorded on plot basis and was converted to q/ha.

A perusal of the data (Table 13) revealed that all the fungicides significantly reduced the powdery mildew severity as compared to control during 2020-21 season. Application of azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC proved to be highly effective in reducing powdery mildew to 21.6 per cent as compared to 36.3 per cent in untreated control and was statistically at par with azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (25.3%) resulting in 40 and 30 per cent reduction in powdery mildew severity over control. Combination of tebuconazole 50% + trifloxystrobin 25% WG was next in order of efficacy being statistically at par with tebuconazole and propiconazole alone resulting in 29.8, 24.8 and 24.5 per cent reduction in powdery mildew severity, respectively.

Application of azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC proved to be highly effective in enhancing the grain yield significantly over control resulting in about 42 per cent (32.5 q/ ha grain yield) increase in grain yield over control and was at par with azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC and tebuconazole 50% + trifloxystrobin 25% WG registering about 32 and 26 per cent increase in grain yield over control. However, treatments of propiconazole and tebuconazole did not have any significant effect on grain yield over control as indicated from data.

Table13: Evaluation of fungicides for the management of wheat powdery mildew during 2020-21

Fungicide	**Dose / L**	**Powdery mildew Severity (%)**	**Per cent reduction in powdery mildew**	**Grain yield (q/ ha)**	**Per cent increase over control**
T1=Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC	0.1%	21.6 (27.6)	40.5	32.5	41.9
T2=Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC	0.1%	25.3 (30.2)	30.0	30.2	31.9
T3=Tebuconazole 50% + Trifloxystrobin 25% WG	0.06%	25.5 (30.3)	29.8	28.8	25.8
T4=Propiconazole	0.1%	27.4 (31.5)	24.5	25.9	13.1
T5=Tebuconazole	0.1%	27.3 (31.5)	24.8	26.0	13.5
T6=Control	-	36.3 (37.1)	-	22.9	-
CD (*P = 0.05*)	-	2.6		4.0	

Figures in parentheses are arcsine transformed values

Wheat

At Bajoura

I. ***Screening of wheat germplasm against Stripe Rust***

A total of 471 Wheat lines/ genotypes received from ICAR-IIWBR under PPSN AVT and PPSN NIVT/ Special Trials were screened against yellow rust during *Rabi* 2020-21. A total of 302 genotypes were found free from Stripe rust

II. ***Screening of wheat germplasm against Hill Bunt***

Five wheat genotypes were screened against Hill bunt under artificially inoculated conditions during *Rabi* 2020-21. Three genotypes were found free from hill bunt infection and one genotype showed less than 5% infection.

III. ***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* 2020-21. Yellow rust appeared in 11 lines of wheat and one barley line. Disease samples were sent to Flowerdale, Shimla as soon as the disease appeared for pathotype analysis.

A. Barley

I. Screening of Barley Germplasm against Stripe Rust

A total of 525 barley lines/ genotypes received from ICAR-IIWBR under IBDSN, NBDSN and EBDSN were screened against yellow rust during *rabi* 2020-21. A total of 400 genotypes were found resistant to Stripe rust.

D. Fungicide Testing

- **Evaluation of Pydiflumetofen15.0% + Propiconazole 12.5% w/v SE against stripe rust of wheat**

  A new fungicide Pydiflumetofen15.0% + Propiconazole 12.5% w/v SE was tested for its bioefficacy for the control of stripe rust of wheat. Fungicide was tested by laying out trial in RBD with three replications with susceptible wheat variety PBW343 during *Rabi* 2020-21. The test fungicide was found very effective for the management of yellow rust at all the doses. Spray with test fungicide @ 600 ml/ha was found most effective which gave 96.2 per cent yellow rust control. An increase in yield was also observed with all doses of test fungicides as compared to control. The doses of test fungicide (500 ml/ha, 600 ml/ha and 700 ml/ha) were found statistically at par in controlling stripe rust of wheat. No phyto-toxic symptoms could be observed on different parameters viz. leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing, wilting & rosetting on 0, 1, 3, 5 , 7 & 10 days after spray at all doses of test fungicide (Table 14).

- **Evaluation of Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC) against stripe rust of wheat**

  A new fungicide Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC) was tested for its bioefficacy for the control of stripe rust of wheat. Fungicide was tested by laying out trial in RBD with three replications with susceptible wheat variety PBW343 during *Rabi* 2020-21. The test fungicide was found very effective for the management of yellow rust at all the doses. Spray with test fungicide @ 350 ml/ha was found most effective which gave 93.3 per cent yellow rust control. An increase in yield was also observed with all doses of test fungicides as compared to control. No phyto-toxic symptoms could be observed on different parameters viz. leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing, wilting & rosetting on 0, 1, 3, 5 , 7 & 10 days after spray at all doses of test fungicide (Table 15).

Table 14: Evaluation of Pydiflumetofen15.0% + Propiconazole 12.5% w/v SE (275SE) against stripe rust of wheat

Treatment	Dosage (ml/ha)	Yellow rust Severity (%)			Control (%)	Grain Yield (q/ha)	Yield Increase (%)
		Before Spray*	10 days After Ist Spray	10 days After 2nd Spray			
Pydiflumetofen15.0% + Propiconazole 12.5% (275SE)	500	Traces	2.3 (8.7)	4.0 (11.5)	95.3	34.49	62.6
Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE)	600	Traces	1.5 (6.9)	3.2 (10.2)	96.2	35.95	69.5
Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE)	700	Traces	1.7 (7.4)	6.2 (14.4)	92.7	34.04	60.5
Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE)	1400	Traces	2.7 (9.4)	4.5 (12.2)	94.7	30.58	44.2
Pydiflumetofen 20% SC	550	Traces	8.7 (17.1)	17.2 (24.5)	79.6	26.41	24.5
Propiconazole 25 EC	500	Traces	2.5 (9.1)	4.3 (12.0)	94.9	35.82	68.9
Tebuconazole 50 + Trifloxystrobin 25 WG	300	Traces	3.7 (11.0)	6.7 (14.9)	92.1	29.09	37.2
Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE	750		4.7 (12.5)	8.0 (16.4)	90.5	28.48	34.3
Control			39.2 (38.7)	84.3 (66.7)		21.21	-
CD (5%)			1.0	0.6		1.59	-

*****Disease start appearing in infector row planted in the periphery.
**Angular transformed values in the parentheses.

Table 15: Evaluation of Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)) against stripe rust of wheat

Treatment Details	Dosage (ml/ ha)	Yellow rust Severity (%)			Control (%)	Yield (q/ha)	Yield increase (%)
		Before Spray*	10 days After Ist Spray	10 days After 2nd Spray			
Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)	250	Traces	5.0 (12.9)	7.0 (15.3)	91.8	30.6	47.3
Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)	350	Traces	4.2(11.8)	5.7 (13.7)	93.3	31.1	49.4
Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)	500	Traces	4.0 (11.5)	5.7 (13.7)	93.3	32.4	56.0
Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)	625	Traces	5.2 (13.1)	7.2 (15.5)	91.6	30.4	46.3
Propiconazole 13.9% + Difernconazole 13.9% w/w (15% w/v) EC)	1000	Traces	5.5 (13.5)	7.3 (15.7)	91.4	27.7	33.2
Propiconazole 25 EC	500	Traces	4.0 (11.5)	6.0 (14.1)	92.9	32.1	54.2
Difenconazole 25 EC	500	Traces	9.0 (17.4)	13.0 (21.1)	84.7	24.1	15.9
Tebuconazole 50%+Trifloxystrobim 25%WG	300	Traces	4.7 (12.5)	8.0 (16.4)	90.6	27.9	34.2
Picoxystrobin 7.05%+Propiconazole 11.7%	1000	Traces	5.5 (13.5)	9.5 (17.9)	88.8	26.5	27.5
control	-	-	39.5 (38.9)	85.0 (67.2)	-	20.8	-
CD (0.05)	-	-	0.9	0.8	-	1.3	-

*****Disease start appearing in infector row planted in the periphery.
**Angular transformed values in the parentheses.

At Dhaulakuan

(a) Screening of wheat germplasm against major diseases:

During Rabi 2020-21, 2073 entries were screened under artificial inoculation conditions against major diseases viz. Karnal bunt, yellow rust, powdery mildew and head scab in various plant pathological nurseries under All India Coordinated Wheat and Barley Improvement Project. The results are summarized below (Table16)

i. During Rabi 2020-21 , 2073 entries were screened under artificial inoculation conditions against major diseases in various plant pathological nurseries under All India Coordinated Wheat and Barley Improvement Project and 1129,18,22 and 22 were found free from yellow rust, powdery mildew, Karnal bunt, and , respectively (Table 16).

ii. Screening of wheat genotypes against powdery mildew: PMSN constituting of 200 genotypes were screened against powdery mildew under artificial inoculation conditions. Only seven gentoypes viz.PMSN-6,-8,-11,-166,-169,-174 and -180 were found free, while 30 genotypes were resistant and 32 were found moderately resistant

iii. Screening wheat genotypes for multiple disease resistance: Out of 40 genotypes evaluated against yellow rust, Karnal bunt and powdery mildew. Sixteen,22,18 and 22 genotypes were found free from yellow rust, Karnal Bunt , powdery mildew and head scab, respectively.only 4 genotypes viz. NIDW1158(d) ,DDW48(d), VL 3020 and VL 3021 Showed multiple disease reaction against all four diseases.

Table 16: Number of wheat stocks free to Karnal bunt, yellow rust, Head scab and powdery mildew in various plant pathological nurseries

Sr.no	Name of nursery	Total entries	No. of free entries			
			Yellow rust	Powdery mildew	Karnal bunt	Head scab
1	IPPSN	1362	773	-	--	--
2	PPSN	200	133	-	--	--
3	NIVT	271	200	-	--	--
4	MDSN	40	16			
5	PMSN	200	7	18	22	22
6	SAARC	20	--	-	---	--
7	TPN	20	--	-	---	--

(b) Campaign for management and survey of yellow rust of wheat:

The wheat growing villages *i.e* Kolar, Puruwala, Majra, Fatehpur, Kartarpur, Misserwala, Behedewala, ampur, Bharapur, Dhaulakuan, Ajoli, Jamniwala, Majra, Gorkhuwala, Bhagani Nihal garh, Rajban, Sainwala, Amarkot and Shivpur etc. of Paonta Sahib Block were surveyed. Most of the farmers have grown HS542, HPW368, WH1080,DBW88,HD-2967, HD-2380,WH-1105, WH-1184,HSS-562,VL-907,VL-953, HPW-373, HPW349 and local. During these surveys (Table 17) the farmers were sensitized regarding rust symptoms, proper spray schedule for the control of Karnal Bunt as per recommendation at the initiation of ear head emergence stage, spray of recommended fungicide at proper time, stage with accurate dose for effective control of yellow rust and Karnal bunt. They were also advised to be vigilant and contact the Department officers or HAREC Dhaulakuan in case of disease appearance.

Table 17: Occurrence of different diseases of wheat in Sirmour district at farmers field

S. No.	Name of the village	Incidence/ Severity/ Score	
		Yellow rust score	Powdery mildew score
1	Gorkhuwala	20S	2
2	Sainwala	10S	3
3	Bhagani	10S	2
4	Puruwala	10S	3
5	Nihal garh	Tr	0
6	kartarpur	20S	0
7	Ajoli	10S	2
8	Majra	Tr	3
9	Fatehpur	Tr	2
10	Rajban	10S	0
11	Satiwala	10S	0
12	Behrewala	10S	2
13	Jamniwala	10S	5
14	Misserwala	20S	0
15	Amarkot	10S	0
16	Shivpur	20S	2
17	Rampur Bharapur	10S	2
18	Kolar	10S	2

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

(c) Evaluation of Pydiflumetofen 15.0% + Propiconazole 12.5% w/v SE (275 SE) against Yellow rust, Powdery Mildew and Head blight of wheat:-

Seven fungicides were evaluated under field condition against Yellow rust, Powdery Mildew and Head blight of wheat for two Rabi sessions i.e. 2019-20 and 2020-21. The data presented (Table 18) indicated that all the test fungicides were effective in controlling yellow rust. Propiconazole 25 EC (0.1%) was found highly effective against Powdery mildew (Table 19) in both the years while in the case of head blight Pydiflumetofen 15.0% + Propiconazole 12.5%(275 SE) (600 and 700 gm/ha) and propiconazole 25EC (500ml /ha) performed better result to manage this diseases as compared to other treatments (Table 20). No phytotoxicity symptoms was observed in any treatment.

