AICRP-MULLARP

Objectives

- Development of high yielding varieties having consistence performance, higher yield, resistance, wider adaptability, medium-short duration, non-shattering and different maturity groups.
- Development of suitable agronomy of newly developed varieties of urdbean, mungbean, lentil and fieldpea for normal and late sown conditions,
- Evaluation and identification of efficient N_2 fixing and widely adaptive strains of *Rhizobium* sp. and to develop suitable management modules including integrated disease management for the major diseases.
- Development and evaluation of safe and economic IPM options against major insects and pests in MULLaRP crops.

A. Pulses breeding:

1. Significant Achievements:

Crop Improvement:

Total 37 varieties of Urdbean, mungbean, lentil and pea have been developed and contributed significantly in the production of the pulses in the different parts of the country.

Crop varieties developed:

Sl. No.	Variety Name	Release agency	Year of release	Recommended areas	Yield (q/ha)
Urdbean					
1.	Pant U 19	SVRC	1981	North eastern plains of the country	10-15
2.	Pant U 30	SVRC	1981	Central and peninsular parts of the country	12-15
3.	Pant U 35	SVRC	1985	Uttar Pradesh and Uttarakhand (kharif and zaid)	14-15
4.	Manikya	SVRC	1988	Karnataka	10-12
5.	Pant U 31	SVRC	2005	Plains and lower hills of Uttarakhand	12-15
6.	Pant U 40	SVRC	2005	As intercrop with cereals in plains and lower hills of Uttarakhand	12-15
7	Pant Urd 10	CVRC	2018	*Kharif* season in North Hill Zone of India (Hills of J & K, Himachal, Uttarakhand and North East States of India)	12-15
Mungbean					
1.	Pant M 1	SVRC	1981	Uttar Pradesh and plains of Uttarakhand in kharif and zaid	10-15
2.	Pant M 2	SVRC	1982	Uttar Pradesh and plains of Uttarakhand for kharif andzaid (specially suitable for late sowing in kharif)	10-12
3.	Pant M 3	CVRC	1985	North-west plains zone of the country	12-15
4.	Pant M 4	CVRC	1997	North-east plains zone of the country	12-15

5.	Pant M 5	SVRC	2002	Uttar Pradesh and Uttarakhand	12-15
6.	Pant M 6	CVRC	2007	North-east hill zone of the country	12-14
7.	Pant M 8	SVRC	2017	Plains of Uttarakhand	12-15
8.	Pant M 9	SVRC	2018	Plains of Uttarakhand	12-15
Lentil					
1.	Pant L 406	CVRC SVRC	1978 1979	Uttar Pradesh, plains of Uttarakhand, Punjab, Haryana, Rajasthan and Delhi	15-16
2.	Pant L 234	SVRC	1980	Uttar Pradesh and Uttarakhand	14-15
3.	Pant L 639	CVRC	1981	Northern plains (west and east) and central zone of the country	16-18
4.	Pant L 4	CVRC	1993	Uttar Pradesh, plains of Uttarakhand, Punjab, Haryana, Rajasthan and Delhi	15-18
5.	Pant L 5	SVRC	1999	Uttar Pradesh and Uttarakhand	18-20
6.	Pant L 6	SVRC	2008	Plains of Uttarakhand	12-15
7.	Pant L 7	SVRC CVRC	2008 2010	Uttar Pradesh, plains of Uttarakhand, Punjab, Haryana, Rajasthan and Delhi	14-15
8.	Pant L 8	CVRC	2010	North Western Plain Zone	15-18
9.	Pant L 9	SVRC	2017	Plains of Uttarakhand	15-18
10	Pant L 10	SVRC	2018	Plains of Uttarakhand	15-18
11.	Pant L 11	SVRC	2018	Plains of Uttarakhand	15-18
Pea:					
1.	Pant P 5	CVRC	1986	Uttar Pradesh and plains of Uttarakhand	20-25
2.	Pant P 14	SVRC	2004	For timely sown condition during the rabi season in Uttarakhand	15-20
3.	Pant P 13	SVRC	2005	For entire Uttarakhand	15-20
4.	Pant P 25	SVRC	2006	Plains of Uttarakhand	20-25
5.	Pant P 42	CVRC	2008	Western Uttar Pradesh, Northern Rajasthan, Punjab, Haryana and plains of Uttarakhand	22-25
6.	Pant P 74	CVRC	2009	Plains of UK, Western Uttar Pradesh, Northern Rajasthan, Punjab and Haryana for timely sown condition	20-25
7.	Pant P 155	SVRC	2017	Plains of Uttarakhand	20-25
8.	Pant pea 250	CVRC	2018	*Rabi* season in North West Plain Zone of India (Punjab, Haryana, Delhi, North-West & Central Rajasthan, Western UP and Plains of Uttarakhand and Jammu & Kashmir)	25-30
9.	Pant Pea-243	CVRC	2018	*Rabi* season in Central Zone of India (Madhya Pradesh, Chhattisgarh and Parts of Rajasthan)	20-25
10	Pant P 195	SVRC	2018	Plains of Uttarakhand	20-25
11	Pant P 200	SVRC	2018	Plains of Uttarakhand	20-25

2. Research Publications:

Sharma, B.L., Singh, D.P. and Singh, K.H. 2000. Evaluation of diverse germplasm lines/ cultivars for yield and yield components in blackgram (*Phaseolus mungo*). *Ind. J. Ag. Sci.,* 70(3):154-157

Paul, A and Singh, DP. 2002. Induced chlorophyll mutations in lentil. *Indian J. Genet*. Pl. Breed., 62(3): 263-264.

Abdalla, A.I. and Singh, D.P. 2004. Stability analysis of yield and yield components in early maturing lines of mungbean. *Indian J. Pulse Res.* 17(2): 121-124.

Pal, Vijay and Singh, J.P. 2004. Correlation and path-coefficient analysis in lentil (*Lens culinaris Madik*). *Agril. Biol. Res*., 20(1): 31-37.

Pal, Vijay and Singh, J.P. 2004. Studies on genetic variability for yield and its component traits in lentil. *Agril. Biol. Res.*, 20(2): 138-143.

Yadav, V.K. and Panwar, R.K. 2004. Genetic variance in relation to heterosis for yield, seed protein and nitrogen fixing characters in field pea (*Pisum sativum* L.) Pantnagar J. of Res., 2(1): 25-28.

Chawda, Chetan and Singh, D.P. 2005. Allelic relationship of resistance and tolerance genes to rust disease in pea. *Indian J. Pulses Res.,* 18(2): 135-136.

Paul, A and Singh, D.P. 2005. Frequency, spectrum and segregation pattern of chlorophyll and macromutations in fieldpea (*Pisum sativum* L.). *Leg. Res.,*28(2): 94-98.

Singh, D.P. and Ahlawat, I.P.S. 2005. Greengram and blackgram improvement in India: past, present and future prospects. *Indian J. Agric. Sci.,* 75(5): 243-250.

Yadav, V.K. and Panwar, R.K. 2005. Heterosis for traits governing nodulation and nitrogen fixation in fieldpea (*Pisum sativum* L.). Indian J. of Pulse Res., 18(2): 137-140.

Chawda, Chetan and Singh D.P. 2006. Inheritance of resistance to rust (*Uromyces vicae fabae*) in pea. *Indian J. Pulses Res.,* 19(1): 17-18.

Yadav, V.K. and Panwar, R.K. 2006. Genetics analysis of traits growing nodulation and nitrogen fixation in fieldpea (*Pisum sativum* L.). *Indian J. Pulses Res.,* 19(1): 24-25.

Yadav, V. K, and Panwar, R.K. 2006. Studies on association of nitrogen fixation with other traits and measurement of direct and indirect effects on seed yield in fieldpea in field pea (*Pisum sativum* L.). *Pantnagar Journal of research* 2(1): 25-28.

Yadav, V.K and Panwar, R.K. 2006. Relationship between nitrogen fixation with its components, direct and indirect effect on seed yield in fieldpea (*Pisum sativum* L.). *Pantnagar J. Res.,* 4(2): 83-85.

Paul, A and Singh, D.P. 2007. Gamma ray induced variavility for polygenic traits in lentil. *J. Food Leg.*, 20(2): 150-152.

Yadav, V.K, Kumar, S and Kumar, R. 2007. Measurement of genetic dissimilarity in fieldpea (*Pisum sativum* L.) genotypes using RAPD markers. *Genetic Res. Crop Evol.*, 54(6): 1285-1289.

Singh, Manju., Singh, D.P and Rani, S. 2008. Inheritance of resistance to cercospora leaf spot (CLS) in mungbean. *Intl. J. Trop. Agric.,* 17(3-4):487-489.

Bisht, Niharika., Singh, D.P. and Khulbe, R.K.

2010. Analysis of genetic diversity in Vigna species using ISSR markers. *Ind. J. Food Legumes* 23(3&4):201-204

Singh, Anupama., Khulbe, R.K. and Panwar R.K. 2012. Evaluation of urdbean (*Vigna mungo*) germplasm for pre-harvest sprouting tolerance. *Journal of Food Legumes* 25(3): 183-186.

Joshi, Meenakshi., Verma, S. K., Singh, J. P. and Anupam, Barh 2013. Genetic diversity assessment in lentil (lens culinaris medikus) genotypes through ISSR marker. *The Bioscan* 8(4): 1529-1532.

Ahmad, Sarfraz., Khulbe, R.K. and Roy, D. 2014. Evaluation of mungbean (*Vigna radiata*) germplasm for pre-harvest sprouting tolerance. *Legume Research* 37(3): 259-263.

Bisht, Niharika., Singh, D.P. and Khulbe, R.K. 2014. Genetic variability and correlation studies in advance inter-specific and inter-varietal lines and cultivars of mungbean (*Vigna radiata*). *Journal of Food Legumes* 27(2): 155-157.

