वार्षिक प्रतिवेदन
Annual Report
2019




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भाकृअनुप-भारतीय दलहन अनुसंधान संस्थान कानपुर 208 024
ICAR-Indian Institute of Pulses Research Kanpur 208 024

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From the Director's Desk

It gives me immense pleasure to present the Annual Report for the year 2019 of ICAR-Indian Institute of Pulses Research, Kanpur. I feel it is a privilege to lead a glorious Institute like ICAR-IIPR which has made outstanding contributions in the service of the nation in agriculture sector and has set global standards in making pulses accessible and affordable. Despite many impediments and challenges towards scaling up pulses production, our country has created a history by record production of pulses to the tune of about 24 million tonnes. The present Annual Report of the Institute highlights the significant achievements made under different research/extension and training programmes.

During the period, under Crop Improvement Programme, four new chickpea varieties were released for UP (Central or Bundelkhand zone) suitable for timely and late sown conditions. Chickpea germplasm accessions T39-1, ICC 5912 and ICC 8397 were identified as the stable high protein (~28%) donors. First pigeonpea hybrid IPH 15-03 was notified for cultivation in the North Western Plain Zone (NWPZ) with an yield superiority of 28.30% over Pusa 992 (National check), Micro RNA triggering CMS in pigeonpea has been mapped and structure predicted. Lentil variety IPL 225 and IPL 329 were released while, two small seeded lentil varieties, IPLS 231 and IPLS 232 and one large seeded lentil variety IPLB 338 have been identified for release in Uttar Pradesh. A highly resistant to MYMV disease, anthracnose and moderately resistant to *Cercospora* leaf spot, mungbean variety IPM 512-1 (Soorya) has been identified for cultivation in NEPZ for spring season. Two other mungbean varieties, IPM 409-4 (Heera) and IPM 312-20 (Vasudha) were recommended for release in UP. Urdbean varieties, resistant to MYMV, IPU 13-1 (with high protein content of 26.12%) and IPU 11-02 have been released in UP State for *Kharif* cultivation. In addition, three other urdbean varieties were released in Madhya Pradesh with significant yield superiority over check. Fieldpea variety IPF 16-13 (*Kharif*) has been released and notified for NEPZ with yield of 1752 kg/ha. Two fieldpea varieties, IPFD 12-8 (*Aakash*) and IPFD 13-2 (*Anant*) have also been released in Uttar Pradesh State with 15% and 24% yield superiority over the best check, KPMR 522, respectively. Fieldpea genetic stock, P-637 (INGR19075), has been registered with ICAR-NBPGR, New Delhi for tolerance to post emergence herbicide metribuzin. Fieldpea genotypes, DMR-7, IPF 6-16, IPF 12-17 and IPF 11-15 were identified to be stable and yielding lines under heat stress. During spring season-2019, a set of cowpea genotypes was rejuvenated in Kanpur and Dharwad and evaluated for different morphological traits. Fifteen new crosses were developed in cowpea. More than 1800 *rajmash* germplasm accessions were procured and maintained at IIPR, Kanpur and trait specific donors identified. Nineteen fresh crosses were generated. *Rajmash* accessions IC 337275, EC 931228, IC 340947, EC 25517, EC 931216, EC 931275, IC 43572 were identified resistant against anthracnose disease.

QTLs mapped Strides were also made in biotechnology chickpea for traits- number of pods per plant (PN), % pod set (PPS), seed per plant (SPP) and yield per plant (YPP). Markers assisted backcrossed breeding (MABC) line, IPC L4-14, performed well under drought conditions and is being been promoted to AVT 2. Integrated molecular marker map of chickpea genome was established using 170 recombinant inbred lines from cross between a cultivar resistant to *Fusarium* wilt IPC 2004-52 and susceptible genotype K 850. A total of 6177 SNPs markers were mapped onto the eight different linkage groups (CaLG01- CaLG08). Marker-free, pod specific *cryIAc* and cry2Aa gene constructs (pCambia 0390-msg-*cryIAc* and pCambia 0390-msg-*cry2Aa*) have been transformed into *Agrobacterium tumefaciens* strain LBA 4404.Molecular cloning and development of bacterial expression vector carrying the *Cice arietin* multi-stress responsive WRKY transcription factor (pET-28a-*CaMSR*-WRKY) coding sequence has been achieved. Complete *in vitro* multiple shoot induction in grasspea cv. Pusa 24 and Mahateora was achieved with embryonic axis as explants. Bioinformatics analysis revealed Grasspea ODAP synthase gene to appear intron less. Cotyledon with embryonic axis of mungbean used as choice explant for *Agrobacterium* mediated genetic transformation using *nptII* as candidate gene revealed encouraging results in effort to establish a genotype independent genetic transformation system. Crossing and sib mating were attempted employing transgenic chickpea (IPCa2) and pigeonpea line (IPCc1), the lines were sown in transgenic containment facility.

In Crop Production, intensive cropping system *viz*., rice/maize/*bajra*-wheat-mungbean (RWMb) was found advantageous over other similar prevalent systems in terms of grain yield, system productivity and economics as revealed from a 14-year crop rotation experiment. In urdbean, recommended dose of fertilizers (RDF) + *Rhizobium* + PSB (liquid based inoculation) had higher harvest biomass production, pods/plant, test weight, grain yield, enzymatic activities and nutrient uptake. Pearl millet was observed to perform better under organic farming comparaed to that of inorganic farming. Higher sorghum grain yield was obtained with zero tillage under conservation agriculture in a sorghum-fieldpea rotation. Improvement in chickpea grain yield was apparent following application of salicylic acid at 100 ppm (SA100) followed by urea (2%)/ NPK (19:19:19) where it was at 0.5% applied at both flower initiation and pod development stages. In rice-lentil relay system, transplanted puddled rice (PTR) had an advantage over non-puddled transplanted rice (NTR) as lentil performed better in the former system (due to higher germination) following surface seeding in a sandy-loam soil of Kanpur. Under long-term conservation agriculture (CA), higher yield of rice (12%) could be realized through zero tillage compared to conventional tillage. Zero tillage combined with residue retention benefitted rice and chickpea as significant reductions were observed in weed growth in terms of population and dry weight also.