(d) Evaluation of Bio –efficicary and Phytotoxicity of Zineb 75%WP against yellow rust & leaf blight of wheat at Dhaulakuan:-

An experiment was conducted to evaluate different doses of zineb with standard check mancozeb 75 % (2kg ai /ha) and propiconazole 25EC (500 gai /ha) to manage yellow rust and leaf blight of wheat .It was found that all the fungicides showed better results to manage both diseases. None of the treatments showed phytotoxicity (yellowing, Chlorosis, epinasty, hyponasty, leaf tip burning (Table 21).

Table 18: Evaluation of Pydiflumetofen 15.0% + Propiconazole 12.5% w/v SE (275 SE) against Yellow rust of Wheat

Treatments		Dose		2019-20			2020-21		
		gm / ha	gm / L	Severity (%)	Disease Control (%)	Yield (q/ha)	Severity (%)	Disease Control (%)	Yield (q/ha)
1	Untreated check			96.9(80.0)*	---	31.1	**84.3(66.67)***	-	31.26
2	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	500	1	1.0 (5.0)	98.9	36.8	4.1(11.67)	95.1	36.13
3	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	600	1.2	1.0 (5.0)	98.9	36.7	2.1(8.33)	97.5	36.4
4	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	700	1.4	1.0 (5.0)	98.9	36.93	1.0(5.0)	98.8	32.4
5	Pydiflumetofen 20% SC	550	1.1	2.1(8.33)	97.8	34.3	11.7(20.0)	86.1	31.8
6	Propiconazole 25 EC	500	1	1.0(5.0)	98.9	37.03	1.0(5.0)	98.8	36.27
7	Tebuconazole 50 + Trifloxystrobin 25 WG	300	0.6	1.0(5.0)	98.9	37.4	1.0(5.0)	98.8	36.67
8	Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE	750	1.5	1.0(5.0)	98.9	36.1	1.3(6.67)	98.5	36.13
CD (P=0.05)				1.01		2.17	2.72		2.89

* Figures in parentheses are arc sine transformed values

Table 19: Evaluation of Pydiflumetofen 15.0% + Propiconazole 12.5% w/v SE (275 SE) against Powdery Mildew of Wheat

Treatments		Dose		2019-20			2020-21		
		gm / ha	gm / L	Severity (%)	Disease Control (%)	Yield (q/ha)	Severity (%)	Disease Control (%)	Yield (q/ha)
1	Untreated check			91.0(72.5)*	-	35.6	91.0(72.5)*	-	32.3
2	fen 15.0% + Propiconazole 12.5% (275SE	500	1	24.3(29.5)	73.3	38.3	17.2(24.5)	81.1	35.1
3	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	600	1.2	21.1(27.3)	76.8	39.1	15.7(23.3)	82.7	35.8
4	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	700	1.4	17.8(25.0)	80.4	40.0	14.1(22.0)	84.5	37.1
5	Pydiflumetofen 20% SC	550	1.1	14.8(22.6)	83.7	41.3	12.1(20.3)	86.7	40.2
6	Propiconazole 25 EC	500	1	9.0(17.5)	90.1	44.5	10.2(18.6)	88.8	43.8
7	Tebuconazole 50 + Trifloxystrobin 25 WG	300	0.6	15.8(23.4)	82.6	41.2	13.5(21.6)	85.2	38.6
8	Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE	750	1.5	16.8(24.2)	81.5	41.5	16.1(23.6)	82.3	36.9
CD (P=0.05)				7.92	73.3	6.78	8.17		6.36

* Figures in parentheses are arc sine transformed values

Table 20: Evaluation of Pydiflumetofen 15.0% + Propiconazole 12.5% w/v SE (275 SE) against Head Blight of Wheat

Treatments		Dose		2019-20			2020-21		
		gm / ha	gm / L	Severity (%)	Disease Control (%)	Yield (q/ha)	Severity (%)	Disease Control (%)	Yield (q/ha)
1	Untreated check			34.0(35.7)	-	25.7	34.7(36.1)	--	26.0
2	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	500	1	21.0(27.3)	38.24	30.3	22.3(28.2)	35.58	29.7
3	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	600	1.2	16.0(23.6)	52.94	31.0	16.7(24.1)	51.93	31.3
4	Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE	700	1.4	11.3(19.6)	66.67	34.3	11.3(19.6)	67.31	33.7
5	Pydiflumetofen 20% SC	550	1.1	27.7(31.7)	18.63	27.0	26.3(30.8)	24.05	26.7
6	Propiconazole 25 EC	500	1	12.7(20.8)	62.75	34.0	13.3(21.4)	61.54	33.3
7	Tebuconazole 50 + Trifloxystrobin 25 WG	300	0.6	23.7(29.1)	30.39	29.0	24.7(29.8)	28.85	29.7
8	Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE	750	1.5	25.7(30.4)	24.51	30.0	27.0(31.3)	22.12	29.3
CD (P=0.05)				2.39		2.96	2.22		2.61

* Figures in parentheses are arc sine transformed values

Table 21: Evaluation of Bio –efficicary and Phytotoxicity of Zineb 75%WP against yellow rust & leaf blight of wheat (2020-21)

Sr No	Treatment	Dose /ha (gai)	Yellow rust severity (%)	Leaf blight Severity (%)	Yield (q/ha) RI RII RI
1	Zineb 75% WP	1250	20.1 (26.67)**	2.1 (8.33)**	33.77
2	Zineb 75% WP	1500	8.2(16.67)	2.1 (8.33)	34.57
3	Zineb 75% WP	1750	5.3 (13.33)	2.1 (8.33)	34.43
4	Zineb 75% WP	2000	3.1 (10.0)	2.1 (8.33)	34.97
5	Zineb 75% WP	2250	3.1 (10.0)	3.0 (10.0)	34.83
6	Mancozeb 75%	2000	25.0 (30.0)	3.0 (10.0)	31.27
7	Propiconazole 25 EC	500	1.0 (5.0)	1.0 (5.0)	35.73
8	Untreated check	-	94.7 (76.67)	52.9 (46.67)	30.17
	CD (P=0.05)		6.12	4.23	5.96
Phytotoxicity* (0-10Scale)					
9	Zineb 75% WP	1875	0		
10	Zineb 75% WP	3000	0		
11	Zineb 75% WP	6000	0		

* None of the treatments showed phytotoxicity (yellowing /chlorosis, epinasty, hyponasty, leaf tip burning.

** Figures in parentheses are arc sine transformed values

C. Pulses and Oilseeds

Soybean

1. Evaluation of breeding materials for resistantdonor(s)

Resistance sources:

i. Evaluation of breeding materials for resistant donor(s): Thirty seven entries including checks in Initial Varietal Trial (IVT), seven entries of AVT-I and seven entries of AVT-II of AICRP on soybean for 2020 were evaluated for disease resistance under natural hot spot conditions. The data on disease was recorded on 0-9 scale at terminal condition. The lines were categorized into different resistance categories (Table 22).

ii. Performance of the previous year's resistant entries against Frogeye leaf spot and Pod blight (Ct): Twenty six lines of soybean found resistant in IVT, AVT, AVT-II, **previous year's resistant entries** trial and germplasm evaluation during 2019, *kharif* season either against frogeye leaf spot (*Cercospora sojina*) and pod blight (*Colletotrichum truncatum*) were evaluated against FLS and pod blight diseases. 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 (Table 23). Eleven lines maintained their high resistance status against frogeye leaf spot (*Cercospora sojina*). Nine lines maintained their high resistance status against pod blight (*Colletotrichum truncatum*). Six lines have shown high to absolute resistance against both the diseases.

iii. Evaluation of germplasm for identification of multiple disease resistant sources: Fifty soybean germplasm lines received from ICAR IISR, Indore were evaluated against diseases in augmented design. Data on disease severity was recorded on 0-9 scale for Frogeye leaf spot (FLS), anthracnose (pod blight) and brown spot (BS) and each entry was categorised into different disease reaction (Table6). The germplasm lines; UPSL 77, TGX 293-41E, EC 391181, EC 39573, EC 172576, UGM 77, EC 14117, Harder, EC 241780 and JSM 277 were observed having multiple disease resistance against frogeye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*) and brown spot (*Septoria glycines*).

Table 22: Resistant sources for important diseases of soybean

Trial	Resistant entries		
	Frogeye leaf spot (*Cercospora sojina*)	**Pod blight (*Colletotrichum truncatum*)**	**Brown spot (*Septoria glycines*)**
IVT	VLS 101, DSb 38, DLSb 2, Himso 1691, DLSb-1&PS 1661	PS 1661	DS 3105, VLS 101, KDS 1144
AVT-I	VLS 99 NRC 149 and JS 21-72	Himso 1689, Himso 1690, and NRC 149	-
AVT-II	AMS 100-39	NRC 149 and AMS 100-39	-

Table 23: Disease reaction of previous resistant entries against various diseases

No	Entry	Year of testing	Frogeye leaf spot (*Cercospora sojina*)		Pod blight(*Colletotrichum truncatum*)	
1	ASb 50	1st Year	1	HR	3	MR
2	ASb 51	1st year	1	HR	3	MR
3	AUKS 218	1st year	0	AR	5	MS
4	DSb 37	1st year	1	HR	3	MR
5	TS 46	1st year	3	MR	3	MR
6	EC 241778	1st year	1	HR	0	AR
7	Cat 195 c (BR4)	1st year	0	AR	7	S
8	Cat 411A	1st year	1	HR	3	MR
10	SKF 6029	1st Year	1	HR	3	MR
12	NRC 154	1st year	1	HR	5	MS
13	EC 1619	1st Year	3	MR	1	HR
14	MACS 1566	1st year	0	AR	5	MS
15	AMS MB 5-18	2nd year	1	HR	1	HR
16	DSb 32	2nd year	3	MR	5	MS
17	TS 53	2nd year	3	MR	3	MR
18	RSC 10-52	2nd year	1	HR	3	MR
19	SL 1123	2st year	1	HR	0	AR
20	CAT 407	2nd year	3	MR	0	AR
21	CAT 473B	2nd year	1	HR	0	AR
22	KDS 992	2nd year	3	AR	3	AR
23	SQL 89	2nd year	3	MR	1	HR
24	Himso 1685	4th year	0	AR	1	HR
25	JS 20-116	4th year	0	AR	3	MR
26	PS 1572	4th year	1	HR	1	HR
	JS 335 (Check)		5	MR	7	S
	Shivalik (Check)		9	S	3	MR

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

Disease management:

Integrated management of the root rot complex and stem borers of soybean: An experiment comprising 12 seed treatment with chemical fungicides or bioagents alone or integrated with insecticide seed treatment was conducted with three replications in RBD. Data on % field stand. % root rot incidence, % girdling incidence, plant growth parameters and yield attributes were taken and presented in table 24. Treatment comprising treatment with trifloxystrobin+ penflufen @ 1ml/kg and thiomethoxam @ 2g/kg was found most effective and resulted highest yield 10.38 g/ha followed by seed treatment with carboxin + thiram @3g/kg and thiomethoxam2g/kg (9.38q/ha) as compared to 6.14 q/ha in control.