Kumar, Sundeep., Panwar, R. K., Mohammad, Naseer and Arora, Anju 2014. Assessment of genetic divergence for nitrogen fixation, yield and yield contributing traits in fieldpea (*Pisum sativum* L.). *International Journal of Basic and Applied Agricultural Research* 12(1): 20-24.

Sahu, Hemant., Panwar, R.K., Jeena, A.S. and Amadabade, Jairam. 2014. Genetic variability and heritability studies in advanced breeding lines of mungbean. *International Journal of Plant Sciences* 9(1): 205-208.

Kumar, Kuldeep., Kumar, Pardeep., Panwar, R. K. and Arora, Anju 2015. Inter-relationship and path analysis study for yield and yield attributing traits in lentil (*Lens culinaris* Medikus). *Environment and Ecology* 33(4A): 1803-1810.

Choudhary, Rakesh., Verma, S.K., Panwar, R.K., Chourasiya, V.K. and Pandey, Deepankar 2017. Morphological characterization of lentil (*Lens culinaris* Medikus.) varieties based on six qualitative traits. *Journal of Pharmacognosy and Phytochemistry* 6(5): 1611-1615.

Nautiyal, Niki and Panwar, R.K. 2017. Assessment of genetic diversity in fieldpea (*Pisum sativum* L.) based on SSR markers. *Green Farming* 8(1) 29-32.

Priyanka, Bhareti., Abhishek, Tyagi and R. K. Panwar. 2017. Pulses: Addressing Constraints to Lower Production and Productivity in India. *Trends in Biosciences*, 10(37): 7678-7681.

Singh, Mamta., Gautam, K. K., Panwar, R. K. and Verma, S. K. 2018. Gene action, heterosis and combining ability studies for economic traits in diallel crosses of lentil (Lens culinaris Medikus.). *Agricultural Science Digest*. 38(4): 248-254.

3. Thesis Research:

Mishra, Sushil Kumar. 2000. Genetic analysis for seed yield and other quantitative characters in fieldpea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Digvijay, Raj Kumar. 2001. Varietal characterization and divergence studies in lentil (*Lens culinaris* Medik.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. J.P.S. Dhaka.

Kumar, R. 2001. Stability analysis for yield and yield components in lentil (*Lens culinaris*

Medikus). Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Yadav, Vinod Kumar. 2002. Genetic Analysis for nitrogen fixation, seed yield and other quantitative characters in fieldpea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Abdalla, A.I. 2003. Stability analysis of yield and yield components in early maturing lines of mungbean. Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Kumar, Sandeep. 2004. Molecular and morphological markers for genetic diversity in fieldpea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Mishra, S.K. 2004. Inheritance, screening and identification of protein markers for resistance to rust in lentil. Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Bisht, Vikash. 2005. Genetics studies for yield and certain yield traits in fieldpea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Singh, Manju. 2005. Studies on generation mean analysis for yield traits and inheritance of resistance to Corcospora leaf spot in the varietal crosses of greengram and wide cross of greengram and blackgram. Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Jaya. 2006. Studies on heterosis and combining ability in rust (*Uromyces viciae-fabae*) resistant and susceptible lines of fieldpea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Sharma, H.K. 2006. Evaluation of F_4 progenies of a wide cross involving mungbean (cv. BDYR-1) and blackgram (cv. DPU 88-31) for yield and yield components. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. B.L. Sharma.

Singh, Amandeep. 2006. Inheritance of resistance to botrytis grey mould (*Botrytis cinerea*) in Chickpea (*Cicer aritinum* L.). Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Bhareti, Priyanka. 2008. Morphological and molecular characterization of advance breeding lines in blackgram. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Kumar, Sandeep. 2009. Path Analysis and Genetic Divergence for Nitrogen Fixation, Yield and Related Traits in Fieldpea. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Bisht, Niharika. 2009. Morphological and molecular characterization of advance breeding lines in *Vigna* species. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. D.P. Singh.

Rana, Asheem. 2010. Genetic Analysis for Seed Yield, Biological Nitrogen Fixation And Other Quantitative Characters in Fieldpea (*Pisum Sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Singh, Puran. 2010. "Characterization of Fieldpea (*Pisum sativm* L.) Genotypes Through

Morphological and ISSR Markers". M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Ahmad, Sarfaz. 2011. Screening of mungbean (*Vigna radiata*) germplasm for pre-harvest sprouting (PHS) resistance. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Khulbe.

Singh, Anupama. 2011. Screening of blackgram germplasm for pre-harvest sprouting resistance. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Khulbe.

Singh, V.K. 2012. Evaluation of advanced breeding lines of blackgram for yield attributes and MYMV resistance. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Khulbe.

Bhareti, Priyanka. 2013. Identification of high yielding genotypes at under normal and deficient phosphorous conditions and molecular diversity using SSR and STMS markers among *Vigna* species. Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Gupta, Richa. 2013. Diversity analysis for quantitative traits, biochemical profiling and screening of MYMV in blackgram (*Vigna mungo* (L.) Hepper) germplasm collected from Uttarakhand hills. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. Anju Arora.

Sahu, Hemant. 2013. Genetic evaluation of advanced breeding lines of mungbean for nitrogen fixation, yield and other quantitative traits. M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R. K. Panwar.

Kumar, Kuldeep. 2014. Estimation of genetic diversity based on morphological and molecular markers in lentil (*Lens culinaris* Medikus). Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Singh, Mamta. 2014. Heterosis and combining ability analysis for some quantitative traits in lentil (*Lens culinaris* Medikus.). Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. S.K. Verma.

Nautiyal, Niki. 2015. Identification of high yielding genotypes at different levels of phosphorous and molecular diversity analysis in fieldpea, lentil and chickpea. Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. R.K. Panwar.

Dhyani, Ajay Kumar. 2016. Genetic architecture of yield components assessed through line x tester analysis in field pea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under the guidance of Dr. R. K. Panwar.

Choudhary, Rakesh. 2017. Gene action, inheritance studies and QTL detection for some morphological traits in lentil (*Lens culinaris* Medikus.). Ph.D. Thesis submitted to GBPUAT under the guidance of Dr. S.K. Verma.

B. Agronomy

1. Significant Achievements:

- In a two year experiment, urdbean planted on raised beds yielded 18% higher than flat bed planting. Use of 15kg seeds/ha was significantly superior to 10 kg/ha. Different fertility levels (50, 75 and 100% RDF) did not bring any significant effect on grain yield.

- Two years experiment conducted during kharif seasons of 2015 and 2016 revealed that pre-emergence application of pendimethalin 30 EC @1.0 kg/ha followed by imazethapyr @ 55g/ ha as post emergence, 25-30 DAS gave significantly higher urdbean yield as compared to either of the herbicides when applied alone
- Pooled analysis of 3 years data revealed that among different non-monetary inputs, time of weed removal was the most crucial followed by sowing time. Delayed sowing(3 weeks after normal), used of local variety (Type-9), broadcast method of sowing and weed removal 6 weeks after sowing caused yield reduction to the tune of 13.3, 10.1, 7.6 and 32.9 % in comparision to normal sowing, improved variety (Pant U-35), line sowing and weed removal three weeks sowing, respectively.
- Urdbean yield was higher under combined use of INM+IWM+IPM practices than others. Among single practice, IWM proved more crucial than INM or IPM .
- Narrow row (20 cm) spaced bold seeded mungbean yielded higher under late planting conditions than 30 cm. Yield reductions was more conspicuous beyond August 10 planting. On an average, 10.1, 11.5 and 7.1% yield increased due to narrow row spacing (20 cm) as compared to 30 cm row spacing when planted on August 20, August 30 and September 9, respectively.
- Three years experiment revealed that combination of INM+IWM+IPM practices gave 101% increased grain yield of mungbean over control. Among different practices, IWM came out to be single most crucial factor than INM and IPM.

Application of three irrigations at 25, 40, and 50 Days after sowing (DAS) in spring sown mungbean registered significantly higher grain yield (702 kg/ha) over two irrigations applied at 25 and 45 DAS. Pre-emergence application of pendimethalin @ 1 kg /ha in mungbean out yielded one hand weeding done at 25 DAS.

- Application of mulch during spring season recorded significantly higher mungbean yield over no mulching. Use of wheat straw mulch @ 5t/ha yielded (737 kg/ha) significantly higher than dust mulch (677 kg/ha).
- Grain yield of bold seeded lentil decreased significantly with delay in sowing beyond November 5. The percentage reduction under November 25 and December 15 sowings was 13 and 36% respectively. On an average, the yield of lentil reduced by 15 kg/ha/day as the sowing was delayed from November 5 to December 15.
- A four years study on lentil (DPL-62) establishment methods revealed that conventional and reduced tillage (one tillage with rotavator), being on par recorded 36 and 25% higher yields over zero tillage.
- Integration of weed, nutrient and pest management practices gave higher yield of lentil compared to remaining practices employed alone or in combinations.
- Application of RDF (20:17:17:20 kg of NPKS/ha) + 25 kg $ZnSO_4$/ha + seed inoculation with *Rhizobium* + PSB + PGPR (20 g each) + 1 g ammonium molybdate/ kg seed gave higher yields of lentil than

remaining treatments.