Conservation agriculture consisting of conservation tillage and residue (+R) management under diversified pulse based cropping systems showed significantly higher system productivity (82%) in rice-wheat-mungbean over conventional practices (conventional tillage without residue retention in rice-wheat system). The herbicide combination, Clodinafop-propargyl + Na-acifluorfen 122.5 g a.i./ha was selective to mungbean (as it was effective for broad-spectrum weed control and gave higher grain yield). Application of broad-spectrum herbicide *viz*., topramezone 20.6 ml a.i./ha in chickpea had minimum weed growth with higher grain yield.

In disease and pest management studies, 13 pigeonpea entries were identified as resistant against Phytophthora stem blight. Promising pigeonpea lines *i.e.* DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-11, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16 and IPA-38, IPA 16F, and IPA 15F) showed resistant reaction against wilt. Volatile metabolites from potential *Trichoderma* strain *i.e.,* IIPRTh-31, *IIPRTh-4 and IIPR Tlongi-31 were characterized*. Eleven lines of rajmash showed resistant reaction against BCMV. Four pathotypes (I, II, III, IV) were identified across the country based on evaluation of standard international chickpea differentials against *Ascochyta rabiei* isolates. Pathotype III was observed at maximum locations followed by pathotype I, IV and II. It was observed that the Population of whiteflies shoots up from mid-August to September after which the population started declining. Whitefly, (*Bemisia tabaci*) population, collected from greengram crop at IIPR campus, showed close resemblance with Asia II 1 genetic group. This was confirmed through phylogenetic analysis with all the available sequences (mtCOI) of 44 different genetic groups. The plant essential oils of *Ocimum* sp., *Curcuma* sp., *Mentha* sp., *Citrus* sp., *Eucalyptus* sp. and *Cymbopogon* sp. exhibited contact toxicity against pulse beetle, *Callosobruchus analis* (F.) infesting stored pulses. The crude extract from 48 actinobacteria strains demonstrated 20-100% larval mortality of *Spodoptera litura*. Actinobacteria strains AIN 29 (*Streptomyces badius* IIPR:KR04:01) and AIN 67 (*Streptomyces* sp. IIPR:SB01:04) have showed more than 80% larval mortality. Infestation of bruchids (*Callosobruchus analis* and *C. maculatus*) was observed on cowpea pods on standing crop at field level.

Four genotypes of mungbean (AVNU1604, AVNU1606, 29/2F9 (m×u)101-102 and 29/3F9(m×u)101-102) were found moderately resistant to bruchid. Six pigeonpea genotypes RVSA 16-1, IPA 206, PUSA 151, PUSA 163, WRGE 93 and PA 291 were moderately resistant against *Meloidogyne javanica.* Seven lines of mungbean namely, COGG 912, IPM 512-1, KM 2241, KM 2355, MH 2-15, PKV AKM 4 and SKNM 1504 were moderately resistant to *M. javanica*. Two lines of urdbean PU 14-19 and KUG 791 showed moderately resistant reaction against *M. javanica*. Two year non host cropping sequence resulted in 65.3% increase in grain yield over susceptible cropping sequence. GSL-2, Neelam varieties of *Brassica napus* and Karan Tara of *Eruca sativa* were found to reduce maximum nematode population when the plant shoot were incorporated in soil and covered with polyethylene for 15 days.

On the Basic Sciences front, chickpea genotypes such as Vijay, ICC 5912, C 214, Pusa 1053, ICCV 10, Tyson, BDG 75 and GNG 663 showed higher chlorophyll index under limited soil moisture. The increased anthocyanin content under rainfed condition was found in ICC 1205, ICC 8950,ICC 4958, Annegiri,PDG 4,Vaibhav, Katila, Pusa 312, PG 96006, BDG 75 *etc*. Four isozymes of SOD were present in the heat tolerant chickpea genotypes whereas, only three isozymes were present in the heat susceptible genotypes. Pigeonpea genotypes such as, NDA 2, MAL 13, ICP 2275, IPACT 2 retained 60-80% flowers/pods under low temperature which were considered as tolerant to cold stress. Five photo-thermo insensitive blackgram genotypes *e.g.* PU 19, IPU 99-79, IPU 99-213, PLU 65, PGRU 95016 were identified at Kanpur under staggered planting. It was observed that the vegetable type fieldpea varieties Arkel and Azad P3, and cowpea have starch composed mostly of amylose. Because of this high amylose concentration, legume starches have been found to exhibit a lower glycemic index (GI) than cereal starches. A total of 50 rhizobial strains isolated from different rajmash genotypes were evaluated for their nodulation potential under pot experiment. Nodule number varied from 1 to 7 per plant. Nodule specific weight varied from 0.002-0.005 g/nodule.

Microbial consortia developed at IIPR for mitigating moisture deficit stress are being evaluated under multilocation trials (MLT) which showed 16-20%r yield over control across the locations. Sixty seven putative nodule-specific cysteine rich (NCR) peptides including 30 unique sequences of *Cicer arietinum* were identified using three different strategies and were characterized. Similarly, 44 putative NCR peptides were identified in *reticulatum* genome. Fieldpea *Rhizobium* PR-3 and mungbean *Rhizobium* IIPR-MR-127 were identified as promising strains for commercialization. The nanostructured granular formulations using nanoparticles embedded with herbicide imazethypar at different concentrations *viz*., 150, and 250 g/h were found effective in reducing weed population and their biomass and density by 30-80% besides lowering in dry matter of the weeds by 30-80% in different treatments.

Through outreach programmes of the Institute, total 94 farmers and 19.88 ha area have been covered under different interventions including improved varieties and technologies of paddy, mango, guava, fish, mustard, chickpea and wheat under Farmer FIRST project. 14 farmers and 3.00 ha area was covered for demonstration of improved variety of paddy (Pusa Basmati-1) as a critical input 38 farmers were provided with wilt resistant variety of chickpea (*Desi* and *Kabuli*). 10 farmers provided zinc rich variety of wheat for demonstration in project area. The feasibility and acceptability of poultry and goat enterprises was assessed among small and marginal rural youth and women farmers. Mobile app services for farmers and web console services for experts were designed and developed on mKRISHI platform. Multilingual PulsExpert Mobile Service for insect-pests symptoms and control measures has been developed for major pulse crops. Nine training programmes, were organized for different stakeholders from MANAGE, Hyderabad, Jharkhand, Bihar, Madhya Pradesh. MGMG and SCSP programme were implemented in Kanpur Dehat, Kanpur Nagar, Fatehpur, Kannauj, Unnao, and Hamirpur districts of UP. Under FLD programme, 40 demonstrations were conducted on pigeonpea, mungbean, cowpea, chickpea, fieldpea and lentil in different districts of Uttar Pradesh to increase the pulse production.