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

Treatment	% field stand	% root rot incidence	Anthracnose	% Girdling	Plant height (cm)	No. of pods/Pt	100g seed wt.(g)	Seed yield (q/ha)
T1= ST with Carboxin +thiram (3g/kg)	72.20	5.92	5.18	3.00	46.40	29.60	11.86	9.24
T2= ST with Trifloxystrobin +Penflufen (1ml/kg)	67.27	8.14	4.44	3.67	46.00	28.67	12.20	8.55
T3= ST with Thiophanate methyl +Pyraclostrobin)(2g/kg)	69.58	8.88	5.18	3.67	46.80	27.73	11.87	7.87
T4= ST with *Trichoderma harzianum* (10g/kg)	63.39	8.88	5.92	3.67	45.33	27.27	12.46	7.63
T5= ST with Thiomethoxam (2g/kg)	66.67	14.81	5.18	1.67	48.00	28.87	11.83	8.04
T6= T1 +T5	74.28	3.70	4.44	2.33	46.93	31.47	11.97	9.38
T7= T2 +T5	71.64	8.14	5.18	1.67	46.47	33.93	11.77	8.40
T8= T3 +T5	72.36	5.18	4.44	1.67	48.00	41.67	11.80	10.38
T9=T4 +T5	64.85	5.92	4.44	2.33	45.87	28.13	11.31	7.50
T10= ST with biopolymer chitosan based Trichoderma formulation (IIOR)@ 4ml/kg	65.45	6.66	17.77	6.67	47.20	27.00	11.76	6.50
T11= ST with biopolymer cellulose based Trichoderma formulation (IIOR),@ 10ml/kg	63.18	6.66	23.77	6.67	47.20	26.87	11.63	6.24
T12=ST with biopolymer cellulose based Trichoderma formulation (IIOR) +Thiomethoxam(@10 + 2g/kg)	68.61	6.66	25.18	7.33	46.73	29.40	11.50	6.38
T13= Untreated control	57.33	14.81	24.44	9.00	45.07	24.60	12.51	6.14
CD (P= 0.05)	5.184	4.735	7.27	2.156	NS	6.529	NS	1.059

ST = Seed treatment
Two sprays with chlorantroniprole @ 0.2ml/L at 15 and 35 DAS in treatment no. T1 to T9
Two sprays with propiconazole @ 1ml/L at 35 and 45 DAS in treatment no. T1 to T9

D. Vegetables

Onion/garlic:

a) Management of onion diseases:

A field experiment was conducted during Rabi 2020-21 at Daulakuan to study the efficacy of different fungicides and bio-agent for minimize the yield losses of onion caused by purple blotch (*Alternaria porri*) and Stemphylium blight (*Stemphylium vesicarium)* disease. Maximum disease control (83.0 %) was recorded in foliar application of Ridomil Gold followed by propiconazole, Mancozeb and Copper oxychloride resulting 79.8, 76.1 and 74.3 percent, respectively. The lowest (42.4%) disease control was noted in *Trichoderma harzianum* treatment Similar trend was observed in case of *Stemphylium* blight. Correspondingly maximum bulb yield of 262.6 q/ha was recorded in Ridomil Gold sprayed plot over control followed by propiconazole (261.2q/ha), Mancozeb (248.9q/ha) and copper oxychloride (240.7q/ha) in case of purple blotch. Similarly trend was observed in case of Stemphylium blight (Table 25)

Table 25: Management of onion diseases through fungicides and bioagent

Treatment	Concentration (%)	Purple blotch		Stemphylium blight		Bulb yield (q/ha)
		Disease severity (%)	% control	Disease severity (%)	% control	
Mancozeb	0.25	16.2 (23.73)*	74.2	15.6 (23.26)*	76.1	248.9
Carbendazim	0.1	24.3 (29.53)	61.3	19.7 (26.35)	69.8	226.4
Propiconazole	0.1	13.9 (21.89)	77.8	13.2 (21.30)	79.8	261.2
Copper oxychloride	0.3	21.0 (27.28)	66.6	16.8 (24.20)	74.3	240.7
Ridomil Gold	0.25	12.1 (20.36)	80.7	11.1 (19.46)	83.0	226.6
Trichoderma harzianum	0.5	36.6 (37.23)	41.7	37.6 (37.82)	42.4	191.4
Control		62.8 (52.42)		65.3 (53.91)		122.7
C.D. at 5%		2.58		2.26		5.89

***Figures in parentheses are arc sine transformed values.**

b) Evaluation of Folio Gold 440 SC (Metalaxyl-M 3.3 % + Chlorothalonil 33.1 % SC) against onion diseases

Folio Gold 440 SC (Metalaxyl-M 3.3 % + Chlorothalonil 33.1 % SC) were tested as foliar spray @1.0,2,0,2.5,3.0 and 6.0 ml/lt water along with Matco @ 0.35g/lt, Chlorothalonil 75% WP @ 2.0g/lt, Azoxystobin 11% +Tebuconazole 18.3%SC@ 0.94ml/lt and Boscalid 25.2% +Pyraclostrobin 12.8% WG @ 1.0g/lt water for bio-efficacy and for phyto-toxicity evaluation at Akrot. Data were recorded on disease severity of purple blotch and *Stemphylium* blight diseases of onion as per standard procedures. All the treatments were significantly effective in controlling purple blotch and *Stemphylium* blight diseases of onion when compared with control. Two sprays of Folio Gold 440 SC (Metalaxyl-M 3.3 % + Chlorothalonil 33.1 % SC) @2.0ml/lt, and 2.5ml/lt at fortnightly interval starting at first appearance of disease were most effective in the management of onion diseases and increase in yield over check. None of the treatment showed phytotoxicity. The trials will be conducted next year also for validation of results and final conclusions

c) Garlic

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

E. Fodder crops

1: Evaluation of breeding material: During *Kharif*, 20 entries of IVTM were evaluated against leaf blight and 8 entries found moderately resistant. However in cowpea all the 9 entries of IVTC were found susceptible. During *Rabi*, 62 entries were evaluated and 11entries i.e. IVTO (SC)-7, 8 & 9, IVTO (MC)-2 & 3, AVTO(SC)-2-6 and AVTO(SC)-2S-10 were found moderately resistant, under different experiments of oats against powdery mildew. Incidence of root rot of berseem was observed low during the season and all entries were observed as resistant or moderately resistant. In clover all the entries of white and red clover were found susceptible for powdery mildew (Table 26).

Table 26: Field screening of *Kharif* & *Rabi* breeding material

Crop and disease	Name of the trial	Entries	Resistant entries	Moderate Resistant
Maize (Leaf blights)	IVTM	19	-	IVTM-1,5,6,8 9, 12, 15 and 18
Cowpea (Root rots)	IVTC	9	None	None
Oats (Powdery mildew)	IVTO (SC)	16	-	IVTO (SC)-7,8,9
	IVTO (MC)	11	-	IVTO (MC)-2,3
	AVTO (SC) -1	7	-	AVTO (SC)-1-4,5,6
	AVTO (MC) -1	8	-	-
	AVTO-2 (SC)	10	-	AVTO(SC)-2-6
Beseem (Root rot)	AVTO-2 (SC) Seed	10	-	AVTO(SC)-2S-10
	IVTB	7	All	-
	AVTB1	6	All	-
	AVTB2	7	All	-
	AVTB2 S	7	All	-

2: Assessment of avoidable crop losses due to diseases and insect-pests in forage Cowpea: The crop losses due to diseases and insect-pests in forage cowpea experiment was assessed with two treatments i.e. protected and unprotected. In the protected treatment the cowpea was protected from all the prevalent diseases and insect pests by seed treatment with tebuconazole 2DS @ 1g/kg seed + NSKP (50 g/kg seed) followed by foliar spray of propiconazole @ 1ml/l at 15 days interval) for diseases management. For insect management foliar application of *B. bassiana* @ 5g/L ($1x10^7$ cfu/ml) and two sprays of imidacloprid 17.8 SL @ 0.3 ml/lit at 15 days interval followed by two sprays of *Verticillium lecani* @ 5 g/L at 10 days interval were given. In protected treatment 73.7, 69.4, 79.1 and 66.7 per cent control of root rot, foliar diseases, YMV and defoliators respectively was found with 46.3 percent increase over unprotected treatment. Hence, by using theses protective measures 46.3 per cent losses of GFY can be avoided in cowpea at Palampur (Table 27).

Table 27: Assessment of avoidable crop losses due to diseases and insect-pests in forage Cowpea

Treatments	Root rot		Foliar diseases		YMV		Defoliators		GFY	
	Incidence (%)	Control (%)	Severity (%)	Control (%)	Incidence (%)	Control (%)	Incidence (%)	Control (%)	(q/ha)	(%) increase
T_1 =Protected	12.0	73.7	8.9	69.4	0.9	79.1	3.1	66.7	184.3	46.3
T_2 = Unprotected	45.7	-	29.1	-	4.3	-	9.3	-	99.0	-
CD (5%)	2.78		1.33		0.33		1.08		12.71	
CV	6.79		4.09		14.06		22.21		6.86	
SE (M)±	0.80		0.38		0.10		0.39		3.67	

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

3 Management of leaf blast in forage pearl millet: The experiment was conducted with 11 treatments for the management of leaf blast (*Pyricularia grisea*) using chemicals & non chemical methods. Among all the treatments the seed treatment with tebuconazole + trifloxystrobin @ 1 g/kg seed followed by two sprays of same fungicide @ 0.4g/l was found most effective which gave 83.1 % disease control with 16.0 % increase in the green fodder yield over check. This treatment was followed by seed treatment with tricyclazole @ 0.6 g/kg seed and two sprays of same fungicide @ 0.3g/l which gave 77.7% disease control with 15.4 % increase in the yield over check. Among the non-chemical methods seed treatment with chitosan @ 0.05% followed by the foliar spray of chitosan @ 0.05% was found effective with 67.6 % disease control with 12.1 % increase in the yield over check. The values of r/day and AUDPC were also observed minimum i.e. 0.267 and 22.0 respectively, in seed treatment with tebuconazole + trifloxystrobin followed by two sprays of same fungicide. The value of r and AUDPC were 0.497 and 63.7 with seed treatment and foliar sprays of Chitosan. The relative infection rate and AUDPC values also showing the effect of the treatment in the management of disease (table 28).

Table 28: Evaluation of IDM components against leaf blast of forage pearl millet

Treatment	Leaf Blast of pearl millet						GFY	
	Leaf Blast		Infection rate (r) (per day)		AUDPC			
	Severity (%)	Control (%)	Rate (r)	Relative rate (%)	AUDPC	Relative AUDPC (%)	(q/h)	Increase over check (%)
T1	35.7 (36.6)^{cde}	27.7	0.10^{abcd}	81.0	521.50^{c}	66.6	315.0 ^{d}	4.4
T2	35.0 (36.3)^{cd}	29.1	0.11^{abc}	84.0	620.67^{b}	79.3	316.7 $_{d}$	5.0
T3	40.3 (39.4)^{ef}	18.2	0.11^{abc}	86.5	691.83^{ab}	88.4	315.0 ^{d}	4.4
T4	44.7 (41.9)^{f}	9.5	0.12^{ab}	95.0	724.50^{a}	92.6	315.0 ^{d}	4.4
T5	36.7 (37.2)^{cde}	25.7	0.12^{abc}	88.5	617.17^{b}	78.9	320.0 ^{cd}	6.1
T6	19.7 (26.3)^{b}	60.1	0.08^{cde}	65.4	352.33^{d}	45.0	335.0 ^{bc}	11.0
T7	8.3 (16.7)^{a}	83.1	0.04^{f}	28.7	154.00^{f}	19.7	350.0 ^{a}	16.0
T8	16.0 (23.5)^{b}	67.6	0.07^{def}	53.4	263.67^{ed}	33.7	338.3 ^{b}	12.1
T9	32.0 (34.4)^{c}	35.1	0.09^{bcd}	70.4	508.67^{c}	65.0	315.0 ^{d}	4.4
T10	11.0 (19.3)^{a}	77.7	0.05^{ef}	38.0	210.00^{ef}	26.8	348.3 ^{a}	15.4
T11	49.3 (44.6)^{g}	-	0.13^{a}	100.0	782.83^{a}	100.0	301.7 ^{e}	-
CD (5%)	3.07		0.02		54.74		17.00	
CV	5.58		13.59		6.49		3.08	

*Figures in parentheses are arc sine transformed values

Treatments:

T1: Seed treatment with carbendazim @ 2.0g/kg seed **T2:** Seed treatment with tebuconazole + trifloxystrobin @ 1g/kg seed
T3: Seed treatment with chitosan @ 0.05% **T4:** Seed treatment with neem seed extract @ 5%
T5: Seed treatment with tricyclazole @ 0.6 g/kg seed **T6:** T1+ foliar spray of carbendazim @ 0.5 g/L

4. Eco friendly management of zonate leaf spot of Sorghum

The experiment was conducted with 9 treatments of chemical and & non chemical methods for the management of zonate leaf spot (*Gloeocercospora sorghi*) of Sorghum. Among all the treatments the three foliar spray of propiconazole @ 0.1% (Chemical check) was found most effective which gave 70.4 % disease control with 22.0 % increase in the green fodder. Among the non-chemical methods three foliar spray of Tamarlassi resulted in 10.2 % increase in the yield. Three foliar spray of Panchgavya @ 10% also found effective with 46.1 % disease control and 13.5 % increase in the yield. The values of r/day and AUDPC were also observed minimum i.e. 0.432and 53.0 respectively, in chemical check. Among non-chemical treatments minimum r and AUDPC were observed in treatment having three foliar spray of Tamarlassi @ 10% i.e. 0.609 and 87.0, respectively. This was followed by three foliar spray of

Tamarlassi @ 10% and three foliar spray of extract of eupatorium ark @ 10% having r (0.666 & 699) and AUDPC (85.2 & 91.0), respectively.(table 29).