- Twenty five per cent higher seed rate+HW, 30 DAS, which was on par with pre-emergence application of pendimethalin @ 0.75 kg/ha + HW 40 DAS recorded almost on par yield of bold seeded lentil as weed free treatment.
- Sowing of pea at a spacing of 25 cm x10 cm recorded 22% higher grain yield than that of 40cm x 10cm. Pant P 13 registered higher grain yield than Pant P 42, Pant P 14 and DMR 7.
- Raised bed planting of pea (Pant P 13) out yielded flat bed planting by a margin of 434 kg grain/ha. Two irrigations applied at critical stages (branching and grain filling) of the crop recorded 30% higher yield over no irrigation. Pre-emergence application of pendimethalin @ 1 kg/ha followed by one hand weeding, 25 days after sowing, gave 33 and 21% higher yield respectively, over weedy check.
- Two years continuous experiment revealed that nipping of plants 5 cm from top at 25 days after sowing gave significantly higher yield of fieldpea irrespective of tall and semi dwarf varieties.
- **Planting technique of fieldpea**

  Increasing seed rate by 25% along with one hand weeding, 30 days after sowing gave as much yield as weed free treatment and was significantly superior to either pendimethalin (pre-emergence) or Isoproturon (Post-emergence) each @ 1kg/ha.
- Application of RDF (20:17:17:20 kg of NPKS/ha) + 25 kg $ZnSO_4$/ha + seed inoculation with *Rhizobium* + PSB + PGPR (20 g each) + 1 g ammonium molybdate/ kg seed gave higher yields of fieldpea than remaining treatments.
- Integration of weed, nutrient and pest management practices gave higher yield of lentil compared to remaining practices employed alone or in combinations.
- Maintenance of high density (5.0 lakh plants/ha) in urd/mungbean yielded significantly higher during *kharif* season than low density (3.3 lakh plants/ha) but had a little effect on succeeding wheat and wheat equivalent yields.
- In urdbean-wheat cropping sequence, application of FYM @ 5t/ha and P_2O_5 @ 40 kg/ha to urdbean had significant effect on urdbean yield but no or a little effect on succeeding wheat crop. A level of 75% RDF applied to wheat gave on par yield with 100% RDF and thus economized 25% of fertilizer in wheat.
- A study conducted for 3 consecutive years (2004-06) on urdbean-wheat cropping sequence revealed that application of 20 kg P_2O_5/ha to urdbean as well as seed inoculation with PSB (*B. megaterium*) not only increased the yield of urdbean by 35% over control but also had 17.7% more residual effect on succeeding wheat.
- Urdbean seeds inoculated with PSB only gave the direct and residual effect in terms of yield increase of 19.2 and 11.5 per cent respectively. However, the respective figures for 40 kg P_2O_5/ha to urdbean were 28 and 10 per cents. Direct effect of Phosphorus application to wheat was continuously on increase upto 60 kg P_2O_5/ha.
- In a two year study, intercropping of maize+urdbean gave the maximum

urdbean equivalent yield and proved superior to other treatments (maize+soybean, maize+mungbean, sorghum+mungbean, sorghum+urdbean, sorghum+soybean).

2. Research Publications:

Dixit, Vivek and Singh, V.K. 2012. Effect of tillage and weed management practices on yield and yield attributes of lentil varieties. *Pantnagar Journal of Research* 10 (1):111-113.

Bhushan, C. and Singh, V.K. 2013. Planting pattern and weed management for enhancing productivity and profitability in urdbean + fingermillet intercropping. *Journal of Food Legumes.*26 (1&2): 112-115.

Brijbhooshan and Singh, V.K. 2014. Effect of planting method, irrigation schedule and weed management practice on the performance of field pea (*Pisum sativum* L. *arvense*). *Journal of Food Legumes* 27(2): 112-116.

Shalini and Singh, V.K. 2014. Effect of pre- and post-emergence herbicides on weed dynamics, seed yield, and nutrient uptake in dwarf field pea. *Journal of Food Legumes* 27(2): 117-120.

Singh,V.P., Singh,V.K., Singh, Ashutosh and Singh, Rakhi. 2014. Effect of tillage practices and seed rates on the yield of bold seeded lentil and properties of soil. *Journal of Community Mobilization and sustainable Development.*9 (1): 52-55.

Mandal, T., Singh, V.K., Bhushan, C. and Kumar, Amrendra. 2015. Weed dynamics, nutrient removal and yield of urdbean as influenced by weed management practices under *tarai* conditions of Uttarakhand. *Annals of plant and soil Research* 17(special issue): 245–249.

Moiranthem, Thoithoi Devi and Singh, V.K. 2015. Composition of weeds and yield as affected by different weed management and planting patterns in fieldpea and baby corn intercropping system. *Annals of Agricultural Research* 36(3): 279–289.

Mandal, Tanumay., Singh, V.K., Bhushan, Chandra and Kumar, Amrendra. 2015. Weed dynamics, nutrient removal and yield of urdbean [*Vigna mungo* (L) *Hepper*] as influenced by weed management practices under Tarai conditions of Uttarakhand. Annals of Plant and Soil Research 17(Special Issue): 245-249.

Meena, Dharmendra., Bhushan, Chandra., Shukla, Anil., Chaudhary, Sumit., Semwal M.P. and Kumar, Kranti. *2016.* Effect of foliar application of nutrients on growth parameter, nutrient content and uptake of Urdbean (*Vigna munga* (L.) Hepper). *Eco. Env. & Cons. 22 (4) : 2016; pp. 537-542.*

Meena, Dharmendra., Bhushan, Chandra., Shukla, Anil., Chaudhary, Sumit and Sirazuddin. 2016. Effect of foliar application of nutrients on Nodulation, yield attributes, yields and quality Parameters of urdbean (vigna mungo)(l.) Hepper. The Bioscan 12(1): 411-414.

Meena, D., Bhushan, C., Shukla, A., Chaudhary, S., Semwal, M.P. and Kumar, K. 2016. Effect of foliar application of nutrients on growth parameter, nutrient content and uptake of Urdbean (*Vigna munga* (L.) Hepper). *Eco. Env. & Cons.* 22(4): 537-542.

Meena, Dharmendra., Bhushan, Chandra., Shukla, Anil., Chaudhary, Sumit and Meena, Shiv Singh. 2017. Effect of foliar application of nutrients

on biological yield and economics urdbean (*Vigna mungo* (L.) Hepper). *Int. J. Curr. Microbiol. App. Sci* (2017) *6*(5): xx-xx

Moiranthem, Thoithoi Devi and Singh, V.K. 2017. Growth, development and yield as affected by planting pattern and weed management in fieldpea and baby corn intercropping system. *Legume Research* 40(1):105-116. (NAAS=6.15, Impact Factor=0.145, Scientific Journal Rating (SJR=0.181).

Brijbhooshan, Singh, V.K and Shalini. 2017. Response of fieldpea *(Pisum sativum L.Var arvense*) to various planting methods,irrigation schedule and weed management practices. *Legume Research*, 40(1):132-137. (NAAS=6.15, Impact Factor=0.145, Scientific Journal Rating (SJR=0.181).

Shalini, Singh, V.K and Brijbhooshan. 2017. Evaluation of efficacy of different herbicides on weed dynamics and performance of dwarf fieldpea in *tarai* soils of Uttarakhand, India. *Legume Research*, 40(3): 586–591. (NAAS=6.15, Impact Factor=0.145, Scientific Journal Rating (SJR=0.181).

Devi, M.T. and Singh, V.K. 2018. Productivity and economics of fieldpea (*Pisum sativum*) and baby corn (*Zea mays*) intercropping systems as affected by planting pattern and weed management. *Indian Journal of Agronomy,* 63 (2): 157-162. (NAAS=5.46).

Hasanain, M., Shukla, D. K., Singh, V. K., Singh, S. P., Bhushan, C. and Gouda, H. S. 2018. Evaluation of fertility levles and weed management practices on summer mungbean [Vigna radiata (L.) Wilczek] under *tarai* region of Uttarakhand. *International Journal of Chemical Studies* 6(6): 893-895. (NAAS rating 5.31)

3. Thesis Research:

Mandal, Tanumay. 2012. Effect of herbicides on weeds and performance of *kharif* planted urdbean [*Vigna mungo* (L.) Hepper]. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Bhandari, Pradeep. 2013. Response of bold seeded lentil (*Lens culinaris,* Medic) to foliar application of urea and thiourea. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Goswami, Gargi. 2013. Fertility and weed management in summer mungbean. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. C. Bhushan.

Bhatt, Pooja. 2014. Bio-efficacy of pre and post emergence herbicides On weeds in urdbean [*Vigna mungo* (l.) Hepper] Under late sown condition in *tarai* region of Uttarakhand. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. C. Bhushan.

Moirenthem. 2014. Studies on planting pattern and weed management in fieldpea + baby corn intercropping system. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Meena, Dharmendra. 2015. Studies on foliar application of Nutrients on the performance of Urdbean (*Vigna mungo* (L.) Hepper). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. C. Bhushan.

Suresh. 2015. Influence of crop management practices on the performance of fieldpea *(Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Prabhaker, Ajay Kumar. 2016. Influence of planting pattern and weed management on the performance of component crops in maize + urdbean intercropping system. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Priya. 2016. Studies on influence of foliar application of nutrients and salicylic acid on prospects of urdbean [*Vigna mungo* (L.) Hepper]. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. C. Bhushan.

Gouda, Himansu Sekhar. 2017. Effect of establishment methods and weed management practices on weed dynamics and performance of *kharif* planted urdbean (2017). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. V.K. Singh.

Hasanain, Mohammad. 2017. Studies on nutrient and weed management practices in summer mungbean (*Vigna radiata* (L.) wilczek) in tarai region of Uttarakhand. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. D. K. Shukla.

Sundriyal, Prerna. 2018. Performance of mungbean (*Vigna radiata* (L.) wilczek) genotypes under different foliar nutritions in tarai region of Uttarakhand. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. D. K. Shukla.

C. Microbiology

1. Significant Achievements:

Identification of efficient Bradyrhizobium strains

A large number of *Rhizobium* sp. (*Vigna*) strains were isolated from different agro-climatic conditions and evaluated for their symbiotic performance together with the *Rhizobium* sp. (*Vigna*) isolates obtained from different AICRP centre in field trials. *Rhizobium* sp. (*Vigna*) strains isolated at Pantnagar namely UP-1, UP-6, UC-1, PUR-34 were found promising. Strain PUR-34 was released for commercial biofertilizer production in Punjab. The isolates BKR-1-04 and GUR-5 were also found promising at Pantnagar.