At Dharwad, 700 kg breeder seed of mungbean (IPM 2-14) and urdbean (IPU 2-43) was produced during *kharif*. In intercropping of maize + cowpea (1:1) the grain yield of maize was 66 q/ha (q/ha) and in maize- chickpea, the yield was 63.90 q/ha.Four entries of horsegram *viz*., HG 2, HG 10, HG 18 and HG 26 showed tolerant reaction to powdery mildew. Emaravirus associated with Pigeonpea Sterility Mosaic Disease was characterized using a set of 11 differential cultivars. In cowpea, foliar application of chlorantraniliprole 18.5 SC @ 0.4 ml/L was found effective and gave 70% reduction in pod damage over untreated control. Three cowpea accessions/lines, *viz*., IC 249141, EC 394779 and NBC 24 recorded 0 -10 % pod damage while IC-249141 showed zero pod damage.

The overall growth and development of the Institute was possible with the able guidance, encouragement and continuous support received from Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR; Dr A.K. Singh, Deputy Director General (Crop Science & Horticulture) and Dr S.K. Jha, ADG (O&P), ICAR, which I acknowledge with sincere gratitude and reverence.

I appreciate the efforts of all Project Coordinators, Drs. G.P. Dixit, Sanjeev Gupta, I.P. Singh,, Shiv Sewak, and all the Heads of Divisions, Drs. Farindra Singh , Meenal Rathore, C.S. Praharaj, Bansa Singh, P.S. Basu, and Rajesh Kumar for research inputs. I am thankful to the members of Publication Committee, Drs. P.S. Basu, Aditya Pratap, Mohd. Akram, (Mrs.) Meenal Rathore and Dr Rajesh Kumar Srivastava (Member Secretary) for their praiseworthy efforts in bringing out the Report in time as usual. Last but not the least, I am thankful to all staff and their families who are supporting and contributing to the progress of the Institute in the service of the nation.

(N.P. Singh)
Director

Contents

Executive Summary

Crop Improvement

- *Desi* chickpea variety IPC 2006-77 was released and notified for cultivation under late sown conditions in Central Zone of India comprising Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Southern parts of Rajasthan and Bundelkhand tracts of Uttar Pradesh.
- Two varieties of *desi* chickpea namely IPC 2004-98 and IPC 2005-62 have been released and notified for cultivation under timely and late sown condition, respectively in Uttar Pradesh.
- One *desi* chickpea namely IPC 2011-112 (*Keshav*) has been released by UP State Varietal Release Committee and also recommended for notification by Central Varietal Release Committee (CVRC).
- Four chickpea varieties including three *desi* varieties, namely IPC 2010-62, IPC 2010-134, IPC 2010-142 and one *kabuli* type, IPCK 2011-179 were identified for release in Uttar Pradesh.
- *Desi* chickpea entry IPC 2015-116 and two *kabuli* entries namely, IPCK 2013-163 and IPCK 2011-37 were found promising in AICRP trials and promoted to advanced varietal trials in different zones (NWPZ, WCZ and SZ) for cultivation under timely sown condition.
- Fifteen entries namely, IPC 2016-107, IPC 2015-12, IPCD 2016-44 (Timely Sown); IPC 2012-31, IPC 2015-123, IPCB 2015-165 (Late Sown); IPC 2015-116, IPC 2015-267, IPCB 2016-222 (Rainfed); IPC 2014-10, IPC 2015-17, IPCB 2015-133 (Mechanical Harvesting); IPCK14-98, IPCK 2016-12, IPCKB 2016-149 (*Kabuli*) are being evaluated in IVTs under AICRP (Chickpea) during *Rabi* 2019-20.
- One hundred four fresh crosses of chickpea were developed during *Rabi* 2018-19 at ICAR-IIPR, Kanpur and *Kharif* 2019 at ICAR-IIPR-RRC Dharwad to generate breeding material of chickpea for grain yield, plant idotypes, earliness, nutritional quality, abiotic stresses (drought, heat) and biotic stresses (wilt, DRR) and their suitability for the cultivation under different ecologies of India. Five 3-way crosses and two double crosses were also developed.
- Five hundred and fifty germplasm accessions of chickpea were evaluated, rejuvenated and maintained. Additional 113 wild germplasm accessions of chickpea belonging to six *Cicer* species were maintained in the wide hybridization garden at ICAR-IIPR, which included 42 *Cicer reticulatum*, 32 *Cicer judaicum*, 27 *Cicer pinnatifidum*, 6 *Cicer echinospermum*, 3 *Cicer cuneatum*, 2 *Cicer yamashitae*, and 1 *Cicer bijugum* accession.
- Nineteen mapping populations of chickpea including 7 segregating for response to heat and drought, 3 for flowering behaviour, 3 for response to *Fusarium* wilt, 2 for dry root rot resistance and 4 segregating for nutritional quality have been advanced to next generation.
- Chickpea germplasm accessions T 39-1, ICC 5912 and ICC 8397 were identified as the stable high protein (~28%) donors.
- First pigeonpea hybrid IPH 15-03 was notified for cultivation in the North Western Plain Zone (NWPZ). Yield of IPH 15-03 is 1595.6 kg/ha, with an yield superiority of 28.30% over Pusa 992 (National check), 30. 2% over ICPL 88039 (Local check) and 55.2% over PAU 881 (Zonal check). Potential yield of IPH 15-03 is 2,426 kg/ha. The hybrid matures in 153 days.
- Pigeonpea genotype IPAV 16-1 has been identified as donor for vegetable and grain purpose and registration proposal has been sent to ICAR-NBPGR, New Delhi.
- One hundred thirty one pigeonpea genotypes which comprising of several vegetable and cleistogamous types were identified as resistant for *Phytophthora* stem blight resistance.
- A set of 21 wild accessions of *Cajanus albicans*, *C. lineatus*, *C. sericeus*, *C. platycarpus*, *C. scarabaeoides*, *Rhynchosia rufescens*, *R. bracteata* were raised in net house for crossing and rejuvenation. Seven hundred and fifty six cultivated germplasm were also rejuvenated.
- Seven wild species of *Cajanus*, namely, *Cajanus scarabaeoides* (23 accessions), *C. platycarpus* (9), *C. cajanifolius* (4), *C. lineatus* (1), *C. crassus* (8), *C. sericeus* (1), *C. albicans* (7) and four *Rhynchosia species*, namely, *Rhynchosia minima* (1), *R. bracteata* (1), *R. suaveolens* (1), *R. rufescens* (1) have been maintained in wild garden.
- Micro RNA triggering CMS in pigenpea has been mapped and structure predicted.
- Lentil variety IPL 225 was released for UP State for timely sown conditions which had 8.86% yield superiority over the check variety KLS 218.