Table 29: Eco friendly management of zonate leaf spot of Sorghum

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	45.3 (42.3)^{d}	34.0	0.10^{b}	75.6	805.0^{c}	65.2	333.3^{cd}	7.5
T2	46.7 (43.1)^{d}	32.0	0.10^{b}	77.1	828.3^{c}	67.0	328.3^{d}	5.9
T3	38.0 (38.0)^{c}	44.7	0.10^{b}	77.0	677.8^{b}	54.9	343.3^{bcd}	10.7
T4	32.0 (34.4)^{b}	53.4	0.09^{b}	65.1	609.0^{b}	49.3	341.7^{bcd}	10.2
T5	34.7 (36.0)^{bc}	49.5	0.10^{b}	74.7	637.0^{b}	51.6	348.3^{bc}	12.4
T6	38.0 (38.0)^{c}	44.7	0.11^{b}	78.7	753.7^{c}	61.0	348.3^{bc}	12.4
T7	37.0 (37.4)^{bc}	46.1	0.10^{b}	71.2	596.2^{b}	48.3	351.7^{b}	13.5
T8	20.3 (26.8)^{a}	70.4	0.06^{a}	46.2	375.7^{a}	30.4	378.3^{a}	22.0
T9	68.7 (56.0)^{e}	-	0.13^{c}	100.0	1235.5^{d}	100.0	310.0^{e}	-
CD (5%)	3.24		0.02		82.32		17.38	
CV	4.80		13.3		6.57		2.93	
SE (M)±	1.08		0.01		27.47		5.80	

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

6: To study the pathogenic variability of Blumeria *graminis f*. sp. *avenae* on oat: The virulence pattern of the 24 isolates of *B. graminis* f. sp. *avenae* was studied on developed differential set comprising of 11 lines *viz.*, ADG-96, HFO-102, IG-03-213, JPO-40, OL-1847, OG-77, PLP-1, JO-11, OL-1867, UPO-212 and a susceptible check HJ-8 using seedling evaluation method. These 24 isolates were grouped into 14 pathotypes on the basis of their reaction to the set of 11 differential lines and data is presented in table 30.

Table 30: Grouping of 24 isolates of oat powdery mildew into pathotypes

Designation of pathotype	No. of isolates	Isolate Name
OMP-1	3	BGA-1 (Palampur), BGA-2 (Aima) and BGA-12 (KVK Bara)
OMP-2	3	BGA-4 (Bir), BGA-9 (Shanan) and BGA-10 (Lad-Bharol)
OMP-3	2	BGA-5 (Manderh) and BGA-16 (Bagianda)
OMP-4	2	BGA-6 (KVK Kangra) and BGA-7 (53 Mile)
OMP-5	2	BGA-11 (Barogala) and BGA-19 (Largi)
OMP-6	3	BGA-21 (Jahalman), BGA-22 (Kukumseri) and BGA-23 (Udaipur)
OMP-7	2	BGA-3 (Utarala) and BGA15 (Salmoha)
OMP-8	1	BGA-8 (Tikkan)
OMP-9	1	BGA-13 (Bhager)
OMP-10	1	BGA-17 (Bajaura)
OMP-11	1	BGA-14 (Samoh)
OMP-12	1	BGA-18 (Shuru)
OMP-13	1	BGA-20 (Keylong)
OMP-14	1	BGA-24 (Trilokinath)

OMP= Oat Powdery mildew Pathotype

7. Integrated disease management in berseem: The experiment was conducted to manage the root rot and leaf blight in the berseem crop. It was observed that seed treatment with carbendazim @ 0.2 % followed by foliar spray of carbendazim @ 0.1 % was proved best with 88.1 and 82.9 per cent control of root rot and leaf blight respectively, with maximum increase (4.8 %) in the GFY over the check, which was followed with non-significant difference by Seed treatment with carbendazim @ 0.2 % followed by foliar spray of Chitosan @ 0.05 % with 81.0 and 80.5 per cent control of root rot and leaf blight respectively with 3.4 per cent increase in the GFY over the check. Minimum disease control and increase in the yield was provided by Seed treatment with *Trichoderma* @ 0.5 % (table 31).

Table 31: Integrated disease management in berseem

Treatment	Root rot		Leaf blight		Yield (GFY)	
	% Incidence	% control	% Severity	% control	(q/ha)	% increase
T1: Seed treatment with Chitosan @ 0.05 %	2.3 (8.8)^{bc}	66.7	8.7 (17.1)^{c}	36.6	335.3^{bc}	2.1
T2: Seed treatment with *Trichoderma* @ 0.5 %	4.3 (12.0)^{d}	38.1	9.7 (18.1)^{c}	29.3	331.7^{c}	1.0
T3: Seed treatment with carbendazim @ 0.2 %	1.0 (5.7)^{ab}	85.7	7.7 (16.1)^{c}	43.9	337.7^{b}	2.8
T4: Seed treatment with Chitosan @ 0.05 % + *Trichoderma* @ 0.5%	2.7 (9.4)^{c}	61.9	8.3 (16.8)^{c}	39.0	334.0^{bc}	1.7
T5: Seed treatment with Chitosan @ 0.05 % + carbendazim @ 0.1%	1.7 (7.4)^{b}	76.2	6.3 (14.6)^{bc}	53.7	342.0^{ab}	4.2
T6: T1 + foliar spray of Chitosan @ 0.05%	2.0 (8.1)^{bc}	71.4	3.7 (11.0)^{ab}	73.2	335.7^{bc}	2.2
T7: T2+ foliar spray of Chitosan @ 0.05 %	3.3 (10.5)^{cd}	52.4	4.7 (12.5)^{b}	65.9	335.0^{bc}	2.0
T8: T3 +foliar spray of Chitosan @ 0.05 %	1.3 (6.6)^{ab}	81.0	2.7 (9.4)^{a}	80.5	339.3^{ab}	3.4
T9: T3 + foliar spray of carbendazim @ 0.1 %	0.8 (5.2)^{a}	88.1	2.3 (8.8)^{a}	82.9	344.0^{a}	4.8
T10: Control	7.0 (15.3)^{e}	-	13.7 (21.7)^{d}	-	328.3^{c}	-
CD (5%)	1.80		2.55		5.58	
CV	11.70		10.13		0.96	

8. Validation of best treatment of trial entitled "Biological management of powdery mildew of oats caused by *Blumeria graminis* f. sp. *avenae*: The experiment was conducted to manage the powdery mildew through biological management in oat crop. It was observed that among the biological management treatments three foliar spray of *Trichoderma viride* @ 0.5% or three foliar spray of *Trichoderma harzianum* @ 0.5% were found effective giving 49.7 per cent control with 10.8 per cent increase in the seed yield followed by 3 foliar sprays of Vitex @ 10% (39.0 % control with 10.2% yield increase over check (Table 32).

Table 32: Validation of best treatment of trial entitled "Biological management of powdery mildew of oats caused by *Blumeria graminis* f. sp. *avenae*"

Treatment	Powdery mildew		GFY		B : C
	% Severity /Incidence	% Control	Q/HA	% Increase	
T_1=Three foliar sprays of *Trichoderma viride* @ 0.5%	26.7 (31.1)^{a}	49.7	349^{a}	10.8	1: 2.57
T2 =Three foliar sprays of Vitex @ 10%	32.3 (34.6)^{b}	39.0	347^{a}	10.2	1: 2.14
T3 =Control	53.0 (46.7)^{c}	-	315^{b}	-	
CD (5%)	1.85		6.79		
CV	4.19		1.71		
SE (M)±	0.59		2.18		

F. Protected Cultivation

Identification of biological control agents (BCAs) against plant pathogens under protected cultivation

i. Eighteen *Trichoderma* spp. isolates were evaluated *in vitro* against the *Ralstonia solanacearum* causing bacterial wilt of tomato and capsicum and isolateTI-6 and TI-9 were found to be most effective with 2.50 cm inhibition zone followed by TH-5 with 2.00 cm zone (Table 33).

Table 33: *In vitro* evaluation of *Trichoderma* isolates (bioagents) against bacterial wilt pathogen *Ralstonia solanacearum* (tomato & capsicum)

Sr. No	*Trichoderma* spp. isolates	Inhibition zone (cm)
1	DMA-8	1.10 (1.45)*
2	JMA-11	0.00 (1.00)
3	TH-4	0.50 (1.23)
4	TH-5	2.00 (1.73)
5	TH-11	0.00 (1.00)
6	SMA-5	0.00 (1.00)
7	TV-1	0.00 (1.00)
8	TI-1	0.00 (1.00)
9	TI-2	0.50 (1.23)
10	TI-3	1.00 (1.41)
11	TI-4	0.50 (1.23)
12	TI-5	1.50 (1.58)
13	TI-6	2.50 (1.87)
14	TI-7	0.50 (1.23)
15	TI-8	0.00 (1.00)
16	TI-9	2.50 (1.87)
17	TI-11	0.00 (1.00)
18	TI-15	0.50 (1.23)
19	Control	0.00 (1.00)
	CD(P= 0.05)	0.05
Figures in parenthesis are the square root transformation		

Water extract of the botanicals (*Eupatorium* spp., *Euphorbia* spp., Darek (*Melia azedarach*), *Euphorbia* sp., *Lantana camera* and *Ajuga* sp.) were found ineffective at any concentration of the extract whereas alcoholic extract of *Eupatorium*, *Euphorbia* and Darek (*Melia azedarach*) showed inhibition zone onward at 50% concentration and above.

Among the tested eighteen *Trichoderma* spp. bioagent isolates evaluated against *Sclerotium rolfsii* causing color rot of tomato and capsicum, DMA-8 was found most effective with 81.55 per cent mycelial inhibition followed by TH-11 with 79.16 per cent mycelial inhibition (Table 34).

Table 34: *In vitro* evaluation of bioagents against *Sclerotium rolfsii* causing collor rot of tomato

Sr. no	*Trichoderma* spp. isolates	Mycelial growth (mm)	% Mycelial inhibition
1	DMA-8	10.33	81.55
2	JMA-11	16.00	71.43
3	TH-4	16.00	71.43
4	TH-5	21.67	61.30
5	TH-11	11.67	79.16
6	SMA-5	13.97	75.05

7	TV -1	27.57	50.77
8	TI-1	14.47	74.16
9	T1-2	13.67	75.59
10	TI-3	20.90	62.68
11	TI-4	14.43	74.23
12	TI-5	17.00	69.64
13	TI-7	24.23	56.73
14	TI-8	17.77	68.27
15	TI-10	25.90	53.75
16	TI-11	19.33	65.48
17	TI-12	28.47	49.16
18	TI-15	14.53	74.05
19	Control	56.00	
	CD(P= 0.05)	8.80	

Twenty-three bio-agent isolates (22 *Trichoderma* spp & 1 bacterium) were evaluated against *Sclerotinia sclerotiorum* and isolate TI-8 was found most effective with 69.49 per cent mycelial inhibition followed by isolate TI-11 with the 65.54 per cent inhibition (Table 35)

Table 35: *In vitro* evaluation of bioagents against *Sclerotinia sclerotiorum* causing white rot of capsicum and tomato

Sr. N.	Bioagents	Mycelial growth (mm)	% Mycelial inhibition
1	DMA-8	21.33	61.22
2	JMA-11	21.00	61.82
3	TH-4	25.56	53.53
4	TH-5	27.33	50.31
5	TH-11	25.22	54.14
6	SMA-5	29.55	46.27
7	TV-1	35.11	36.16
8	TI-1	25.44	53.75
9	TI-2	29.00	47.27
10	TI-3	22.67	58.78
11	TI-4	24.44	55.36
12	TI-5	25.77	53.14
13	TI-6	21.78	60.40
14	TI-7	20.67	62.42
15	TI-8	16.78	69.49
16	TI-9	25.44	53.75
17	TI-10	23.33	57.58
18	TI-11	19.00	65.54
19	TI-12	20.67	62.42
20	TI-13	28.11	48.89
21	TI-14	26.11	52.52
22	TI-15	30.22	45.05
23	*Pseudomonas*	52.00	5.45
24	Control	55.00	
	CD(P=0.05)	**4.39**	

G. Zero Budget & Natural Farming

In *Kharif* 2020, crop demonstrations/ trials were conducted under three sets of conditions i.e. natural farming, organic farming and control under ZBNF project. The crops grown consisted of vegetable crops (Chilli var Surajmukhi and Cucurbits viz., Cucumber, Sponge gourd, Bottle gourd and Pumpkin), cereals & oilseed crops (Maize, Soybean, Maize + Soybean, Finger millet + Soybean and Rice) and pulses (Cowpea, Mash, Rice bean and Adjuki bean). The different treatments along with their rate and intervals of application (seed treatment & foliar application) in various crops are given in Table 36. For the management of diseases Beejamrit, Jeevamrit, Ramban and Saunthastra while, for the management of insects Drekastra, Neem oil, Agneyastra and Dashparni were considered/ applied. Beejamrit (20%) was applied as seed treatment before the sowing of crops while Jeevamrit (10%) was sprayed at 15 days (Fortnightly) interval 6 – 8 times in different crops. Sprays of Ramban at weekly intervals were started at the appearance of powdery mildew in different crops and varied, three sprays in Chilli, four sprays in cucurbits and two sprays in pulses. All the preparations/ formulations were applied/ sprayed alternately.