Phosphorus solubilisation potential of PSB

The P solubilisation ability of five P solubilising bacteria namely *Pseudomonas striata, Bacillus* sp.*, Bacillus megaterium, Bacillus cereus, and Bacillus stratosphericus* was compared qualitatively on Pikovaskaya and NBRIP medium and quantitative in Pikovaskaya broth medium containing 0.5% TCP. The solubilisation level of phosphorous varied with different isolates. The P solubilisation activity of different strains ranged from 42.6 to 76.7 µg/ml at 10 days. *Bacillus cereus* showed the highest P solubilisation among different strains**.**

Effect of PSB with *Bradyhizobium sp.* on nodulation and yield

Legumes crops require relatively more P than cereals because of its more requirements for BNF. In a study conducted for 3 consecutive years during *kharif* 2009 to 2011, combined inoculation of *Bradyrhizobium* with different PSBs increased the nodule number from 27.2 to 21.4 per cent and grain yield from 7.5 to 13.4 per cent over the uninoculated control in field trials. The increase in nodule dry weight and grain yield due to co-inoculation of different PSB ranged from 6.2 to 10.6 and 3.7 to 9.3 per cent over *Bradyrhizobium* alone, respectively.

Use of bioinoculants consortia

Application of different bioinoculants comprising different PGP traits is being advocated for obtaining benefits of cost effective and environment free sources of plant nutrients and improving BNF and productivity of pulse crops. A field study was conducted for 3

consecutive years during *kharif* 2012 to 2014 on use of *Rhizobium*, PSB, PGPR, Potassium Releasing Bacteria (KRB), VAM and *Methylobacterium* in urdbean. Use of *Rhizobium*+PSB+PGPR in urdbean showed increases in nodule dry weight of 32.6 per cent and grain yield of 18.6 per cent over the control. Additional use of Potassium Releasing Bacteria (KRB) and VAM along with biofertilizer package resulted increase of 40.2 per cent in nodule dry weight and 16.2 per cent in grain yield over biofertilizer package alone.

Development of consortia inoculant of *Rhizobium* and PGPR

Urdbean rhizobacteria PUK-171, PUK-315 and PUK-46B6 survived well with *Rhizobium* sp. (UP-1) in broth culture registering up to 10^{10} cells/ mL at 6 days (Table 8). It was also observed that *Rhizobium* (UP-1) and PGPR (PUK-46B6) survived almost similarly in Charcoal based mono and consortia inoculants. Consortia inoculants indicated slightly more population of *Rhizobium* than in its mono inoculant.

Evaluation of efficient *Rhizobium* strains

Bradyrhizobium sp. (*Vigna*) strains isolated at Pantnagar PMR-1, PMR-3 and PMR-2001 of mungbean were found promising for improving noudulation and grain yield across the locations. Mungbean *Rhizobium* sp. strains MOR-1, GGR-10, CRM-3 and MOR-12 isolated at other AICRP cenres were also found promising at Pantnagar.

Identification of efficient *Rhizobium* strains

Lentil *Rhizobium* isolates LB-4 and LR-35B-01 were found most promising in field trials. The other strains which were found promising includes LR-63-01, LLR-1 and DL-1.

Nutrient management for enhancing biofertilizer use efficiency

Field trials were conducted for three consecutive years during 2010-11 to 2012-13 with application of sulphur, boron and urea spray along with Biofertilizers (*Rhizobium*+PSB+PGPR). Application of biofertilizers package alone increased the nodulation, by 33.7 per cent, and grain yield, by 15.5 per cent (mean of three years) over the uninoculated control. Application of RDF+20 Kg S/ ha and RDF+20 Kg S/ ha + 2 % urea foliar spray along with biofertilizer gave 4.2 and 17.1 per cent more grain yield, respectively over the biofertilizer package.

Conjoint use of Potassium releasing bacteria and *Rhizobium* sp.

Seed inoculation of *Rhizobium* sp. (LR-35B-01) alone gave 13.8 per cent more nodule number and 3.7 per cent more grain yield over uninoculated control (average of 2012-13 to 2014-15). Application of Potassium Releasing Bacteria (KRB-1) was fund comparable with *Rhizobium* nodulation and grain yield. Combined use of KRB-1 with different *Rhizobium* strains resulted in 16.4 to 28.1 per cent increases in grain yield over *Rhizobium* alone and 11.4 to 22.6 per cent over KRB-1 alone.

2. Research Publications:

Pareek, R. P., Chandra, Ramesh and Pareek, N. 2001. Role of pulses BNF technology in sustainable agriculture. ISPRD, National Symposium on pulses for sustainable agriculture and nutritional security. Proceedings of National symposium held on 17-19, 2001 (eds. Ali, Masood; Chaturvedi, S. K. and Burha, S. N.), IIPR, Kanpur.

Prasad, H., Chandra, R., Pareek, R.P. and. Kumar, N. 2002. Synergism among phosphate solubilizing bacteria, Rhizobacteria and *Rhizobium* with urdbean. *Indian J. Pulses Res*., 15: 131-135.

Chandra, Ramesh and Pareek, Navneet 2003. Effect of inoculation of different strains of *Rhizobium leguminosarum* Bv. *Viciae* on nodulation and yield of Lentil genotypes. *Legume Res.* 26(4): 292-295.

Prasad, Harkeshwar and Chandra, R. 2003. Growth pattern of urdbean *Rhizobium* sp. with PSB and PGPR in consortia. *J. Indian Soc. Soil Sci*., 51:76:78.

Ravindar, Kumar and Chandra, R. 2005. Effect of adhesives on survival of inoculated *Rhizobium lguminosarum* on seed and symbiotic performance in lentil under field conditions. *Indian J. Pulses Res*., 18:206-210.

Chandra, Ramesh and Pareek, Navneet 2007. Comparative performance of liquid and carrier based inoculants in urdbean and mungbean. *Journal of Food Legumes* 20(1): 80:82.

Ravindar, Kumar and Chandra, R. 2008. Influence of PGPR and PSB on *Rhizobium leguminosarum* bv. *viciae* strain competition and symbiotic performance in lentil. *World Journal of Agricultural Sciences* 4 (3): 297-301.

Chandra, R. 2010. Development and evaluation of liquid biofertilzer for grain legumes. *Indian J. Agric. Chem.* 44:121-134.

Sahai, R., Chandra, R., Kumar, S. and Upadhyay, R.K. 2011. Influence of Rhizobactera on performance of urdbean (*Vigna mungo*)-*Rhizobium* symbiosis. Crop. Res. 42:92-93.

Karmakar, Rajib and Chandra, Ramesh. 2012. Effect of Soil type and Moisture content on Survival, Mobility, Nodule occupancy of inoculated *Rhizobium leguminosarum* bv. *viciae* and Lentil growth. *Intl. J. Agric., Env. Biotech.* 5 : 7-12.

Singh, Ajay Veer., Chandra, Ramesh and Goel, Reeta. 2012. Phosphate solubilization by Chryseobacterium sp. and their combined effect with N and P fertilizers on plant growth promotion, Archives of Agronomy and Soil Science, DOI:10.1080/03650340.2012.664767.

Kumar, Vijay., Garkoti, Ankita., Pareek, Navneet and Tripathi, H.S. 2014. Management of lentil rust using the strains of *Rhizobium* and Plant growth promoting rhizobacteria. *Pantnagar Journal of Research* 12(3): 382-385.

Kumar, Vijay., Garkoti, Ankita., Pareek, Navneet. and Tripathi, H.S. 2015. Management of lentil wilts through *Rhizobium* strains alone and Plant growth promoting rhizobacteria. *Pantnagar Journal of Research* 13(2): 162-165.

Upadhayay, Sandeep Prakash., Pareek, Navneet and Mishra, Gaurav 2015. Isolation and biochemical characterization of *Rhizobium* strains from nodules of lentil and pea in Tarai agro-ecosystem, Pantnagar, India. *Nusantara Bioscience* 7(2) 73-76.

Chandra, Ramesh and Pareek, Navneet 2015. Comparative performance of plant growth promoting Rhizobacteria with rhizobia on symbiosis and yields in Urdbean and Chickpea. *Journal of Food Legumes* 28(1): 86-89.

Rana, Monika., Raverkar, K.P., Pareek, N., Chandra, R. and Singh, D.K. 2015. Impact of biodynamic preparation and *panchgavya* in organically managed cropping system comprising legumes on soil biological health. *Legume Research* 38(2) 219-228.

Chandra, R. 2016. Effect of Rhizobacteria on

Rhizobium sp. strain competition for nodulation sites in urdbean. *Indian J. Plant and soil* 3(1): 31-34.

Raverkar, K. P., Pareek, N., Chandra, R., Chauhan, S., Zodape, S.T. and Ghosh, A. 2016. Impact of foliar application of seaweed saps on yield, nodulation and nutritional quality in green gram (*Vigna radiata* L.). *Legume Res.* 39(2): 315-318.

Singh, Pratap, V., Pareek, Navneet., Singh, S. P., Raverkar, K. P., Satyawati, Kavita., Bisht, Neema., Joshi, Neeshu., Kumar, A. and Kaushik, Shikhar 2017. Halosulfuron + metribuzin effect on weed control in sugarcane and their carry over effect on succeeding lentil. *Indian Journal of Weed Science*. 49(4): 364-369.

Yaseen, Mohd., Raverkar, K.P., Pareek, Navneet., Chandra, Ramesh., Zodape, S. T. and Ghosh, Arup 2017. Effect of foliar application of seaweed saps on chemical soil quality, growth and yield of black gram. *Journal of Hill Agriculture*. 8(3): 313-318.