It has average yield 1032 kg/ha and matures 124 days.

- Lentil variety IPL 329 was released for UP state for timely sown conditions with yield superiority of 9.03% over the check variety DPL 62. It has average yield 1012 kg/ha and matures in 124 days.
- Thirteen lentil entries were evaluated in AICRP trials during 2018-19. IPL 237 having average yield 1189 kg/ha and 7.6% yield superiority over the best check VL 126 has been promoted to AVT -1 for NHZ.
- Two small seeded lentil varieties, IPLS 231 and IPLS 232 and one large seeded lentil variety, IPLB 338 have been identified for release in Uttar Pradesh.
- Two station trials with 15 entries each were evaluated for their yield performance.
- Twenty eight crosses were developed in lentil. Twenty nine F_1, 8 F_2 , 22 F_3, 44 F_4 and 16 F_5 segregating populations were advanced.
- Out of four hundred and fifty of active germplasm of lentil, a diverse set of 94 accessions and 225 accessions of wild species are grown for maintenance. >800 accessions are being grown for evaluation at RRS Bhopal.
- Mungbean variety IPM 512-1 (Soorya) has been identified for cultivation in the North East Plain Zone during spring season. It has yield advantage of 15.83% over Pusa Vishal and 13.57% over Pant Mung 5. This variety is highly resistant to Mungbean Yellow Mosaic disease, anthracnose and moderately resistant to *Cercospora* leaf spot. Very less pod damage due to thrips has been observed in this variety.
- Mungbean varieties IPM 409-4 (Heera) and IPM 312-20 (Vasudha) were recommended for release in Uttar Pradesh.
- Fourteen mungbean entries were evaluated in AICRP during 2019. Entry IPM 101-102 was promoted to AVT I in NEPZ during Spring season. IPM 610-2 was promoted to AVT 1 in central zone for cultivation during Summer season.
- Two station trials of mungbean were conducted during summer 2019.
- Two hundred and eighteen accessions were maintained in the mungbean wild garden, compritsing, *Vigna radiata* (7), *V. radiata var. radiata* (8), *V. trilobata* (100), *Vigna mungo* (10), *V. umbellata* (17), *V. sublobata* (5), *V. aconitifolia* (8), *V. sylvestris* (7), *V. stipulaceae* (31), *V. radiata var. setulosa* (2), *V. hainiana* (4), *V. trinernia* var. *bournei* (3), *V. glabrescens* (1), *V. pilosa* (3), *V. trinernia* (1), *V. dalzelliana* (3), *V. unguiculata* (3), *V. vexillata* (2), *V. khandalensis* (1).
- Five mungbean accessions *viz.,* VI004957AG, VI004934AG, VI004973B-BLM, VI004937AG and VI002190BG were found highly resistant to yellow mosaic virus based on multi-season and multi-location data.
- Urdbean varieties IPU 13-1 (with high protein content of 26.12%) and IPU 11-02 have been released in UP State for *Kharif* cultivation. Both varieties mature in 72 days and have a potential yield of 10-12 q/ha. The varieties are resistant to most of prevalent diseases like MYMV, ULCV, powdery mildew, anthracnose, and *Cercospora* leaf spot.
- Three urdbean varieties IPU 10-26 (10-12 q/ha, 72 days maturity, high protein content of 25.27%), IPU 13-1 (7.20 q/ha, 72 days maturity) and IPU 11-02 (6.96 q/ha., 71 days maturity) have been released in Madhya Pradesh State with significant yield superiority over check. These varieties are resistant to Mungbean Yellow Mosiac Virus and *Cercospora* Leaf Spots and resistant to Urdbean Leaf Crinkle Virus, Stem Necrosis, Web Blight, Bacterial Leaf Blight, Anthracnose and Powdery Mildew and also resistant to white fly and jassids insects under field conditions.
- Analysis of F_2 phenotypic data in urdbean, reveals that shiny testa trait was dominant over Dull testa trait. MYMIV resistance was dominant over MYMIV susceptibility. Mottled green seed colour was dominant over black seed colour. In all of these cases, single gene was found to be operative which was further confirmed in 346 $F_{2:3}$ families.
- In the Station Trials of urdbean, genotype IPU 19-27, matured significantly early (60-65 days) during summer as well as rainy seasons as compared to other released urdbean varieties (70-80 days) in the North-Eastern Plain Zone (NEPZ). This urdbean genotype showed resistance to mungbean yellow mosaic India virus (MYMIV).
- A set of 310 urdbean germplasm lines was evaluated during *Kharif* 2019 for screening and evaluation for heat and drought, photo-thermo insensitivity and yield attributing traits. 22 accessions were found to be promising.
- Fifty two new crosses were developed in

urdbean in the *Kharif* 2019 for yield improvement, MYMIV resistance, photo-thermo insensitivity, drought and heat tolerance.