Different diseases and their terminal incidence/ severity recorded on different crops are given in Table 36. It is evident from the data that ZBNF preparation, Ramban was effective in managing powdery mildew in different crops viz., Chilli, Cucurbits and pulses giving 50.0-71.4% control of the disease. Whereas, in case of leaf spots, anthracnose and blights, 2.86-10.0% disease control was achieved which was non significant. In rice, 14.29 and 5.6% control of Brown spot and narrow brown spot was achieved with ZBNF preparations as these diseases mostly appear in poor soils and probably these preparations helped in the nutrition of crop. In case of Downey mildew of cucurbits the control achieved ranged from 2.5-10.0% which was not comparable to fungicides. However, no control of Maydis leaf blight, Pod blight, Web blight, False smut, Blast, Cercospora leaf spot of cowpea was achieved with these preparations.

Conclusion: From the above discussion it can be concluded that ZBNF preparations (Ramban) are quite effective against powdery mildews but not much effective against leaf spots, blights, blast, false smut, downy mildews etc. Experimentation is needed to fortify theses preparations with botanicals/ bio control agents to make them more effective.

Table 36: The incidence/ severity of different diseases on various crops

S. No.	Crop	Management practice	Formulation	Rate	Application time/ Spray interval	Disease recorded	Terminal incidence/ severity (%)		
							Natural	Organic	Control
1	**Vegetables**								
	Chilli var Surajmukhi	Seed treatment Foliar sprays applied alternately	Beejamrit	20%	Before sowing	Cercospora leaf spot	16.0	15.0	16.0
			Jeevamrit	10%	6 sprays Fortnightly interval	Phytophthora blight	4.5	4.5	5.0
			Drekastra	10%	2 sprays, Weekly interval				
			Neem oil	10%	2 sprays, Weekly interval				
			Agneyastra	10%	2 sprays, Weekly interval				
			Ramban	10%	3 sprays, Weekly interval				

	Cucurbits: Cucumber Spongegourd Bottle gourd Pumpkin	Seed treatment Foliar sprays applied alternately	Beejamrit Jeevamrit Ramban Saunthastra Drekastra Agneyastra Neem oil	20% 10% 10% 10% 10% 10% 10%	Before sowing 6 sprays Fortnightly interval 4 sprays, Weekly interval 2 sprays, weekly interval 2 sprays, weekly interval (Natural Farming) 2 sprays, weekly interval (Natural farming) 4 sprays, weekly interval (Organic)	 Powdery mildew Downy mildew Powdery mildew Downey mildew Powdery mildew Downy mildew Powdery mildew Downey mildew	 10.0 38 10.0 34.0 8.0 9.0 20.0 29.0	 10.0 39 10.0 34.0 8.0 9.0 20.0 29.0	 35.0 40.0 25.0 35.0 20.0 10.0 45.0 30.0
2	**Cereals & Oil seed crop(s)**								
	Maize Soybean Maize + Soybean Finger millet + Soybean Rice	Seed treatment Foliar sprays applied alternately	Beejamrit Jeevamrit Drekastra Neem oil Agneyastra	20% 10% 10% 10% 10%	Before sowing 8 sprays Fortnightly interval 2 sprays, Weekly interval 2 sprays, Weekly interval 2 sprays, Weekly interval	Maydis leaf blight Frog eye leaf spot Pod blight Web blight Finger millet blast False smut Blast Brown spot Narrow brown spot	35.0 28.0 20.0 7.0 4.0 8.0 1.0 6.0 8.5	35.0 28.0 20.0 7.0 4.0 8.0 1.0 6.0 8.5	35.0 30.0 20.0 7.0 4.0 8.0 1.0 7.0 9.0
3	**Pulses**								
	Cowpea Mash Rice bean Adjuki bean	Seed treatment Foliar sprays applied alternately	Beejamrit Saunthastra Ramban Dashparni	20% 10% 10% 10%	Before sowing 2 sprays weekly interval 2 sprays, Weekly interval 2 sprays, Weekly interval	Cercospora leaf spot Powdery mildew Cercospora leaf spot Anthracnose Powdery mildew Cercospora leaf spot Pod blight Cercospora leaf spot Web blight Pod blight	20.0 10.0 34.0 24.0 12.0 14.0 10.0 24.0 20.0 12.0	20.0 10.0 34.0 24.0 12.0 14.0 10.0 24.0 20.0 12.0	20.0 20.0 35.0 25.0 30.0 15.0 10.0 25.0 20.0 12.0

H. Molecular Plant pathology

Mapping of anthracnose resistance gene(s) in land race KRC-8 using molecular markers

a. Bulked Segregant Analysis (BSA) using parental polymorphic markers

Among nineteen parental polymorphic RAPD markers, only five *i.e*. OPO-20, OPAM-7, OPW-13, OPAD-19 and OPV-10 showed polymorphic bands on the two DNA bulks but on the bulk individuals, they failed to provide any information about their segregation behaviour, hence were not used further. Among ISSR markers, five parental polymorphic markers when checked on two contrasting DNA bulks, yielded monomorphic bands and were rejected. Out of sixteen parental polymorphic SSRs (Fig. 1, 2), IAC 238 and BM146 were found to be polymorphic on parental genotypes. These were further used for background screening of the $F_{2:9}$ RIL mapping population (Fig. 3). The marker IAC-238 resulted in identical amplification in bulks to that of parents and similar amplification pattern was also observed in the individuals of susceptible and resistant bulks (Fig. 7.6). The Co-dominant nature of this marker resulted in the amplicon of ~240 bp size in susceptible parent (Jawala), bulk as well as individuals, whereas in case of resistant parent (KRC-8), bulk and individuals, it yielded the amplicon of ~220 bp (Fig. 3).

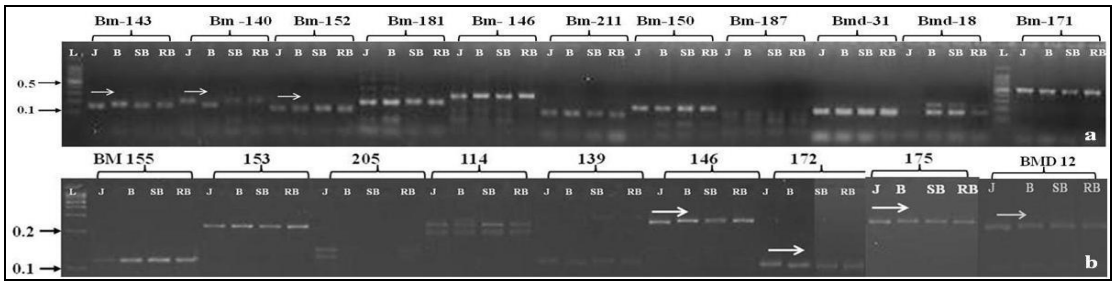

Fig. 1. BSA using polymorphic SSR (a & b) on parents, susceptible resistant bulks their individuals where, J: Jawala; B: KRC-8; SB: susceptible bulk (of 10 individuals); RB: resistant bulk (of 10 individuals), S1to S10 (Susceptible individuals), R1 to R10 (Resistant individuals) L: 100 bp DNA ladder on 3% agarose gel electrophoresis

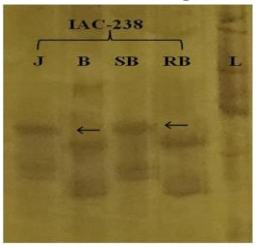

Fig. 2. BSA using IAC238 primer on parents, susceptible and resistant bulks where, J: Jawala; B: KRC-8; SB: susceptible bulk (of 10 individuals); RB: resistant bulk (of 10 individuals). L: 100bp on 6% Denaturing Polyacrylamide Gel Electrophoresis

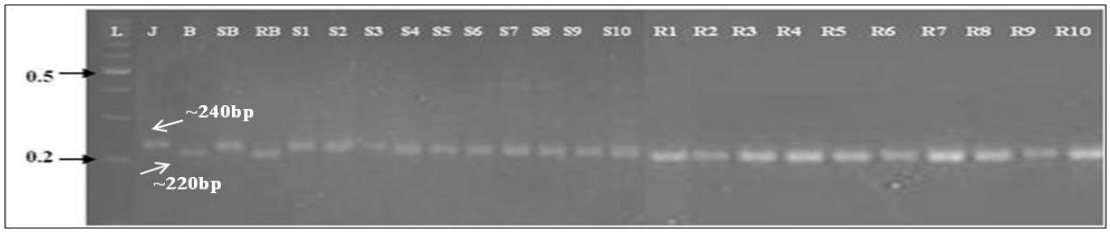

Fig. 3. BSA using IAC238 primer on parents, susceptible, resistant bulks and their individuals where, J: Jawala; B: KRC-8; SB: susceptible bulk (of 10 individuals); RB: resistant bulk (of 10 individuals). L: 100bp on 3% agarose gel electrophoresis

b. Parental polymorphism survey using additional SSR markers

IAC 235, IAC 259 and BM146 were found to be polymorphic on parental genotypes. BM146 along with IAC 235 and IAC 259 were used for background screening of the $F_{2:9}$ RIL mapping population (Fig. 4 and 5).