Parveen, Hina., Singh, Ajay Veer., Khan, Amir., Prasad, Birendra and Pareek, Navneet 2018. Influence of plant growth promoting rhizobacteria on seed germination and seedling vigour of green gram. *International Journal of Chemical Studies* 6(4): 611-618.

3. Thesis Research:

Balyan. S. K. 1995. Rates and methods of *Rhizobium* inoculation in urdbean (Vigna mungo) to enhance biological N2 fixation. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Rautela, L.S. 1996. Studies on blackgram (Vigna mungo L.) Rhizobium strain evaluation and synergism for strain competition. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Prasad, Harkeshwar 2000. Effect of rhizobacteria on Rhizobium sp. inoculum efficiency in blackgram (Vigna mungo L.). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Kumar, Ravindar 2004. Effect of Rhizobacteria and adhesives on lentil *Rhizobium* symbiosis. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Sahay, Ratna 2005. Influence of Rhizobacteria on performance of urdbean- Rhizobium symbiosis. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Chauhan, Kavita 2011. Characterization and evaluation of PGPR strains for improving urdbean-*Rhizobium* symbiosis. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Rana, Monika 2014. Isolation and characterization of chickpea endophytic bacteria and their effect on nodulation, yield, nutrient uptake and soil properties in urdbean and chickpea. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Kumar, Sharad 2015. Interaction of different Phosphorus Solubilising Bacteria with *Bradyrhizobium* sp. (*Vigna*) in Urdbean on Nodulation, Yields and Soil properties. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

Kaphaliya, Rashmi 2017. Characterization and Evaluation of Lentil Rhizobial Isolates from N-

W Himalayas for Nodulation and Yield. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Navneet Pareek.

Neha 2017. Comparative performance of rhizobial isolates from diverse soils of Uttarakhand on nodulation, growth and yield of urdbean and soil properties. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Ramesh Chandra.

D. Pulse Pathology:

1. Significant Achievements:

Yellow Mosaic Virus (YMV)

Screening for resistance

***Mungbean*:** Some resistant donors identified are as follow ML-1464, IPM-306-6, ML-818, ML-1628, NDMK-10, ML-1666, PUSA-672, MH-2-15, ML-1907, IPM-02-14, KM-2293, GM-04-02, UNNATI, Co-6 , LGG-460, SML-1082, LGG-450, LGG-460, DGGV-05, LGG-450, ML-818 , ML-2037, TRCM2-2-1, KM-2328, IPM-02-03, TMV-45, IPM-02-14, IPM-410-03, IPM-2K-15-15, PUSA-1371, IGMKM-05-16-02, ML-2037, KM-2293, Co-6, MH-805, MH-721, DGG-5, IPM99-01-8, DGG-1, MG-2-15, KM-23-42, IPM-410-3, IPM-2K-15-4, VGG05-006, TRAM-1, PM-09-11, Pusa-1472, HUM-27, DGG-06, COGG-10-10, IPM-2-3, TMB-45, ML-2333, Pusa-1471, ML-2056, PM-4, Pusa-1371, IPM-2-14, NDMK-13-1, MH-934, IMP-5-17, PM-10-12

***Urdbean*:** Some resistant donors identified are as follow: NDU-12-300, PU-09-35, PU-09-36, VBG-10-024, IPU-10-23, Uttara, MH-07-06, NDU-11-202, IPU-2-43, KPU-1-10, KU-154, KU-96-7, TU-67, PU-1114, DKU-11, PU-09-37, Vamban-7, IPU-11-2,, MU-46, PU-10-16, NIRV-003, RUG-59, NDUK-15-9, VBG-12-062, RMG-353, IU-05-01, VBG-11-53, IPM-94-1, IPU-13-1,

Molecular diversity analysis among different isolates

- The sequences of the present investigation along with five other sequences showing maximum similarity to Pantnagar isolate were subjected to multiple alignment analysis in 'Clustal W' programme available online. The Phylogenic tree (Fig. 1) obtained revealed three distinct clusters. All MYMIV isolates collected from different hosts from Kumaon tarai region formed a single cluster along with French bean isolate of MYMIV from Palampur. Among these isolates, Soybean and Gomphrena isolate shown maximum similarity and Dolichos bean isolate singly formed a separate sub cluster. Cluster II having maximum similarity isolates from Pantnagar, had the isolates *viz.,* **M20844** (Mungbean, Pakistan) **AY26992** (Urdbean, Pakistan), **AM950268** (Mungbean, Faisalabad). Cluster III had all rest of the isolates of MYMIV from India *viz.*, **AJ416349** (Soybean, Jabalpur), **KC911720** (Urdbean, New Delhi), **KC911719** (Urdbean, New Delhi), **DQ389153** (Cow pea New Delhi), **EU523045** (Soybean, New Delhi).
- From the molecular studies it is concluded that, the virus causing yellow mosaic in tarai region of uttarakhand is predominantly MYMIV with maximum similarity with Palampur isolate. For the first time it has been reported through molecular studies that, the weed *Gomphrena sessilis is* one of the host MYMIV.

Disease Management modules

- **Module 1.** Seed treatment with phorate 10G @ 3g/kg seed, tolerant cv. Pant U-19 or Pant U-35, late sowing (post rainy) up to mid August and sowing during spring season.
- **Module 2.** Seed treatment with phorate 10G @ 3g/kg seed, tolerant cv. Pant M-4, Pant M-5, late

July or early August sowing and foliar spray of monocrotophos +endosulfan (0.1% each), 2 spray at 15 day intervals,

- **Module 3.** Seed treatment with phorate 10G @ 3g/kg seed, tolerant cv., Pant M-4, and Pant M-5 July or spring sowing and foliar spray of 0.1% methyl-o-demeton+0.1% endosulfan, 2 sprays at 15 days intervals.

Urdbean Leaf Crinkle Virus (ULCV)

- Plant extracts 0.1% viz., onion, neem garlic black pepper ginger, when used as seed dresser as well as spray reduced the ULCV incidence drastically and virex 0.3% and piper @ 750ppm was also effective.

Web Blight

- ***Mungbean*:** Some resistant donors identified are as follow PM-09, Co-06, LGG-460, SML-1082, PM-06,
- ***Urdbean*:** Some resistant donors identified are as follow LBG-752, VBG-10-024, NUL-7, Uttara, UH-08-05, UH-07-06, COBG-761, NDU-11-202, IPU-2-43, KPU-1-10, LBG-623, PU-10-23, PU-10-16, VBG-12-062, RMG-353,
- Seed treatment with carbendazim followed by three foliar sprays of carbendazim was found superior over all other treatments followed by propiconazole in respect of disease severity as well as increased grain yield.
- Foliar spray of 125 ppm concentration of silver nano particle showed lowest disease severity whereas at 75 ppm maximum grain yield was obtained.
- Seed treatments with a mixture of *Trichoderma (*T3) + *Pseudomonas fluorescens* (FLP28) showed lowest disease severity and increased grain yield.
- Three foliar sprays of eucalyptus extract was found effective in reducing the disease severity and increased grain yield.

Anthracnose

***Mungbean*:** The promising entries are as follows: LGG-460, BMU, Co-05, Selection-04, LGG-460,

***Urdbean*:** The promising entries are as follows: Uttara, IPU-2-43, Pant U-3, Co-5, LBG-623, DVGV-5, VLC-29, KU-96-7, MU-06, TU-67, PU-11-14.

- Five isolates of *Trichoderma harzianum* were screened in dual culture method, isolate Th12 was significantly inhibited the mycelial growth. However out of five strains of *P. fluorescens,* strain Pf 4 was found the best in inhibition of mycelial growth.
- In case of plant extracts, Neem extracts was found most effective at 15% concentration in reducing the fungal growth.

Cercospora leaf spot (CLS):

***Mungbean*:** The promising entries are as follows: LGG-460, IPM-306-6, K-851, DGGS-04, ML-818, AKM-8802, LGG-450, DGGV-2, DGG-5, DGG-3, ML-2333, IMP-5-17

Bacterial Leaf Spot (BLS):

***Mungbean*:** The promising entries are as follows: KM-2328, IPM-02-03, LGG-450, K-851(wbc), COGG-11-03, ML-2037, DGGV-2, DGG-5,COGG-912, Pant M-03, SML-10-82, KM-23-42, NVL-516, IGKM-05-26-30, DDG-3, IPM-410-3, TRAM-1,MH-810, HUM-27, LGG-460, IPM-2-3, ML-2333, PM-4, PM-10-12, AKM-4, AKM-8802, Pusa-0672

LENTIL

(Screening for resistance against Rust: The following entries were found resistant viz; LL1318,

PL160, DPL62, Pant L027, IPL332, PL175, PL157, IPL334, IPL222, IPL227, KLB14-12, IPL331, VL524, VL525, LL1375, IPL315, PL165, PL-192, LL1374, IPL406, IPL321, VL149, IPL225, LL1373, IPL533

Screening for resistance against Wilt disease: Lentil entries were evaluated under sick plot for Wilt root rot disease. The following lines were found promising viz; IPL-324, VL-521, L-4588, LL-1218, VL147, IPL-330, IPL526, IPL-215, IPL-331, IPL-332, KLB14-12, DPL-62, PL192, IPL576, LL 1136, LL 1197, LL1374, IPL229, PL 156, PL 168, JL 3, PL172,

Cultural study of *Fusarium oxysporum* f.sp. *lentis*

- All the 26 isolates were categorized on the basis of their cultural characteristics. There are four categories on the basis of mycelium color i.e. white (20), off white (4), peach (1), and cream (1) and five groups i.e. purple (11), peach (1), cream (1), pink (1) and without pigment (12) based on pigmentation. On the basis of growth pattern there are three groups i.e. cottony (11), fluffy (11) and appressed (4).