- Fieldpea variety IPF 16-13 (*Kharif*) was released and notified for NEPZ with an yield of 1752 kg/ha. It recorded 12.45% yield superiority over the best check VL 42 and 28.53 % yield advantage over the ruling check variety, HUDP-15. It is resistant to powdery mildew and moderately tolerant to rust disease.
- Two fieldpea varieties, IPFD 12-8 (*Aakash*) and IPFD 13-2 (*Anant*) have been released in Uttar Pradesh state with 15% and 24% yield superiority over the best check KPMR 522. IPFD 12-8 and IPFD 13-2 have yield potential of 1158 kg/ha and 1409 kg/ha, respectively.
- Fieldpea genetic stock i.e. P-637 (INGR19075) has been registered at ICAR-NBPGR, New Delhi for tolerance to post emergence herbicide (metribuzin).
- Fieldpea entries IPF 18-17, IPF 18-14 and IPF 18-20 of tall type have been promoted from IVT to AVT-1 in NEPZ in AICRP trials. Entry IPFD 18-2 (dwarf type) has been promoted from IVT to AVT-1 in NHZ.
- Forty new crosses have been generated in fieldpea. Two station trials were conducted, in one of those, genotypes IPFD 19-9 (4206 kg/ha) and IPFD 19-3(3869 kg/ha) were found promising as compared to best check IPFD 10-12 (3822 kg/ha).
- Fieldpea genotype IPFD 18-14 was identified extra early type, which flowered and matured in less than 36 days and 75 days, respectively.
- Fieldpea genotypes DMR-7, IPF 6-16, IPF 12-17 and IPF 11-15 were identified to be stable yielding lines under heat stress our of 151 genotypes screened.
- During spring season-2019, a set of 119 cowpea genotypes were rejuvenated in Kanpur. At IIPR-RRC, Dharwad, 190 accessions of cowpea germplasm were rejuvenated and evaluated for different morphological traits. Fifteen new crosses were developed in cowpea.
- 1800 rajmash germplasm accessions have been procured and maintained at IIPR, Kanpur and trait specific donors identified. Nineteen fresh crosses have been generated.
- Rajmash accessions IC337275, EC931228, IC340947, EC 25517, EC931216, EC931275, IC43572 were identified resistant against anthracnose disease.

Plant Biotechnology

- QTLs were mapped for the chickpea traits-number of pods per plant (PN), % pod set (PPS), seed per plant (SPP) and yield per plant (YPP) on chromosome number 4, 5, 6 and 8 Heat7 and NCPGR202 markers found to be located at reported QTL intervals (Paul *et al.*, 2018) and present on chromosome 5 and 6, respectively and have association/linkage with PN, PPS, SSP and YPP expression based on single marker analysis and interval mapping approaches in chickpea.
- Marker assisted backcrossed (MABC) lines (IPC L4-14, IPC L4-16 and IPC L19-1) were evaluated under AICRP chickpea during 2018-19 and of these, IPC L4-14 performed well under drought conditions and is being been promoted to AVT 2.
- Integrated molecular marker map of chickpea genome was established using 170 recombinant inbred lines from cross between a cultivar resistant to *Fusarium* wilt IPC 2004-52 and susceptible genotype K850. A total of 6177 SNPs markers have been mapped onto the eight different linkage groups (CaLG01- CaLG08).
- Marker free, pod specific *cryIAc* and *cry2Aa* gene constructs (pCambia 0390-msg-cryIAc and pCambia 0390-msg-cry2Aa) have been transformed into *Agrobacterium tumefaciens* strain LBA 4404
- Molecular cloning and development of bacterial expression vector carrying the *Cicer arietinim* multi-stress responsive WRKY transcription factor (pET-28a-CaMSR-WRKY)coding sequence has been achieved.
- Complete *in vitro* multiple shoot induction in grasspea cv. Pusa 24 and Mahateora was achieved with embryonic axis as explant under the influence of 6-Benzyl Aminopurine.
- Bioinformatics analysis reveals Grasspea ODAP synthase gene to appear intron less.
- Cotyledon with embryonic axis of mungbean used as choice explant for *Agrobacterium* mediated genetic transformation using nptII as candidate gene revealed encouraging results in effort to establish a genotype independent genetic transformation system..
- Sib mating was attempted employing transgenic chickpea (IPCa2) and pigeonpea line (IPCc1). The lines have been sown in Transgenic Containment Facility. Screening using PCR and ELISA are in progress for these lines.

Crop Production

- Depending upon the agroecology (upland/lowland), intensive cropping system *viz.*, rice/maize/bajra-wheat-mungbean (RWMb) was found is advantageous over other similar prevalent systems in terms of component grain yield, system productivity and economics as revealed in 14-years crop rotation based long-term experiment. Being responsive to fertilizer inputs, cereal yields (maize, bajra, and wheat) were higher under inorganic fertilization (RDF) while pulses performed better under integrated nutrient management (INM).
- In urdbean, recommend dose of fertilizers (RDF) + *Rhizobium* + PSB (liquid based inoculation) had higher harvest biomass production, pods/plant, test weight, grain yield, enzymatic activities and nutrient uptake. Pearl millet performed better under organic farming which was comparable to that of chemical/inorganic farming.
- Higher sorghum grain yield was obtained with zero tillage under conservation agriculture in sorghum-fieldpea rotation.
- Improvement in chickpea grain yield was apparent following application of salicylic acid at 100 ppm (SA 100), followed by urea (2%)/ NPK (19:19:19) at 0.5% applied at both flower initiation and pod development stages.
- In a rice-lentil relay system, transplanted puddled rice (PTR) had an advantage over non-puddled transplanted rice (NTR) as lentil performed better in the former (due to higher germination) following surface seeding in a sandy-loam soil of Kanpur.
- Under long-term conservation agriculture (CA), higher yield of rice (12%) could be realized through zero tillage compared to conventional tillage. Zero tillage combined with residue retention benefitted rice and chickpea (significant reductions in weed growth in terms of population and dry weight) also.
- Conservation agriculture consisting of conservation tillage and residue (+R) management under diversified pulse based cropping systems showed that system productivity was significantly higher (82%) in rice-wheat-mungbean over conventional practices (conventional tillage without residue retention in rice-wheat system). In this study, amylose and amylopectin content in rice grains was higher in PTR-ZT, PTR-ZT+R.
- In a study on summer mungbean under CA practices in rice-wheat-mungbean, the sequence for decreasing grain yield of mungbean varieties was: IPM 205-7> HUM 16 > Samrat> IPM 2-3> IPM 2-14. System productivity in terms of mungbean equivalent yield (MEY) was higher under ZT, residue retention and IPM 205-7 in comparison to conventional tillage, residue burning and IPM 2-14, respectively.
- Under CA practices, system productivity was in decreasing order of rice-wheat-mungbean > rice+*dhaincha*–wheat–mungbean > maize-wheat-mungbean > pearl millet-lentil+linseed.
- The herbicide combination, Clodinafop-propargyl + Na-acifluorfen 122.5 g a.i./ha was selective to mungbean (as it showed effective in broad-spectrum weed control with higher grain yield). Application of broad-spectrum herbicide *viz.*, topramezone 20.6 ml a.i./ha in chickpea had minimum weed growth with higher grain yield.