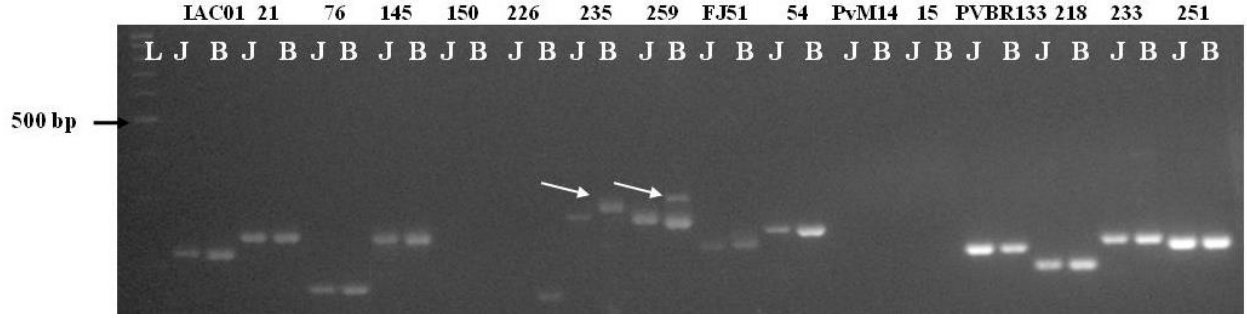

Fig. 4. Polymorphism survey of parental genotypes Jawala (S) and KRC-8 (R) using Chromosome 1 specific SSR markers on 4 per cent agarose gel electrophoresis where L: 100bp molecular marker; J: Jawala; B: KRC-8 and white arrow indicating the parental polymorphic markers

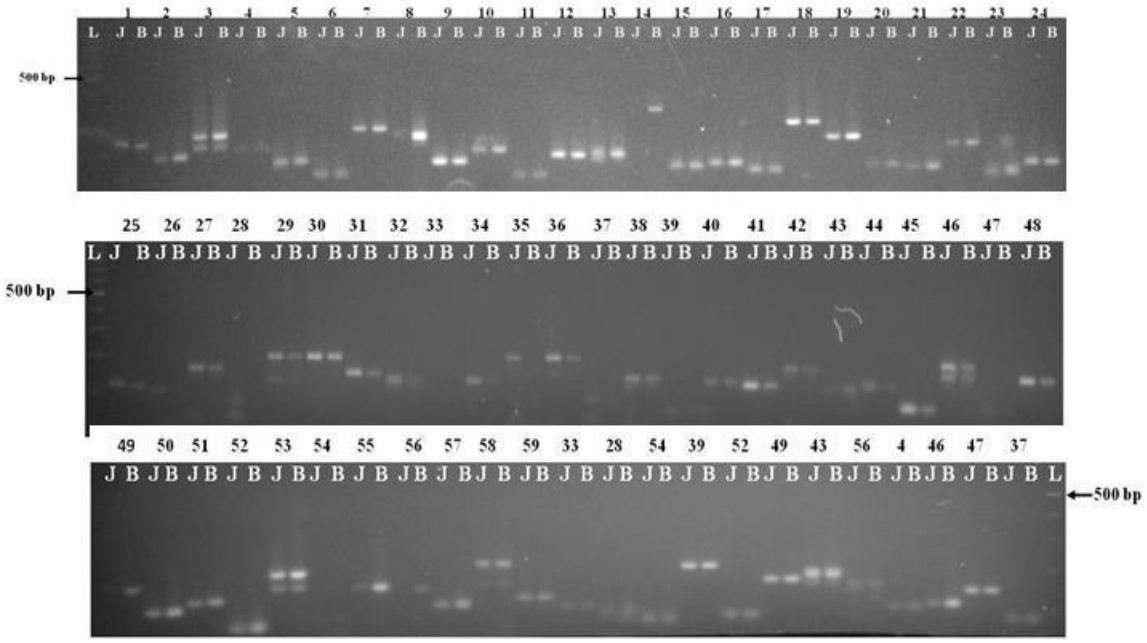

Fig. 5. Polymorphism survey of parental genotypes Jawala (S) and KRC-8 (R) using InDel markers on 4 per cent agarose gel electrophoresis where L: 100bp molecular marker; J: Jawala; B: KRC-8 and white arrow indicating the parental polymorphic markers

c. Segregation of SSR markers with mapping population

The banding pattern on 223 $F_{2:9}$ RIL individuals with IAC-238 marker are presented in the fig. 6 and 7. Out of 223 $F_{2:9}$ RILs, 113 individuals yielded an amplicon of ~240 bp size and110 individuals resulted in the amplification of ~220 bp product.

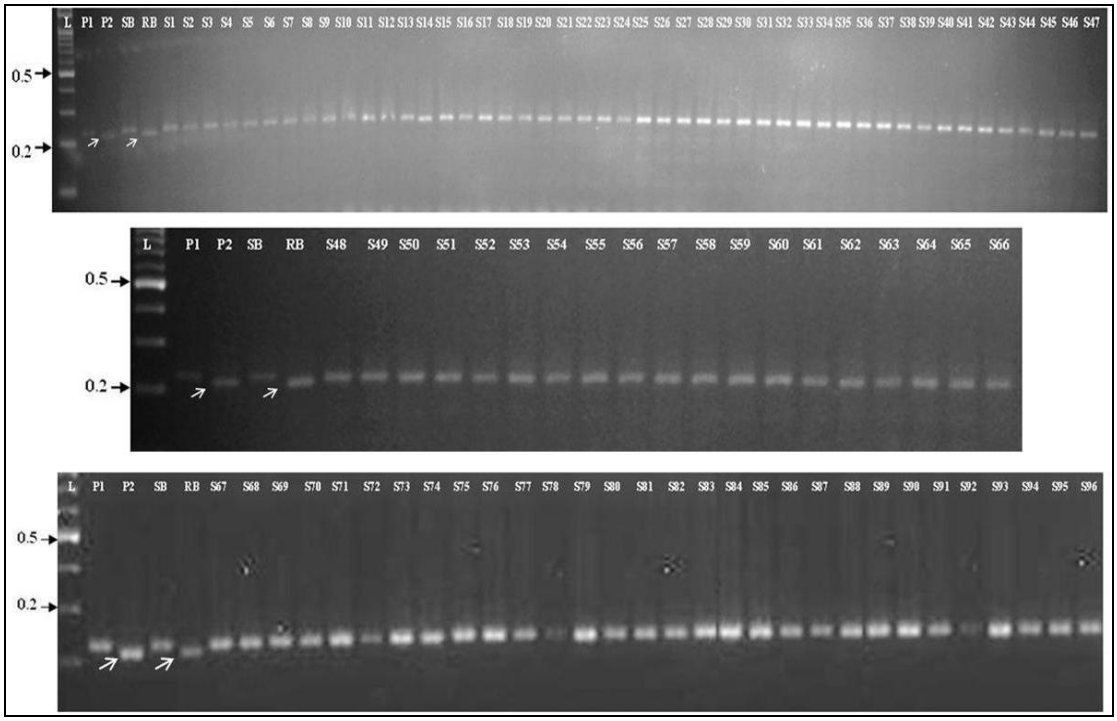

Fig. 6. Genotyping of susceptible population using IAC-238 marker, where, P1: Jawala (Susceptible parent); P2: KRC-8 (Resistant parent); SB: susceptible bulk and RB: resistant bulk, S1 to S96 susceptible population, L: 100bp DNA ladder on 3% agarose gel electrophoresis

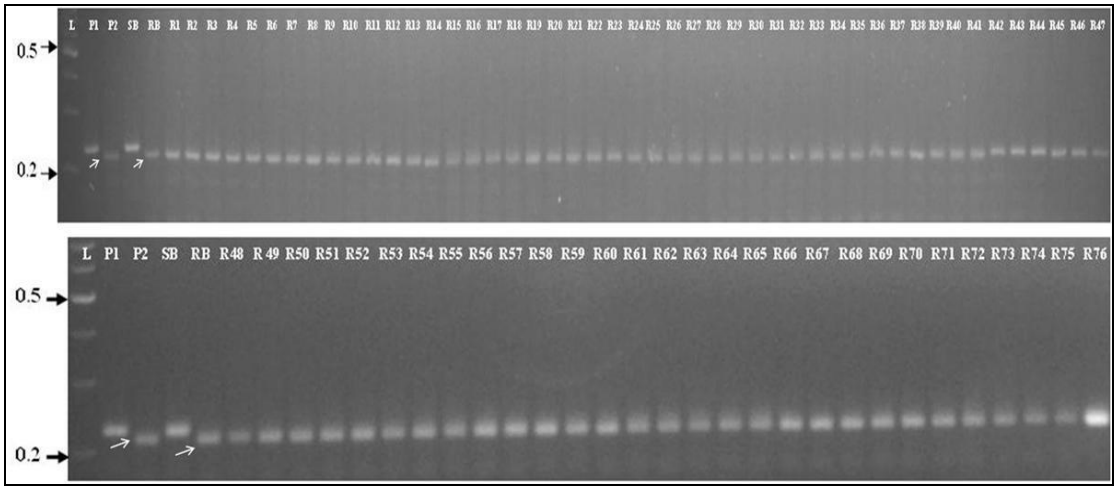

Fig. 7. Genotyping of resistant population using IAC-238 marker, where, P1: Jawala (Susceptible parent); P2: KRC-8 (Resistant parent); SB: susceptible bulk and RB: resistant bulk, R1 to R76 resistant population, L: 100bp DNA ladder on 3% agarose gel electrophoresis

The genotypic data of IAC-238 SSR marker exhibited a segregation ratio of 1:1 and no recombinant was observed, indicating complete absence of linkage distortion. However, five recombinants were observed with BM146 in mapping population.

I. Mushrooms

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

Five strains were evaluated in five replications using 10 Kg of compost /bag. Moisture in the compost was 62% and nitrogen was 1.9%. Spawning was done @ of 3%. Results are presented in (Table 37). It was observed that Maximum yield was recorded in AVTB-20-203 (17.1 Kg) followed by AVTB-20-201 and 204 (16.5 Kg) and minimum yield was recorded in AVTB-20-205 (14.6 kg). Time taken for first harvest (post casing) was between 16-23 days and average fruit body weight ranged between 8-10.6 gms.

Table 37: Performance of selected white accessions of *Agaricus bisporus* of AVT

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
AVTB-20-201	16.5	20.6	9
AVTB-20-202	16.1	20.2	9.6
AVTB-20-203	17.1	16.2	10.6
AVTB-20-204	16.5	20.2	9.2
AVTB-20-205	14.6	23	8.2
SE (m+-)	0.76	2.02	1.08

Initial Varietal trial for selected white accessions of *Agaricus bisporus*

Ten strains were evaluated in five replications using 10 Kg of compost /bag. Moisture in the compost was 62% and nitrogen was 1.9%. Spawning was done @ of 3%. It was observed that Maximum yield was recorded in IVTB-20-01 and 10 (16.9Kg) followed by IVTB-20-09 (16.3 Kg) and minimum yield was recorded in IVTB-20-03(15 Kg). Lower yields may be because of rise in temperature in the month of April and May. Time taken for first harvest (post casing) was between 16-23 days and average fruit body weight ranged between 7.1 - 9.9 gms (Table 38).

Table 38: Evaluation of selected white accessions of *Agaricus bisporus* of IVT for Fruiting parameters

Strains	Yield kg/100kg compost	Time take for first harvest (post casing)	Average fruit body weight (g)
IVTB-20-01	16.9	20.40	9.9
IVTB-20-02	15.7	20.60	7.5
IVTB-20-03	15.0	23.00	7.1
IVTB-20-04	15.8	20.40	7.4
IVTB-20-05	15.9	16.40	9.4
IVTB-20-06	15.6	20.00	7.4
IVTB-20-07	15.4	20.60	7.9
IVTB-20-08	16.1	22.60	9.5
IVTB-20-09	16.3	20.00	9.5
IVTB-20-10	16.9	16.80	9.6
SE (m+-)	3.73	1.95	1.4

Advance Varietal trial-2 of high yielding varieties/strains of Oyster Mushroom (*Pleurotus* spp) on wheat straw

The experiment was conducted with six strains of PL-20-201 to Pl-20-206 ***Pleurotus* spp** having 5 replications with 10 bags of 1 kg dry weight wheat straw in each replication. The spawn rate was 1% of dry substrate PL-20-205 gave the highest yield of 119.1 kg /100 kg dry weight of wheat straw having average weight per fruit body was 12.0 grams. The pileus size was 7.7X5.8 cm with stipe of2.0 X 1.1 cm. followed by PL-20-204 recorded the yield of 98.1kg /100 kg dry weight of wheat straw having average weight per fruit body was 12.0 grams. The pileus size was 8.1x6.9 cm with stipe of 4.5x1.4 cm followed by PL-20-203 (79.0 Kg), PL-20-206 (62.0 Kg) PL-20 -202 (56.8kg) and PL-20-201 (52.8 kg) PL-20-201 gave lowest yield of 52.8 kg /100 dry weight of wheat straw kg, having average weight per fruit body of 11.0 grams. The pileus size was 8.8 X 7.0 cm with stipe of 3.0 X 1.1 cm (Table 39).