Management of wilt

All the fungicides tested, significantly suppresses the wilt incidence over check however, the seed treated with Iprodione + carbendazim (Quintal) was found the best treatment followed by carbendazim in reducing the wilt incidence and increasing grain yield.

Integrated disease management module:

- Early sowing (1st fortnight of November)
- Resistant cultivar
- Early maturing cultivars
- Seed treated with Iprodione + carbendazim (Quintal) @3g/kg seed

Screening of germplasm against powdery mildew: The following lines were found promising for powdery mildew: PP-172, PP-63, IPFD99-13, PP-184, IPFD-11-10, HFP-4, IPF-11-13, PP-177, HUDP-963, IPF-10-21, Pant P-197, Pant P-198, Pant P-199, Pant P 243, Pant P-217, Pant P-218, Pant P-266, HFP-554, HFP715, HFP-802, HFP-920, HFP-921, HFP-1125, HUDP 15, LFP-487, LFP-484, LFP-879.

Screening for resistance against pea rust: The evaluation of pea germplasm lines showed that HUDP 15 genotypes are highly resistant. Whereas, RFP 42, KPMR 851, Pant P244 and Pant P42 were moderately resistant reaction.

Management of pea rust

- Efficacy of 16 fungicides alone and in combination tested against pea rust disease of pea during both season revealed that all the fungicides are effective for the management of disease as compare to control. However, tebuconazole (alone), carbendazim + tebuconazole, mancozeb + tebuconazole, carbendazim + flusilazole, penflufen + trifloxystorbin are very effective against the disease.

Integrated disease management module:

- Use of resistant varieties
- Early sowing (1st fortnight of Nov.)
- Spray of elicitors
- Spray of fungicide (Tebuconazole)

2. Research Publications:

Sharma, J. and Tripathi, H.S. 2001. Biological and chemical control of web blight disease of urdbean. *Indian Phytopath,* 54 (2): 267-269.

Sharma, J. and Tripathi, H.S. 2001. Influence of environmental factors on web blight development in urdbean *(Vigna mungo* (L.) Hepper, *J.Mycol. & Plant Pathol*, 31 (1): 54-58.

Sharma, J. and Tripathi, H.S. 2001. Host range of *Rhizoctonia solani* Kuhn the causal agent of web blight of urd bean (*Vigna mungo* (L) hepper, *J.Mycol & Plant Pathol,* 31 (1): 81-82.

Mukherjee,S., Tripathi, H.S., and Rathi, Y.P.S. 2001. Integrated management of wilt complex of French bean (*Phaseolus vulgaris* L.) *J. Mycol and PlantPathol,* 31 (2): 213-215.

Singh, D. and Tripathi, H.S. *2001.* Integrated management of rust of field pea *(Pisum sativum L.) Indian Phytopath.* 54: 3-4.

Singh, D. and Tripathi, H.S. 2002. Evaluation of systemic and non systemic fungicides against rust of field pea (*Uromycis vicia fabae* (Pers.) de Bary under field conditions*.) Indian Phytopath.* 55(3): 380.

Sharma, J. and Tripathi, H.S. 2002. Studies on survival of *Rhizoctonia solani,* incitent of web blight of urdbean. *Indian Phytopath,* 55 (1): 90-91.

Joshi, D. and Tripathi, H.S. 2002. Perpetuation of *Colletotrichum capsici* in infected seeds and crop debris of urdbean.) *J. Mycol and Plant Pathol,* 32 (1): 28-30.

Joshi, D. and Tripathi, H.S. 2002. Cultural, biological and chemical control of anthracnose of urdbean. *J. Mycol and Plant Pathol,* 32 (1): 52-55.

Joshi, D. and Tripathi, H.S. 2002. Effect of Indofil M-45 in disease severity of anthracnose in urd bean. *J. Mycol and Plant Pathol,* 32 (1): 86-87.

Sharma, J. and Tripathi, H.S. 2002. *In vitro* response of urdbean isolate of *Rhizoctonia solan*i Kuhn. to different carbon and nitrogen sources. . *Indian J. Pulses Research,* 15 (2): 199-200.

Thirumalaiswamy, P.P., Rathi, Y.P.S. and Tripathi, H.S. 2003. Screening of some plant extracts inhibitory to urd bean leaf crinkle virus. *Indian Phytopath*, 56 (2): 233-235.

Shailbala and Tripathi, H.S. 2003. Fungicidal management of web blight of urd bean. *Indian Phytopath,* 57 (1:) 99-100.

Singh, D. and Tripathi, H.S. 2004. Evaluation of field pea germplasm for resistance to *Uromycis vicia fabae. J. Mycol and Plant Pathol,* 34 (2): 588-589.

Singh, D. and Tripathi, H.S. *2004*. Epidemiology and management of field pea rust. . *J. Mycol. and Plant Pathol,* 34 (2) 675-678.

Shailbala and Tripathi, H.S. 2004. Seed treatment with fungicides and bio control agents on urd bean pathogens. *J. Mycol. and Plant Pathol,* 34 (3): 851-852.

Shailbala and Tripathi, H.S. 2004. Effect of different fungicides *in vitro* and *in vivo* on the control of web blight of urdbean. *Indian* Phytopath. (Abs), 57 (3): 342.

Saxena, Purva and Tripathi, H.S. 2006. Fungicidal management of Cercospora leaf spot of mung bean *(Vigna radiata*) *Indian J. Mycol. & Plant Pathol* 37(2): 336-337.

Joshi, Arti and Tripathi, H.S. 2007. Studies on Epidemiology of Lentil Rust (*Uromyces viciae fabae)*(Pers.)de Bary (Abs*) J. Mycol. Pl. Pathol.* 37 (1): 167.

Joshi, Arti and Tripathi, H.S. 2007. Fungicidal Management of Lentil Rust (Abs) *J. Mycol. Pl. Pathol.* 37 (1): 168.

Joshi, Arti and Tripathi, H.S. 2007. Management of Lentil Rust Disease with Plant and Animal Products. *J. Mycol. Pl. Pathol*. 37(1): 167-168.

Tripathi, H. S. and Sorari, Rashmi 2007. Rust of Field Pea and its Management (Abs). *J. Mycol. Pl. Pathol.* 37(1): 167.

Sorari, Rashmi and Tripathi, H. S. 2007. Effect of weather factors on the severity of Rust of Field Pea.*J. Mycol. Pl. Pathol*. 37(1): 167.

Shailbala and Tripathi, H.S. 2007. Current status on research on Web blight disease of Urdbean -A Review. *Agric.Rev*., 28 (1): 1-9,

Shailbala and Tripathi, H.S. 2010. Biological and chemical Management of web blight disease of urdbean caused by *Rhizoctonia solani* kuhn. *Journal of Plant Disease Sciences:* 5 (1): 121-125.

Neelam, Kushwaha, K.P.S. and Upadhyay, Vinod 2014. Screening of Urdbean Germplasm for resistance against rhizoctonia solani Kuhn causing web blight disease. *International Journal of Agriculture, Environment & Biotechnology.* 7(2): 293-298.

Neelam, Kushwaha, K.P.S. and Upadhyay, Vinod 2014. Eco-friendly approach to manage web blight disease in urdbean [Vigna mungo (L.) Hepper] through botanicals. *International journal of Eco. Env. and Cons.*. 20: S485-489.

upadhyay, Vinod., Kushwaha, K.P.S. and Pandey, Puja 2015. Inspection of Different Localities in Uttarakhand and Uttar Pradesh for the Prevalence of Rust Disease of Pea (*Pisum sativum* L.). *Trends in Biosciences.* 8(16): 4336-4340.

Joshi, Himanshu., Kushwaha, K.P.S. and Neelam 2015. Efficacy of fungicides for the management of web blight of Mungbean [*Vigna radiate* (L.) Wilczek]. International *Journal of Basic and Applied Agricultural Research*. 13(3): 429-431.

Singh, Vaibhav and Kushwaha, K.P.S. 2015. Screening of Lentil Germplasm against *Fusarium* wilt. *Trends in Biosciences*. 8(23): 6491-6494.

Kushwaha, K.P.S. and Yadav, L.B. 2016. Management strategy of web blight of urdbean. *Journal of Hill Agriculture* 7(1): 159-161.

Neelam and Kushwaha, K.P.S. 2016. Studies on the inoculation Techniques and host range of *Rhizoctonia solani* Kuhn causing web blight in urdbean [*Vigna mungo* (L.) Hepper]. *Advances in Life Sciences* 5(11): 4524-4526.

Yadav, L.B. and Kushwaha, K.P.S. 2016. Efficacy of Seed Dressing Agents and Foliar Spray of Fungicides Against Web Blight of Mungbean [*Vigna radiate* (L.) Hepper]. *Advances in Life Sciences* 5(13): 5365-5367.

Srinivasaraghavan, A., Lingwal, Shrishti and Kushwaha, K.P.S. 2016. Field evaluation of urdbean germplasms against Mungbean Yellow Mosaic India virus in Northwestern Tarai region of India. *International Journal of Basic and Applied Agricultural Research*.14 (2): 203-207.

Pandey, Puja., Kushwha, K.P.S. and Upadhyay, Vinod 2017. Development of crop loss model using

liner regression and pea against downy Mildew. *Trends in biosciences* 10(41): 8671-8673.

Upadhyay, Vinod., Kushwha, K.P.S and Pandey, Puja 2017. Influence of weather paramenters on progress of rust scverity in pea (*Pisum sativum L.) Jouranl of Apllied Natural Science* 9(3): 1724-1728.

Upadhyay, Vinod., Kushwha, K.P.S. and Pandey, Puja 2017. Moleculat Screenig of Pea Germplasm for Rust Disease Resistance using SST Marker. *Journal Of Pure and Applied Microbilogy ,* 11(1): P 343-348.