Crop Protection

- A total of 500 early and medium pigeopea genotypes screened in Phytophthora stem blight sick field to identify the resistant sources/donors, 11 pigeonpea lines *viz.*, IPAC-79, IPAPB 7-2-1-7, IPAPB-7-2-1, KPBR-80-2-1, IPAC-3, IPA 15-01, IPA 15-07, IPAP 19-08, IPH 18-02, IPH 18-01 and IPA 16E-7) have been identified as donor.
- Promising pigeonpea lines *i.e.*, DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-11, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16 and IPA-38, IPA 16F, and IPA 15F) showed resistant reaction against Fusaricen wilt.
- Isolation and characterization of the volatile metabolites from the culture filtrate of potential *Trichoderma* strain *i.e.*, IIPRTh-31, IIPRTh-4 and IIPR Tlongi-31was done. A talc based formulation of *Trichoderma harzianum* (IIPRTh-31) has been developed
- Observation on different weather parameters and per cent pest/disease incidence were recorded from farmer fields of four blocks in Hamirpur district of Bundelkhand region indicate that the minimum/maximum temperature, relative humidity and rainfall play an important role in the development of pest/disease in pigeonpea.
- Data were subjected to correlation analysis and results revealed that the correlation coefficient between wilt incidence and maximum temperature (0.13), minimum temperature (0.45) and rainfall were positive (0.50). The correlation

coefficient between wilt incidence and relative humidity (-0.29), wind speed (-0.08) were negative.

- Ten mungbean genotypes (IPM 1205-2, IPM 14-49-5, KPM 16-17, IPM 139xSPS 187-1, RMG 1034, IPM 2K 08-1-1, PDM 139, RMG 1045, IPM 2K 14-7 and IPM 305-1-2) and 18 urdbean genotypes (IPU 99-220, IPU 131, IPU 85-86, IPU 96-3, IPU 13-1, PUL 570, IPU 99-4, EH 84-4, NP21, IPU 99-336, PDU 3, NKDU2, IPU 13-3, IPU 13-7, IPU 99-22, IPU 16-6, V3108 and IPU 10-1) were found completely free from yellow mosaie disease.
- Eleven lines of rajmash *viz.*, EC 5644797, EC 150250, IC 340947, GPR 203, EC 400445, IC 341435, ET 8409, EC 540173, EC 541703, BLF 141, ET 4515B showed resistance against BCMV.
- Four pathotypes (I, II, III, IV) were identified across the India based on evaluation of standard international chickpea differentials against *Ascochyta rabiei* isolates. Pathotype III was observed at maximum locations followed by pathotype I, IV and II.
- Among four different dates of sowing tested 15th and 25th March, 5th and 15th April for mungbean in the summer and 22nd July, 1st, 11th and 21st August for both mungbean and urdbean in the *Kharif*, early sowing on 15th March in summer and 22nd July in *Kharif* recorded less population of whitelly at 35 DAS of plant age.
- Urdbean recorded higher population of whiteflies in all dates of sowing compared to Mungbean. Population of whiteflies shoots up from mid-August to September after which it started declining.
- Whitefly, *Bemisia tabaci* population, collected from green gram crop of IIPR campus, showed close resemblance with Asia II 1 genetic group. This was confirmed through phylogenetic analysis with all the available sequences (mtCOI) of 44 different genetic groups reported till date.
- The plant essential oils of *Ocimum* sp., *Curcuma* sp., *Mentha* sp., *Citrus* sp., *Eucalyptus* sp. and *Cymbopogon* sp. exhibited contact toxicity against pulse beetle, *Callosobruchus analis* (F.) infesting stored pulses.
- A process for formation of sodium alginate-based microcapsules was standardized and formulated as emulsion concentrate for microencapsulation of microbial inoculants / bio-compounds.
- The crude extract from 48 actinobacteria strains had demonstrated 20-100% larval mortality of *Spodoptera litura*. Actinobacteria strains AIN 29 (*Streptomyces badius* IIPR:KR04:01) and AIN 67 (*Streptomyces* sp. IIPR:SB01:04) have showed more than 80% larval mortality. Further elucidation of bioactive insecticidal compounds from those strains is being done.
- Infestation of bruchids (*Callosobruchus analis* and *C. maculatus*) found on cowpea pods on standing crop at field level. Infestation started from 4th week after flowering (WAF) and increased towards crop end when majority of the pods were dried with nearly 1 per cent oviposition and 0.5 percent pod damage and the same infestation was observed to enter storage and cause subsequent damage to grains.
- Among 99 mungbean genotypes screened for bruchid resistance, 4 genotypes (AVNU 1604, AVNU 1606, 29/2F9(m×u)101-102 and 29/3F9(m×u)101-102) were found moderately resistant, 10 genotypes were moderately susceptible, 53 were susceptible, 32 were highly susceptible and none of the lines found highly resistant.
- Six pigeonpea genotypes RVSA 16-1, IPA 206, PUSA-151, PUSA-163, WRGE 93 and PA 291 were moderately resistant against *Meloidogyne javanica*
- Seven lines of mungbean namely, COGG 912, IPM 512-1, KM 2241, KM 2355, MH 2-15, PKV AKM 4 and SKNM 1504 were moderately resistant against *M. javanica*.
- Two lines of urdbean PU-14-19 and KUG-791 showed moderately resistant reaction against *M. javanica*.
- Two year non host cropping sequence resulted in 65.3% increase in grain yield over susceptible cropping sequence.
- GSL-2, Neelam varieties of *Brassica napus* and Karan Tara of *Eruca sativa* were found to reduce maximum nematode population when the plant shoot were incorporated in soil and covered with polyethylene for 15 days.