Table 39: Performnce of Advance Varietal trial-2 high yielding varieties/strains of Oyster Mushroom (*Pleurotus*spp) on Wheat straw

Strains	Yield kg/100kg dry straw	Time take for first harvest (days)	Average fruit body weight (g)
PL-20-201	52.8	34	11
PL-20-202	56.8	38	10
PL-20-203	79.0	34	10
PL-20-204	98.1	36	12
PL-20-205	119.1	32	12
PL-20-206	62.0	38	11
SE (m+-)	1.20	23.13	0.11

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:

(i) Lectures delivered (number): 134

(ii) **Participation in Extension activities** (On farm trials/ FLDs/ Adaptive Research Trials/ Field Day etc.): (numbers as given under in the table)

Advisory	**1050** 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
Advisory through news papers	**4**
Trainings conducted	**75** training programmes on different topics were conducted at head quarter (DEE) and out stations/ KVKs and more than **2500 farmers** were trained
Participation in Extension Training Programmes	**134** numbers of lectures were delivered to farmers in various training programmes conducted at head quarter and out stations / KVKs / other agencies
Front Line Demonstrations	**12** numbers of Demonstrations were conducted (KVKs)
On farm trials	**19** numbers of on farm trials were conducted
Field demonstrations	Nil
Adaptive trials	**4** numbers of adaptive trials were conducted
Kisanmelas/ divas	**1** number of kisan mela/ divas organized (KVK)
Workshops organized/ attended	**Nil** **38** Faculty members participated in different workshops
Radio & TV talks	**3** radio/ TV talks delivered
Disease samples analyzed	**33** numbers
Seed samples analyzed	Wheat: **522** (against Karnal Bunt) Ginger: **258** (against Rhizome rot and pest)
Mushroom cultivation	**1928 kg** of oyster mushroom spawn produced and sold @ Rs 100/kg **248 kg** of button mushroom spawn produced and sold @ Rs 100/kg **317 kg** of fresh mushroom produced and sold @ Rs. 150/kg Total economic activity generated =**2,65,170.00**

7. MISCELLANEOUS ACTIVITIES

i) Honour & Awards:

Award of certificate of reviewing for 2018-19 by Indian Phytopathology (Dr. D.K Banyal)

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

The faculty of Plant Pathology participated in 25 Workshops/ Conferences/ Symposia/ Trainings etc. during 2020-21 as enlisted below:

S. No.	Date	Details of programme	Name of participants
1.	06-07.07.2020	Annual Zonal Review Workshop of KVKs (Zone-1) via Google Meet	Dr Suman Kumar Dr Pradeep Kumar
2.	23.09.2020	Webinar on 'Management of Biotic & Abiotic Stresses in Protected Agriculture' under NAHEP, CAAST on Protected Agriculture & Natural Farming and chaired the Technical Session – II of the webinar	Dr S K Rana
3.	28.09.2020	AICRP Fodder *Rabi* workshop online	Dr. D.K. Banyal
4.	20.10.2020	Online Workshop Of National Extension Programme.	Dr Pradeep Kumar
5.	27.10.2020	Agricultural Officers Workshop on *Rabi* crops at CSKHPKV, Palampur	All the faculty of Plant Pathology
6.			
7.	21.12.2020	Sanitization Workshop On Agricultural Infrastructure Find (AIF) And Other GOI Schemes For Entrepreneurship Development At DDA- Hamirpur	Dr Pradeep Kumar
8.	04-08.01.2021	Five days online training programme on "**Introduction to Plant Bio-security & Plant Quarantine**" from 4th to 8th January, 2021	Dr S K Rana Dr D K Banyal Dr Amar Singh
9.	19-23.01.2021	Online training programme on "Linking farmers to marketing and processing industries" organized by Extension Education Institute, Nilokheri (Haryana)	Dr Pradeep Kumar
10.	29.01.2021	Workshop on Achievements of Centers (Online) under AICRP on Mushrooms, DMR, Solan	Dr Deepika Sud
11.	19.06.2021.	Online Annual Workshop for Zone-1 of NICRA project and made the presentation of annual report, organized by ATARI, Ludhiana	Dr Pradeep Kumar
12.	25.6.2021	International Conference on Sustainable Agriculture challenges and opportunities organized by DAV, Jalandhar and **chaired** a session on **"Crop Protection**"	Dr Deepika Sud

8. PUBLICATIONS

a) Research papers with NAAS ratings

Published:

1. Rana D., Thakur BR. and **Rana SK.** (2020). Efficacy of plant extracts and bio-agents against Fusarium wilt of chickpea. Plant Disease Research 35(2):122-126. NAAS: 4.
2. Sharma S., Katoch V. and Banyal, D K. 2021. Review on harnessing biotechnological tools for the development of stable bacterial wilt resistant solanaceous vegetable crops. *Scientia Horticulturae* 285 (2021) 110158 **(NAAS 8.77)**
3. Bhardwaj, N.R., Banyal, D.K. and Roy, A. K 2021. Prediction model for assessing powdery mildew disease in common Oat (*Avena sativa* L.) **Crop Protection** 146 (2021) 105677. **(NAAS 8.38)**
4. Dogra, P. Singh, A. and Banyal D. K. 2020. Survival of *Cercospora sojina* causing frogeye leaf spot of soybean and impact of weather factors on the disease development. ***Pl. Dis. Res.*** *35 (1)*: 14-19
5. Banyal, D. K., Chatak, S., Malannavar, A. B., Thakur, A. and Singh, A. 2020.Evaluation of bioefficacy of pydiflumetofen 7.5% +difenoconazole 12.5% w/v (200 SC) against early blight of potato. ***Pl. Dis. Res.*** *35 (1)*: 67-69
6. Malannavar, A.B. and Banyal, D.K. 2020. Components of slow mildewing in oat powdery mildew caused by *Blumeria graminis* f. sp. *avenae*. ***Himachal Journal of Agricultural Research*** *46 (1): 62-68.*
7. Shiney Chatak and Banyal, D.K. 2020 Evaluation of IDM components for the management of urdbean anthracnose caused by *Colletotrichum truncatum* (Schwein) Andrus and Moore**.** ***Himachal Journal of Agricultural Research.*** *46 (2): 156-161*
8. Thakur, Naresh, **Devlash, R. K.** and Lata, S. (2021). Evaluation of quality protein maize (QPM) inbred lines and their f1's under natural epiphytotic and artificial conditions for turcicum leaf blight [(*Exserohilum turcicum*) (pass.) Leonard and Suggs.] International Journal of Chemical Studies 2021; 9(1): 2130-2134.
9. Thakur, Naresh, **Devlash, R. K.** and Lata, S. (2021). Screening of QPM Maize Genotypes against Maydis Leaf Blight (*Helminthosporium maydis*) under Natural Epiphytotic Conditions. *International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706* Volume 10 Number 02 (2021).
10. Ramalingam, J., Alagarasan. G., Savitha, P., Lydia, K., Pothiraj, G., Vijayakumar, E., Sudhagar, R., **Singh Amar**, Kumari, V. and Vanniarajan, C. (2020). Improved host plant resistanceto *Phytophthora* rot and powderymildew in soybean (*Glycine max*(L.) Merr). *Scientific Reports.* | https://doi.org/10.1038/s41598-020-70702-x (NAAS: 10.2)
11. Katoch, S. and **Singh Amar**. (2021). Screening of capsicum germplasm for resistance against *Phytophthora capsica* causing leaf blight and root rot. *Journal of Entomology and Zoology Studies* 9: 627-630
12. Basandrai,A.K.,A.Mehta,,V.K.Rathee ,D.Basandrai and **Sharma,B.K**.2020. Efficacy of fungicides in managing yellow rust of wheat. *Journal of Cereal Research* **12(2)**: 103-108
13. Sharma,Sanjay and **Sharma,B.K.** 2020.Economic security of the farmers in Himachal Pradesh: Challenges and Solutions. *Indian Journal of Plant Protection*.**48 (3)**: 217-225

Accepted:

1. A. Arora, Sood V.K, Chaudhary H.K , Banyal D.K, Kumar S, Devi R, Kumari A, Khushbu, Priyanka and Yograj S.2021. Genetics diversity analysis of Oat (*Avena sativa* L) germplasm revealed by agro-morphological and SSR Marker. ***Rangeland Management and Agro Forestry.*** **(NAAS=6.10).**

2. Malannavar, A.B. Banyal, D.K and Sood V K 2020 Screening of oat germplasm for identification of resistance sources against powdery mildew caused by *Blumeria graminis f. sp. avenae* Em. Marchal. **Rangeland management and Agroforestry.**
3. Mehra, A.K., Malannavar, A.B. and Banyal, D.K. 2019. Evaluation of IDM components for management of gray mould of capsicum under protected cultivation in Himachal Pradesh. **Journal of Mycology and Plant Pathology**

b) Book/ Book Chapters

1. Kumar, N., Sood, V K., Banyal, D K and Katoch, R. **2020. Fodder and Livestock Scenario in Himachal Pradesh pages 53-62.** Indian Fodder Scenario: Redefining State Wise Status (2019). Editors : A K Roy, R K Agrawal and N R Bhardwa. All India Coordinated Research Project on Forage Crops and Utilization, Jhansi-284 003, India. **Tech. Pub. Number- 06/2019** pp. 1-201.
2. Kumar, N., Sood, V K., Banyal, D K and Katoch, R. 2020. An approach for improving forage and livestock productivity in Himachal Pradesh through Tribal Sub- Plan, 41-47 **Editors: A K Roy, R K Agrawal, N R Bhardwaj and Subhash Chand.** Glimpses of Tribal Sub Plan Activities of All India Coordinated Research Project on Forage Crops and Utilization. AICRP on Forage Crops and Utilization, ICAR-IGFRI, Jhansi, India. **Tech. Pub. Number- 9/2020.** pp 1-100.
3. Banyal D K, Thakur Ashima, Sinha Diksha and Singh Amar. 2021.Management of Plant Diseases under Protected Cultivation - 413-434. Editors: N K Bharat and H R Gautam. Technology mastrides in plant health management. pp 1-506
4. Sud Deepika and Thakur Yash Pal .(2020). "Khumb Utpadan se aaye Uparjan".Publisher**:** Directorate of Extension Education, CSKHPKV, Palampur 45p.
5. Sharma, Vinod., dogra, Vishal.,Sud Deepika., Bhushan Lav, Choudhary ,D.R and Rana R.S (2020). Himachal Pradesh mein rabi faslon ke liye anumodan. Publisher ; Directorate of Extension Education, CSKHPKV, Palampur 74p.
6. Sharma, Vinod., dogra, Vishal.,Sud Deepika., Choudhary .,D.R Rana R.S and Bhushan Lav, (2020). Himachal Pradesh mein kharif faslon ke liye samporan anumodan. Publisher ; Directorate of Extension Education, CSKHPKV, Palampur 137p.
7. Bhushan,lav.,Sud, Deepika Chaudhary, D.R. and Thakur.Y.P.(2021). Dynamic Agricultural Scenario in Himachal Pradesh : Stories of promising rural agri preneurs. Dirctorate of Extension Education, CSK HP Krishi Vishvavidyalaya,Palampur:94p. ISBN No. 978-93-5445-439-4.

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

1. Tarushi, Deepika Sud and Arun Sud.(2021).Evaluation of different substrates for the spawn production of shiitake mushroom (*lentinulaedodes*) **in National web conference-Mushroom 2021 Mushroom biology: opportunities and challenges 15-17 April 2021. (Abstract RF 04) 37p.**
2. Tarushi, Deepika Sud and Arun Sud. (2021).Comparison of sawdust and grain substrates for spawn production of shiitake mushroom:.**in International Conference on sustainable Agriculture : Challenges and opportunities. 25 June.**

d) Popular articles

1. **Banyal DK**., Malannavar AB and Thakur Ashima. 2020. Matar ki Parmukh Bimarian avum unki Roktham. Technological notes. *Himalayan Phytopathological Society*. 3; 1: 5-7.
2. Singh Akhilesh (2020). Adrak me rog evam keet prabandhan. Kissan Bharti ,August 2020 :-12-15
3. Singh D, Singh Akhilesh and Rathee V.K (2020). Rabi faslon me rog prabanhan Kheti Duniya 4.1.2020: 2&6)
4 Singh D,Manchanda AK ,Rathee V.K, Kapila Rakesh and Singh Akhilesh 2020 Dhan ke pramukhrog v keet March 2020:pp 8 (Booket)

5 Kushwaha Arun, Kushwaha KPS and Singh Akhilesh(2020).Kam lagat se adhik labh hetu Dhingri mushroom ugayein.Rajarshi Sandesh(ISSN 2582-1911)Jan-June 2020:9-11

6 Mahajan Girish, Kumar Pardeep, Chaman Lal, Anjana and Dhanbir. 2020. Krishi vikas mei sahkarita ka mahtav- Bhag- (K), Girija Saptahika14 October, 2020, 43 (2): 5