Pandey, Puja., Kushwaha, K.P.S. and Upadhyay, Vinod 2017. Evaluation of Potential Fungecides and Bio Agents for the Management of Pea Downy Mildew and Yield under Field Condition *Int.J. Curr. Microbiol. App. Sci* 6 (12): 1381-1388.

Parihar, A.K, Basndrai, A.K., Sirari, A., Dinkaran, D., Singh, D., Kannan, K., Kushawaha, K.P.S., Adi Narayan, M., Akaram, M., Krishanaswamy, T., Latha, S., Paranidharan, V. and Gupta, S. 2017. Assessment of mungbeen genotypes for durable resistance to Yellow Mosaic Disease : Genotype x Environment interactions .*Plant Breeding*. 136: 94-100.

Upadhyay, Vinod., Kushwha, K.P.S. and Pandey, Puja 2018. Evaluation of Potential Fungecides for the Management of Pea rust under Field Condition. *International Journal of Chemical Studies*.6(2): 3085-3090.

Arya, Anshul and Kushwaha, K.P.S. 2018. Evaluation of Chemicals for the management of lentil wilt, carsed by *Fusauium oxysporum* f.sp.*lentis .Jouranl of Pharmacognosy and Phytochemistry* 7(5): 2320-2323.

Parihar, A.K., Basndrai, A.K., Kushawaha, K.P.S., Chandra, S., Singha, K.D., Bal, R.S., Saxena, D., Singh, D. and Gupta, S. 2018. Targeting test environment and rust-resistant genotypes in lentils (*Lens culinaris*) by using heritability- adjusted biplot analysis. *Crop and Pasture Science* 69: 1113-1125.

3. Thesis Research:

Thirumalaisamy, P.P. 2000. Physical and chemical properties of plant extracts inhibitory to urdbean leaf crinkle virus. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr.

Saxena, Purva 2002. Effect of some fungicides and/ or bio agents on seed micro flora, root rot and aerial blight of soybean (*Glycine max* (L.) Merr.) M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr.

Shailbala 2002. Studies on biological and chemical control of web blight disease of urdbean caused by *Rhizoctonia solani* Kuhn. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. H.S Tirpathi.

Ansari, Shadma 2003. Eco friendly management of vascular wilt of Lentil (*Lens culinaris* Medik.). Ph.D. Thesis submitted to GBPUAT under guidance of Dr. H.S. Tirpathi

Shukla, Vineeta 2003. Management of web blight of mung bean through bio control agents. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr.

Singh, Deepak 2003. Epidemiology and Management of rust of field pea (*Pisum sativum* L.) caused by *Uromyces viciae fabae* (Pers.) de Bary. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. H.S. Tirpathi.

Sorari, Rashmi 2004. Integrated management of rust of field pea (*Pisum sativum* L.) caused by *Uromyces viciae fabae* (Pers.) de Bary. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr.

Saxena, Nitin 2004. Evaluation of some botanicals, chemicals and bio control agents against web blight disease of mung bean caused by *Rhizoctonia solani* (Kuhn). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr.

Kumar, Vijay 2005. Chemical control of lentil rust caused by *Uromyces viciae fabae* (Pers.) de Bary. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. H.S Tirpathi.

Saxena, Purva 2005. Studies on Morphological, cultural characteristics and management of *cercospora* leaf spot of mungbean (*Vigna radiata* (L.)Wilcze. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. H.S. Tirpathi.

Joshi, Arti 2006. Epidemiology and management of lentil rust *(Uromyces viciae fabae* (Perse.) de Bary. Ph.D. Thesis submitted to GBPUAT under guidance of Dr.H.S. Tirpathi.

Kumar, Vijay 2006. Chemical control of lentil rust caused by *Uromyces viciae fabae* (Pers.) de Bary. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. H.S Tirpathi

Kumar, Pradeep B.A. 2007. Eco-friendly management of fusarial wilt of lentil caused by *Fusarium oxysporum f.sp. lentis*. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. H.S Tirpathi.

Kumar, Vijay 2009. Integrated management of major diseases of lentil. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. H.S. Tirpathi.

Joshi, Himanshu, 2010. Studies on web blight of mungbean [*vigna radiata* (L) wilczek]. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Dr.K.P.S Kushwaha.

Kumari, Snehlata 2010. Role of certain agronomic practices on major diseases of field pea (*Pisum sativum* L.). M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. H.S Tirpathi.

Singh, S. K. 2010. Biology, disease development and management of rust of fieldpea (*Pisum sativum* L.) caused by *Uromyces fabae* (Pers.) de Bary. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. H.S. Tirpathi.

Badoni, Shweta 2011. Epidemiology and management of rust of pea (*Pisum sativum* L.)caused by Uromyces fabae (Pers) de Bary. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. K.P.S Kushwaha.

Divakar 2012. Survival and management of anthracnose of mungbean [*Vigna radiata* (L.) Wilczek]. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. K.P.S Kushwaha.

Neelam 2014. Molecular diversity epidemiology, host plant resistance and management of mungbean yellow mosaic virus infecting mungbean and urdbean. Ph.D. Thesis submitted to GBPUAT under guidance of Dr. K.P.S. Kushwaha.

Upadhyay, Vinod 2015. Sustainable approaches for the management of rust disease in field pea (*Pisum sativum* L.). Ph.D. Thesis submitted to GBPUAT under guidance of Dr. K.P.S Kushwaha.

Singh, Vaibhav 2015. Biochemical Changes in Lentil due to *Fusarium oxysporum* f.sp. *lentis*, the Incitant of Wilt Disease and its Management". Ph.D. Thesis submitted to GBPUAT under guidance of Dr. K.P.S. Kushwaha.

Chauhan, Sadhna 2017. Etiology and management of web blight disease of mungbean, incited by *Rhizoctonia solani* Kühn. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. L.B Yadav.

Pandey, Puja 2017. Studies on Management of Peronospora pisi Syd. the Incitant of Downy Mildiew of Pea (Pisum sativum L.). Ph.D. Thesis submitted to GBPUAT under guidance of Dr. K.P.S Kushwaha.

Ramkrishna 2018. Etiology of *Rhizoctonia solani* Kühn causing web blight disease of Urdbean and its management M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. L.B Yadav.

E. Entomology:

1. Significant Achievements:

KHARIF URDBEAN

- Seventy species of insects belonging to 8 order and 44 families were observed on urdbean crop at Pantnagar. The major insect pests recorded in urdbean from seedling to maturity were *Melanoagromyza sojae*, *Empoasca* sp., *Bemisia tabaci* at early stage of the crop, Lepidopteran defoliators viz., *Thysanoplusia orichalcea, Spodoptera litura, Spilarctia obliqua* during vegetative stage, whereas, sucking bug, *Riptortis* sp.; flower beetle, *Mylabris* sp., *Megalurothrips sp.*, *Helicoverpa armigera* and *Etiella* sp. were observed at flowering and podding stage of the crop. The populations of *M. sojae, Empoasca* sp., *B. tabaci*, *Riptortis* sp., *H. armigera* were peaked during 41st standard week. Whereas, the populations of *Mylabris* sp., and *Etiella* sp., were recorded maximum during 39th Standard Week (SW). High mean ambient temperature and high relative humidity favoured insect pest population build up. The population of stem fly, jassid, whitefly, lepidopteran defoliators (*S. litura*, *S. obliqua* and *T. orichalcea*) had negative correlation with temperature, relative humidity and total rainfall. Populations of *Mylabris* sp. and *Etiella* sp. were positively correlated with temperature. Among the natural enemies, spiders and ants were abundant throughout the crop period but peak populations were observed during 40th and 41st SW. Parasitoids population was high during 38th to 40th SW.

Integrated Pest Management

- ***Biological control*:** The important parasitoids *Sympiesis dolicogaster, Chelonus pectinophorae*, C*otesia* sp., *Allophatnus fulvitergus, Tetrastichus* sp., *Eurotoma* sp., *Mutilla* sp., *Chalybion bengalensis* and *Cerceris tristis* and predators were *Acantholepis simplex, polistis* sp., *Vespa orientalis, Coccinella septempunctata*, *Menochilus sexmaculata*, *Cantheconida furcellata*, *Chrysopearla* and spiders were observed in urdbean crop. Temperature ranges of (31-32^{0}C) and relative humidity of (89-90%) were found favorable for buildup of parasitoid population.
- The spiders and ants were the most abundant natural enemies during 40th and 41st SW of the year.
- Seed treatment (ST) of biopesticides such as *Beauveria bassiana* @10g/kg, *B.*

bassiana+*Pseudomonas fluorescens* @5g+3g/Kg were effective in reducing grain damage and increasing the yield of crop.

- Combination of biopesticides such as *B. bassiana*@10g/kg seed treatment followed by *B .bassiana* spray @2g/l, *P. fluorescens* ST @10g/Kg seed + *B. bassiana* spray @2g/l, *B. bassiana*+ *P. fluorescens* @5g + 3g/kg were found effective in reducing pod damage and increasing yield of the crop.
- **Chemical control:** Seed treatment with dimethoate 30 EC@ 5 ml/kg seed, imidacloprid 600FS@ 3 ml/kg, monocrotophos @10ml/kg, *B. bassiana* @10g/Kg ST, imidacloprid 5ml/Kg and *P. fluorescens* 10g/Kg gave significant reduction in pod damage and increase in grain yield.
- The combination of seed treatment with foliar spray of insecticides such as NSKE 5%, and imidacloprid ST @ 5g/kg followed by foliar spray of profenophos @ 2 ml/lt gave significant reduction in crop damage and increase in grain yield.
- Spraying of insecticides thiamethoxam @0.3 g/l and acetamiprid@0.3 g/l were found effective against the sucking pests of urdbean.

IPM modules: Seed treatment with monocrotophos or imidacloprid or thaimethoxam followed by mechanical control and foliar spray of NSKE 5% in intercropping with sorghum gave considerable increase in grain yield.