Basic Science

- Genotypes VB Vijay, ICC 5912, C 214, Pusa 1053, ICCV 10, C 235, BDG 75 and GNG 663 showed higher chlorophyll index under limited soil moisture. Anthocyanin, an important pigment in leaf protecting leaves from oxidative stress. Some of the genotypes have been observed to have increased anthocynanin when grown under limited moisture (rainfed) as compared to their irrigated counterpart. This findings inferred that these genotypes are better adapted to water-limiting environment. The genotypes shown to have increased anthocyanin content under rainfed were ICC 1205, ICC 8950, ICC 4958, Annegiri, PDG 4,Vaibhav, Katila, Pusa 312, PG 96006, BDG 75 *etc*. It was observed that in chickpea, four isozymes of SOD were present in the heat tolerant genotypes whereas only three isozymes were present in the heat susceptible genotypes

- Pigeonpea genotypes such as NDA 2, MAL 13, ICP 2275, IPACT 2 retained 60-80% flowers/pods under low temperature and were considered as tolerant to cold stress.
- Five photothermo insensitive blackgram genotypes *e.g.* PU-19, IPU 99-79, IPU 99-213, PLU 65, PGRU 95016 were identified at Kanpur based on similar flowering time of crop at different dates of sowing.
- It was observed that the vegetable type fieldpea varieties, Arkel and Azad P3 have starch composed mostly of amylose. These varieties have 94.88 and 93.15% amylose of total starch, respectively. In cowpea also, vegetable type varieties have higher amylose % as compared to grain type varieties. Because of this high amylose concentration, legume starches have been found to exhibit a lower glycemic index (GI) than cereal starches.
- A total of 50 rhizobial strains isolated from different rajmash genotypes were evaluated for their nodulation potential under pot experiment. Nodule number varied from 1 to 7 per plant. Nodule specific weight varied from 0.002-0.005 g/nodule.
- Microbial consortia developed at IIPR for mitigating moisture deficit stress are being evaluated under AICRP-Chickpea multilocation trials (MLT) at six centres *via* Ludhiana, Hisar, Kalaburagi, Kanpur, Sehore, and Durgapura. Pooled mean data from 2nd year MLT trail indicated that microbial consortia gave 16.12-20.4% enhanced yield over control across the locations.
- Sixty seven putative Nodule-specific Cysteine Rich (NCR) peptides including 30 unique sequences of Cicer arietinum were identified using three different strategies and characterized. Similarly, 44 putative NCR peptides were identified in Cicer reticulatum genome.
- Fieldpea *Rhizobium* PR-3 and mungbean *Rhizobium* IIPR-MR-127 were identified as promising strains for commercialization
- The nanostructured granular formulations using nanoparticles embedded with herbicide imazethypar were prepared and evaluated for their herbicidal action and release kinetics in field experiments of chickpea during *Rabi*. The formulations on their different concentrations *viz*., 150, and 250 g/h were found to reduce weed population and their biomass and density by 30-80% besides lowering in dry matters of the weeds by 30-80% in different treatments as compared to untreated control (weedy check).

Social Science

- 94 farmers and 19.88 ha area was covered for different agricultural interventions such as in corporation of paddy, mango, guava, fish, mustard, chickpea and wheat under Farmer FIRST project
- 14 farmers and 3.00 ha area was covered for demonstration of improved paddy variety (Pusa Basmati-1) as critical input for enhancing production and income in the project area. The yield was 84.50 q/ha q/ha Net return of ₹ 102057 /ha was recorded. The farmers adopted SRI method of paddy cultivation. 16 farmers were provided improved variety of mustard. 38 farmers were provided with wilt resistant variety of chickpea (*Desi* and *Kabuli*). 10 farmers were provided zinc reach variety of Wheat for demonstration in project area.
- The feasibility and acceptability of poultry and goat enterprises was assessed in village condition among small and marginal rural youth and women farmers
- Taking consideration of wilt infestation along with genotypic stability and average yield an index was developed and computed to rank the chickpea genotypes for the promotion to the next level of the trial.
- Mobile app services for farmers and web console services for experts have been designed and developed on mKRISHI platform. Contents related to the diseases and insect-pest symptoms and control measures for the major pulse crops *viz*., chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea have been developed in four languages (English, Hindi, Marathi and Kannada) and shared in the customized platform for the development of PulsExpert Mobile Service.
- Nine training programmes were organized for

different stakeholders from MANAGE Hyderabad, Jharkhand, Bihar, Madhya Pradesh and Uttar Pradesh. Social Science Division also participated in two farmers fairs/ *Kisan mela* held at different districts of Uttar Pradesh. 1200 farmers visited from different districts of Uttar Pradesh.

- MGMG and SCSP programme were implemented in Kanpur Dehat, Kanpur Nagar, Fatehpur, Kannauj, Unnao, and Hamirpur districts of Uttar Pradesh for benefiting of Schedule Caste community farmer by covering 1189. Under FLD programme, 40 demonstrations were conducted on pigeonpea, mungbean, cowpea, chickpea, fieldpea and lentil in different districts of Uttar Pradesh to increase the pulse production.

Regional Station, Bhopal

- Four varieties of pulses (urdbean and lentil) were released and notified for Madhya Pradesh. M.P. State trial for *rabi* 2019-20 is being carried out for Chickpea. Further, 1544 genotypes of pigeonpea were screened for early yield related traits. ICPL 20340 and ICPL 11252 were identified as early maturing (105 d) entries in trials constituted by ICRISAT. Shuttle breeding programme in Pigeonpea was also conducted. 2457 genotypes were evaluated and unique genotypes for open flower (IC 349468) and earliness (IC 271435, IC 209236, IC 468644, PA03716) were identified in chickpea. Era trial in chickpea compristy of 30 entries is grown to assess genetic gain under BMGF project. International trials in chickpea were conducted and ICC 14203 (49.9 g) followed by ICCV 181307 (47.2 g), FLIP 11-164c (43.4 g) were identified as extra large seeded entries. A set of 310 entries through genomic selection were grown during rabi 2019-20 for evaluation in central zone. 666 genotypes of grasspea is being evaluated for low ODAP content. 144 mutants of three varieties were grown in M4 generation to assess low ODAP lines. International nursery for low ODAP, earliness and high biomass is being evaluated. 244 wild accessions of pulses are being maintained at the station. 126 q breeder seed of chickpea, 2.80 q field pea, 105q of lentil was produced during rabi 2019 and 25 q of pigeonpea, 92 q pea, 50 q chickpea and 20 q lentil BS is expected to be produced during 2020. FLD on pigeonpea, urdbean, chickpea and lentil were conducted. Seed distribution programme was organized alongwith farmers training on advanced pulse technology under SC-sub-plan.