7 Mahajan Girish, Kumar Pardeep, Chaman Lal, Thakur Anjana and Singh Dhanbir. 2020. Krishi vikas mei sahkarita ka mahtav- Bhag- (K), Girija Saptahika 21 October, 2020, 43 (3): 5

8 Sud Deepika, Ssood Pankaj and Yadav Dinesh **(**2020). Ragisthn tidi- parichya avom prabandhan. Parvatiya Khetibari.40(3):1-2

9 Sud Deepika. (2020). Dhan min lagne wale mukhia rog keet ki roktham ke upaya. Girija Saptahika**.** 42(47): 5.

10 Sud Deepika. **20**20**.** Khumb utpadan bana kissano ke aya ka jaria**.** Girija Saptahika 43(4): 5

11 Sud Deepika and व Sood Ajay**. 2020**. Gobhi vargiya sabjion main rog avam keet niyantran. Parvatiya Khetibari.40(4):22-23

12 Sud Deepika. 2020. Japani mushroom shitake kee kheti , Phalphul (Mushroom visheshank) 42 (1) 40-23

13 Tarushi and Sudm Deepika. 20220. Japani mushroom shitake ke postik and aoshdhiya laph. Grириraj Saptahika. 43(16): 9

e) Pamphlets

1. Pardeep Kumar, Sanjay Sharma, Deep Kumar, Neetu Sharma and Rakesh Thakur. 2020. Dhan ke pramukh rog avam prabandhan. 82: 2020.
2. **Rana SK**, Rana Vijay and Kapila RK. 2020. Gehun ka peela ratua va karnal bunt: lakshan evam prabhandhan. CSK HPKV, Palampur (Pamphlet). P 4.
3. **Rana SK**, Rana Vijay and Kapila RK. 2020. Gehun ka peela ratua va karnal bunt: prabhandhan. CSK HPKV, Palampur (Card). P 2.
4. **Singh Akhilesh**, Rathee VK, Manchanda AK, Kapila Rakesh and Singh Dhirendra. 2020. Gehun ka peela ratua: Pahchan evam prabandhan.
5. **Upmanyu S**, Bhardwaj N, Pandey DP, Srivastava A, Bindra AD and Kapila RK. 2021. *Lal Dhan Bana Himachal Pradesh ka Gaurav*. CSK HPKV, Rice and Wheat Research centre, Malan. p 5.

f) Technical bulletin/Booklets

1. Bhardwaj NR**, Banyal DK**, Atri A, Dhal A, Langde S, Tambe A, Behra P, Mawar R, Bhaskar RB, Chand S, Agrawal RK, Roy AK. 2020. Technological Advances in Forage Crop Protection. AICRP on Forage Crops and Utilization, ICAR-IGFRI, Jhansi. **Tech. Pub. Number- 8/2020** p 29.
2. Sharma Sanjay, **Sharma BK**, Sharma Yogita, Kapoor Deepali, Sharma Parveen, Sinha BN and Meenakshi. 2021. Sarson vargiye faslon ki Himachal Pradesh ke nichle avm madhyam pahari kshetron mein unnat kheti. *TechnicalBulletin* KVK Una. p 30.
3. Rakesh Thakur, Bupinder Mankotia, Sanjay Sharma, Deep Kumar, Neetu Sharma and Jagdish Chand 2020. Bakari Palan.
4. Girish Mahajan, Chaman Lal, Anjana Thakur, Navneet Jaryal, Pardeep Kumar and Parven Kumar. 2020Adhunik Krishi ke vibhin arthik pahalu- Ek parichaye. 144p

h). Lead Lectures

1. Delivered lead lecture on Diseases and their integrated management under protected cultivation, on Nation Webinar on management of Biotic and Abiotic stresses in protected Agriculture on 23.09.2020 under CAAST Project (22-24.09.2020)
2. Delivered lead lecture in conference organised by Himalayan Phytopathological Society UHF Solan on 5-6.05.2021 online and delivered a lead lecture on Management of Plant Diseases under Protected Cultivation on 05.05.2021

g) Radio/ TV talks

Sr. No.	Topic	Recording Date	Telecast Date	Speaker
1.	Diseases of rice and their management	14.9.2020	Kisan Bani programme at 6.30 – 7.0PM From AIR Dharamshala	Dr. Pardeep Kumar
2.	Mushroom ki Unnat Kheti	15.12.2020	Live Phone In Kisan Bani Programme at 6.30 – 7.0PM from AIR Hamirpur	do
3.	Wheat diseases and their management	16.2.2021	Live Phone In Kisan Bani Programme at 6.30 – 7.0PM from AIR Hamirpur	do

i). Recommendation Accepted:

1. **Management of clover rot and powdery mildew of red clover. 2020** Seed treatment with carbendazim @ 2 g/kg seed followed by three foliar spray of hexaconazole @ 0.1 %. (AICRP forage crops)

2. **Biological management of powdery mildew of oats caused by *Blumeria graminis* f. sp. *avenae***.2021. Three foliar sprays of *Trichoderma viride* @ 0.5% (AICRP forage crops)

j) Success stories

1. Upliftment of socio-economic status through mushroom cultivation. Kumar Pardeep, Rana R K and Singh R (2020) ARYA ARMY, ICAR-ATARI, Zone-I, Ludhiana, India: 13-1
2. Mushroom cultivation- A future for youths. 2020. Kumar Pardeep, Chauhan, C L, Rana R K and Singh R (2020) ARYA ARMY, ICAR-ATARI, Zone-I, Ludhiana, India: 13-18

9. SALIENT FINDINGS

a) Cereals

- Out of 706 entries of rice from various screening nurseries, 56 entries from NSN-1, 67 from NSN-H, 46 from NHSN and 41 entries from DSN were found promising against leaf blast whereas, 44 entries from NSN-H and 23 from NHSN were found promising against neck blast at RWRC, Malan
- Of all the fungicides tested, Isoprothiolane 40% EC was found most effective to reduce the neck blast incidence as well as enhancing the grain yield followed by Kasugamycin 3% SL and Kitazin 48% EC respectively.
- Treatment combination of seed treatment with carbendazim (2 g/kg) + one blanket application of combi-fungicide Nativo 75 WG (trifloxystrobin 25% + tebuconazole 50%) @ 0.4 g/l at booting stage proved to be highly promising resulting in 50% reduction in neck blast incidence and increased the grain yield by 89% over control followed by treatment combination of Seed treatment with bio-control agent + one application of bio-control agent at 15-20 DAT (10 g/litre) + One blanket application of propiconazole (1 g/litre) at booting stage.
- A new maize composite **L315** was found promising in AICRP testing and identified for release through Central Variety Release Committee during AICRP maize workshop, 2021.
- Wheat varieties/ lines viz., WH1105, WH1142, VL829, VL616, VL404, VL829, VL832, VL421, Sarbati sonara, UP2338, HS542, PBW175 were found immune to the flag smut of wheat
- Carboxin + thiram, carbendazim and tebuconazole at concentrations (1-3g/ kg seed) gave cent percent control of flag smut
- New fungicides Pydiflumetofen15.0% + Propiconazole 12.5% w/v SE and Propiconazole 13.9% + Difenconazole 13.9% w/w (15% w/v) EC) were found effective for the control of yellow rust of wheat
- Propiconazole 25EC (500 ml/ha) was found highly effective against powdery mildew of wheat.
- Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE) (600 &700 gm/ ha) and Propiconazole 25EC (500 ml/ ha) were found effective to manage head blight of wheat.
- Two sprays of Zineb 75 % WP @ 1750, 2000 and 2250g/ ha at fortnightly interval starting at first appearance of disease were most effective in the management of wheat diseases (yellow rust and leaf blights) and increase in yield over check and none of the treatments showed phytotoxicity.
- Barley variety **HBL 804 (Him Palam Jau 2)** having resistance to yellow rust got identified for state release in Rabi Workshop for low and mid hills of Himachal Pradesh under timely sown rainfed conditions.

b) Vegetables

- Increased incidence of Bacterial spots and bacterial canker of tomato was observed in farmers' field during the year under report as compared to previous years.
- For the management of purple blotch and Stemphylium blight of onion, maximum disease control (80.7 and 83.0 %) was recorded with two foliar applications of Folio Gold 440 SC (Metalaxyl-M 3.3 % + Chlorothalonil 33.1 % SC) @ 2.0 ml/ l, and 2.5ml/ l at fortnightly interval with highest yield (262.6q/ha)

c) Pulses

- To identify bean anthracnose resistant recessive gene (R-gene) at molecular level present in landrace KRC-8, 687 different ISSRs, SSRs and RAPD**s** markers were screened and SSR marker IAC-238 was found linked with the adult plant resistance gene as the genotypic data exhibited a segregation ratio of 1:1 (113suseptible:110 resistant) and no recombinant was observed in mapping $RIL_{F2\text{-}F9}$ population.

d) Oil seeds

- In AVT-II entries of soybean, line NRC 149 was observed to be highly resistant against pod blight (Ct) while entry AMS 100-39 was found moderately resistant against both FLS and pod blight diseases
- Out of 26 soybean lines showing resistance in previous years, 11 lines maintained their high resistance status against frogeye leaf spot (*Cercospora sojina*), 9 lines maintained their high resistance status against pod blight (*Colletotrichum truncatum*) and 6 lines have shown high to absolute resistance against both the diseases.
- Out of 50 germplasm line screened for having multiple disease resistance, the germplasm lines, UPSL 77, TGX 293-41E, EC 391181, EC 39573, EC 172576, UGM 77, EC 14117, Harder, EC 241780 and JSM 277 were observed having multiple disease resistance against frogeye leaf spot (*Cercospora sojina*), pod blight (*Colletotrichum truncatum*) and brown spot (*Septoria glycines*).

e) Organic and Natural Farming

- Ramban was quite effective in managing powdery mildew in different crops giving 50.0-71.4% control of the disease.
- Jeevamrit gave maximum control (83.52%) of flag smut of wheat.
- Among the eighteen bioagent (*Trichoderma* spp.) isolates evaluated against *Sclerotium rolfsii* causing collar rot of tomato and capsicum, DMA-8 was found most effective with 81.55 per cent mycelial inhibition followed by TH-11 (79.16 %).
- Twenty-three bio-agent isolates (22 *Trichoderma* spp & 1 bacterium) were evaluated against *Sclerotinia sclerotiorum* and isolate TI-8 was found most effective with 69.49 per cent mycelial inhibition followed by isolate TI-11 (65.54%).
- Three foliar spray of *Trichoderma viride* @ 0.5% or three foliar spray of *Trichoderma harzianum* @ 0.5% were found effective giving 49.7 per cent control of powdery mildew of oat with 10.8 per cent increase in the seed yield over check.

f) Fodder

- Seed treatment with tebuconazole + trifloxystrobin @ 1 g/ kg seed followed by two sprays of same fungicide @ 0.4 g/ l was found most effective in the management of leaf blast of pearl millet which gave 83.1 % disease control with 16.0 % increase in the green fodder yield over check wheras, among the non-chemical methods, seed treatment with chitosan @ 0.05% followed by the foliar spray of chitosan @ 0.05% was found effective with 67.6 % disease control with 12.1 % increase in the yield over check.
- Three foliar sprays of propiconazole @ 0.1% (Chemical check) were found most effective in the management of zonate leaf spot of sorghum which gave 70.4 % disease control with 22.0 % increase in the green fodder yield over check whereas, among non-chemical methods three foliar spray of Tamar lassi @ 10% disease gave 53.4% disease control with 10.2 % increase in the yield over check.
- Seed treatment with carbendazim @ 0.02 % followed by a foliar spray of carbendazim @ 0.01 % proved best with 88.1 and 82.9 per cent control of root rot and leaf blight of berseem, respectively, with maximum increase (4.8 %) in the GFY over the check.
- The virulence pattern of 24 isolates of *Blumeria graminis* f. sp. *avenae* causing powdery mildew of oat was studied on the differential set comprising of 11 lines using seedling evaluation and three isolates each were placed in pathotype OMP-1, OMP-2 and OMP-6, two isolates each in OMP-3, OMP-4, OMP-5 & OMP-7 and one isolate each in pathotype OMP-8, OMP-9, OMP-10, OMP-11, OMP-12, OMP-13 and OMP-14.

8. Photos of important events/activities:

Management of *Stemphyllium* blight and Lentil wilt at Akrot

ELP Students performing various operations in mushroom cultivation

Trainings of Farmer groups on Mushroom Cultivation