SUMMER

Biology and Ecology

- The incidence of stem fly, whiteflies and jassids occurred at early stage of crop growth and reached their peak during 19th SW in summer, whereas, thrips occurred at flowering stage and bugs appeared during pod formation stage. The minimum temperature showed positive correlation with whiteflies, parasitoids and relative humidity with bugs, beetles and spider population on summer crop, whereas, positive correlation of relative humidity with bug population was found.

Effect of date of sowing on population of insect pests

- During the spring season thrips, stem fly, jassids and whitefly were found to be major insect pests of urdbean. Mid-March sown crop showed lowest mean pod damage (7.39%) as compared to other late sown crops with highest average yield.

Biological Control

- Seven species of hymenopteran parasitoids viz., *Chelonus pectinophorae, Cotesia* and *Tetrastichus* sp., *Echinomon* sp., *Xanthopimpla flavolineata, Temelucha philippinensis* and *Tetrastichus* sp. and *Eurotoma* sp. were recorded on urdbean crop.
- Among the natural enemies, spiders were most abundant throughout the crop period with peak population during 21st -22nd SW and parasitoids population was high during 19th-20thSW.
- Population density of parasitoids was found significantly positive correlated with minimum temperature and it was negatively correlated with relative humidity.
- **Chemical Control-** Seed treatment with monocrotophos @10ml/kg seed, followed by foliar

spray of monocrotophos @0.04%, oxydemeton methyl @0.04%, spinosad @45g a.i/ha, dimethoate @0.03%, profenophos @0.04%, imidacloprid @0.04%, lambda-cyhalothrin @0.04 %, acephate @0.04%, novaluron @60g.a.i./ha, flubendiamide @0.04%, proved highly effective in reducing the pest complex of urdbean during summer.

KHARIF

Biology and Ecology

- More than 60 insects were recorded from seedling to maturity stage of crop. Stem fly and galerucid beetle at seeding stage; whiteflies at vegetative stage; flower beetle, *Mylabris sp*., thrips *Megalurothrips sp.*, and sucking bugs *Riptortis* sp. and *Nezara* sp. at reproductive stage were the major constraints. *Maruca, Lampedes* and *H. armigera* were observed at flowering and podding stage of the crop. The populations of insect pests such as *M. sojae, Empoasca* sp., *B. tabaci*, *S. obliqua, Mylabris* sp., *Riptortis* sp. and *H. armigera* were peaked during 41st S.W. The populations of *M. sojae, Riptortis* sp., *Mylabris* sp., *Empoasca* sp., *B. tabaci*, *S. litura, H. armigera, S. obliqua* and *T. orichalcea,* were negatively correlated with temperature, relative humidity and total rainfall. Temperature was positively correlated with population of *Thysanoplusia orichalcea* and *Etiella* sp.

Integrated Pest Management

Biological control

- Spider and ants were the most abundant during 39th SW of the year in the mungbean crop.
- Application of biopesticides in seed treatments such as *B. bassiana* seed treatment @ 10g/ kg Seed, *P. fluorescens* @ 10 g/kg seed and other combinations of biopesticides such as *P. fluorescens* 10 g/kg seed+ *B. bassiana* spray @ 2g/lt and *B. bassiana*+*P. fluorescens* @ 5g + 3g/kg were effective in reducing grain damage and increasing the yield of mung bean crop.

Chemical control

- Seed treatment with dimethoate 30 EC @ 5 ml/kg seed, imidacloprid 600 FS @3 ml/kg, and imidacloprid 600 FS @ 5g/kg seed gave significant reduction in pod damage and increase in grain yield.
- Combination of seed treatment with foliar spray of other insecticides viz., NSKE 5%, imidacloprid ST @ 5g/ kg seed+profenophos spray @ 2 ml/lt, *P. fluorescens* 10 g/kg seed+profenophos spray @ 2ml/lt, 1lt/ha *B. bassiana* ST @ 10g/ kg seed+profenophos spray @ 2ml/lt, 1lt/ha gave higher grain yield and lower pod damage.
- Spraying of insecticides thiamethoxam 25WG@ 0.3 g/lt and acetamiprid20SP@ 0.3 g/lt were found effective against the insect pests of mungbean.

SPRING/ SUMMER MUNGBEAN

Biology and Ecology:

- During the spring season thrips, stem fly, Jassids and whitefly were found to be major insect pests of mungbean. Mid-march sown crop showed lowest pod damage as compared to other late sown crops with highest yield.

Integrated Pest Management

- Seed treatment with imidacloprid 600FS and thiamethoxam25WG followed by foliar application of thiamethoxam/ acetamiprid/ indoxacarb/ clothionidin at flowering and

podding stages of crop.

- Seed treatments with biopesticides *Beauveria bassiana* @ 10g/kg seed, *P. fluorescens* @ 10 g/kg seed and other combinations of biopesticides such as *P. fluorescens* 10 g/kg seed + *B. bassiana* spray@2g/lt and *B. bassiana*+ *P. fluorescens* @5g + 3g/kg were effective in Mungbean.

IPM Module for sucking pests Mungbean & Urdbean

1. Seed treatment with imidacloprid 600FS@ 5ml/kg+*Trichoderma* 4g/kg;

2. NSKE 5% or neem based formulation 30-40 DAS;

3. Novaluron @ 1 ml/lit (45-50 days after sowing);

4. Yellow sticking traps @ 100/ha

Chemical control

Seed treatment with monocrotophos @ 10ml/kg seed, followed by foliar spray of monocrotophos @ 0.04%, methyldemeton @ 0.04%, dimethoate @ 0.03%, profenophos @ 0.04%, spinosad @ 45ga.i/ha, imidacloprid @ 0.04%, lambda cyhalothrin @ 0.04 %, acephate @ 0.04% , novaluron @ 60ga.i./ha, flubendiamide @ 0.04% and thiamethoxam 0.4g/l followed by indoxacarb 14.8 SC proved highly effective in reducing the pest complex of urdbean.

Biology and Ecology

The major insect pests included stem fly, *Melanagromyza phaseoli*, pea leaf miner, *Chromatomyia horticola*, aphids, *Acyrthosiphon pisum* and *Aphis craccivora*, thrips, semiloopers, *Plusia orichalcea* and *P. eriosoma*, pod borers viz., blue butterfly, *Lampedes boeticus* and *Euchrysops cnejus* and *Helicoverpa armigera*. Stem fly damage in early sown crop whereas, pea leaf miner and pod borers in late sown crop were the major constraint. Maximum stem fly damage was recorded at 6 weeks after germination and thrips, leaf miner and pod borers damage at flowering and podding stage of the crop. Stem fly and pea leaf miner damage ranged from 16 to 30 and 20 to 60 per cent, respectively.

Integrated Pest Management

Insect Pest Monitoring and relation with weather parameters

Leafminer (*Chromatomyia horticola*) marked its peak appearance in 3rd SW. A correlation between different weather parameters and population of leaf miner revealed that there is positive correlation between parasitoid and humidity, rainfall and wind velocity. Whereas, negative correlated with temperature and sunshine hrs.

Overall mean parasitisation of *Chromatomyia horticola* pea leaf miner was recorded maximum in 9th SW (56.59%) followed by 10th SW (44.93%) and minimum during 1st SW (13.06 %).

IPM Module for fieldpea insect pests

- Intercropping with mustard (6:2 ratio) with seed treatment with imidacloprid 600 FS (3 ml/kg seed)+carbendazim @ 3g/kg+ *rhizobium* treatment followed by spray of NSKE 5% at 40 DAS and need based spray of indoxacarb15.8EC @ 50 g. a.i./ha at flowering stage.

Seed treatment with thiomethoxam 25WG proved highly effective in control of stem fly damage.

2. Research Publications:

Mahendran, B. and Agnihotri, Meena 2013. Natural parasitism of agromyzid leafminr, *Chromatomyia horticola* (Goureau) (Diptera: Agromyzidae) on field pea. *African Journal of Agricultural Research*.18 (13): 1174-1179.

Yadav, Sunil K., Agnihotri, Meena and Bisht, R. S. 2015. Seasonal incidence of insect-pest of blackgram, *Vigna mungo* (Linn.) and its correlation with abiotic factors. Agric. Sci. Digest., 35(2):146-148.(3.88)

Yadav, Sunil K., Agnihotri, Meena and Bisht, R. S. 2015. Efficacy of Insecticide and Bio-pesticide against defoliators and spotted pod borer, *Maruca vitrata* in Black gram. *Annals of Plant Protection Science*. 23(1): 65-68.

Yadav, Sunil K., Patel, Sweta., Agnihotri, Meena and Bisht, R. S. 2015. Efficacy of Insecticide and Bio-pesticide against sucking pest in Black gram. *Annals of Plant Protection Science*. 23(2): 223-226.

Yadav, S.K., Agnihotri, Meena and Bisht, R. S. 2016. Efficacy of insecticides against pea leaf miner *Chromatomyia horticola* (Goweau) and its parasitoids. *Indian Journal of Entomology*, 78(4): 373 391.

Lalbabu, K., Snehel, C., Agnihotri, Meena and. Karnatak. A.K 2017. Field efficacy of certain insecticides against pod borer, Helicoverpa armigera (Hübner) infesting blackgram. *Journal of Experimental Zoology*, India 20 (2), 773-777.

Kumar, L., Chakravarty, S., Agnihotri, Meena and Karnatak, A.K. 2017. Efficacy of some plant oils against pulse beetle, *Callosobruchus chinensis* (L.) infesting greengram under storage conditions. *Research on Crops* 18 (1), 157-163.

3. Thesis Research:

Tiwari, Himani. 2014. Seasonal incidence and management of Insect –Pest of Vigna Group and Field Pea. M.Sc. Ag. Thesis submitted to GBPUAT under guidance of Dr. Meena Agnihotri.