Regional Station, Dharwad

- IMIN trial, Mungbeam genotypes *viz*., VI001408BG, VI001419BG, VI001509AG and VI002529, B-BL were found to be resistant to MYMV, *Anthracnose*, powdery mildew and *Cercospora* leaf spot disease. 150 urdbean, 100 cowpea and 150 horsegram accessions were evaluated for different quantitative traits. in station trial, Mungbean genotypes *viz*., IPM-14-6 (1240 kg/ha), IPM-14-10 (1090 kg/ha) and IPM-604-1-6 (1008 kg/ha) were found to be promising for summer cultivation in Karnataka. In chickpea, generation advancement of segregating materials of 8 AICRP centres was carried out at the centre. In mungbean, eight crosses were attempted involving diverse breeding lines or parents for breeding for drought and heat tolerance. Total 700 kg of breeder seed of mungbean (IPM 2-14) and urdbean (IPU-2-43) was produced during *Kharif* season. In intercropping of Maize + cowpea (1:1) the grain yield of maize was 66 q/ha and in Maize- chickpea the yield was 63.90 q/ha.

- Four entries of horsegram viz., HG 2, HG 10, HG 18 and HG 26 showed tolerant to powdery mildew. Emaravirus associated with Pigeonpea Sterility Mosaic Disease was characterized using set of 11 differential cultivars. Based on genotypic reactions PPSMV of Dharwad belonging to strain 3. Total 233 entries of pigeonpea lines and advanced breeding lines were screened in PSMD nursery established at the centre. Sowing of cowpea during first fortnight of July recorded lowest pod damage by *M. vitrata* (17.73%) as compared to the crop sown during the second fortnight of July (28.93%) and first fortnight of June (20.87%). In cowpea, foliar application of chlorantraniliprole 18.5 SC @ 0.4ml/L was found effective and gave 70% reduction in pod damage over untreated control. Three cowpea accessions/lines, *viz*., IC-249141, EC-394779 and NBC-24 recorded 0-10% pod damage and line IC-249141 showed no pod damage.

About the Institute

Pulses continue to be an important ingredient of human diet, especially for the large vegetarian population in the country. In the era of Green Revolution with major focus on staple food like rice and wheat, pulses were relegated to the marginal lands with least inputs. This, coupled with the increasing population, resulted in reducing per capita availability of pulses to the masses. To enhance the productivity of the existing varieties by improved production technologies, besides breeding for high yielding varieties of different pulse crops became the prime concern. To take up the cause, All India Coordinated Pulses Improvement Project (AICPIP) started in 1966 at the Indian Agricultural Research Institute (IARI), New Delhi. Later in 1978, its headquarter was shifted to the then Regional Station of IARI at Kanpur under the name of Project Directorate (Pulses). It was further elevated as Directorate of Pulses Research (DPR) in 1984 and became an independent entity under the direct control of ICAR. In 1993, the DPR was upgraded and elevated to the status of Indian Institute of Pulses Research, and simultaneously, AICPIP was trifurcated into three coordinated projects on chickpea, pigeonpea and MULLaRP (mungbean, urdbean, lentil, lathyrus, *rajmash* and pea) to provide focused attention on each crop. Since then, the Institute is playing a key role in strengthening the nutritional security and sustenance of soil health. Besides generating basic knowledge and material, other activities of the Institute include development of appropriate crop production and protection technologies, production and supply of nucleus and breeder seeds of improved varieties, demonstration and transfer of technologies, and strategic coordination of pulses research through wide network of testing centers across the country.

The Institute is located at Kanpur, Uttar Pradesh at $26^{0}27'$N latitude, $80^{0}14'$E longitude and 152.4 meter above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central Railway Station towards New Delhi.

The overall climate varies from semi-arid to arid. The summers are very hot and winters are cool and dry. The monthly weather data for the year reveals that the mean monthly maximum temperature varied from 19.2°C to 41.7°C and the minimum temperature from 3.4^{0}C to 26.8°C. The relative humidity varied from 15.7% to 99.00%.

Multi-disciplinary research of both strategic and basic nature is conducted under six Divisions namely, Crop Improvement, Plant Biotechnology, Crop Production, Crop Protection, Basic Science and Social Science. For region specific and strategic research, the Institute has one Regional Centre *cum* Off-Season Nursery at Dharwad in Karnataka and one Regional station at Bhopal in Madhya Pradesh. Two more station, viz., Bikaner is Rajasthan & Bhubaneshwar in Odisha have been established recontly to cater to region splific research needs in pulses. To cater to the of the Institute's activities and mandate, service units such as Farm Management, Library & Informatics, AKMU, Hindi Cell, Art & Reprography and Publication & Documentation are in place.

The Institute has a well developed 84 ha research farm at its headquarters, Kanpur. Physical Containment Facility has been created for advancing generation of the transgenic plants and further validation of the transgenic lines. In addition, screening facilities against major diseases of pulse crops have been developed. Rain-out shelter to screen genotypes against drought, well-equipped laboratories of biotechnology, molecular biology, biochemistry, physiology, pathology, bio-control, soil chemistry, medium-term germplasm storage and weather observatory provide necessary infrastructures for R & D activities. The computer cell provides facilities for database management, documentation, and statistical analyses. The library houses exhaustive literature on pulse crops besides CAB abstracting on CD ROM. The museum depicts pulse technologies developed by the Institute. The Institute has sanctioned strength of 100+1 scientists, 59 technical, 27 administrative and 51 supporting personnel.

Organizational Set-up

DIRECTOR

- **Institute**
  - **Research Divisions**
    - Crop Improvement
    - Plant Biotechnology
    - Crop Production
    - Crop Protection
    - Basic Science
    - Social Science
  - **Regional station/Centre**
    - RS, Bhopal
    - RS, Dharwad
    - RC, Bikaner
    - RS, Bhuvneshwer
  - **Administration & Finance**
    - Administration
    - Purchase
    - Stores
    - Finance & Accounts
    - Audit
  - **Supporting Services**
    - Farm Operations
    - Library & Information
    - Computer (AKMU)
    - Publication & Documentation
    - PME Cell
    - Transport
    - Telecommunication
    - Works & Maintenance
    - Security
- **Institute Management Committee**
- **Research Advisory Committee**
- **Institute Research Council**
- **Coordination Units**
  - Chickpea
  - Pigeonpea
  - MULLaRP
  - Arid Legumes

Staff Strength

As on 31.12.2019

Category	Sanctioned	In position	Vacant Post
RMP	01	01	-
Scientist	100	76	24
Technical	59	45	14
Administrative	27	25	02
Skilled Support Staff	51	30	21
Total	**238**	**177**	**61**

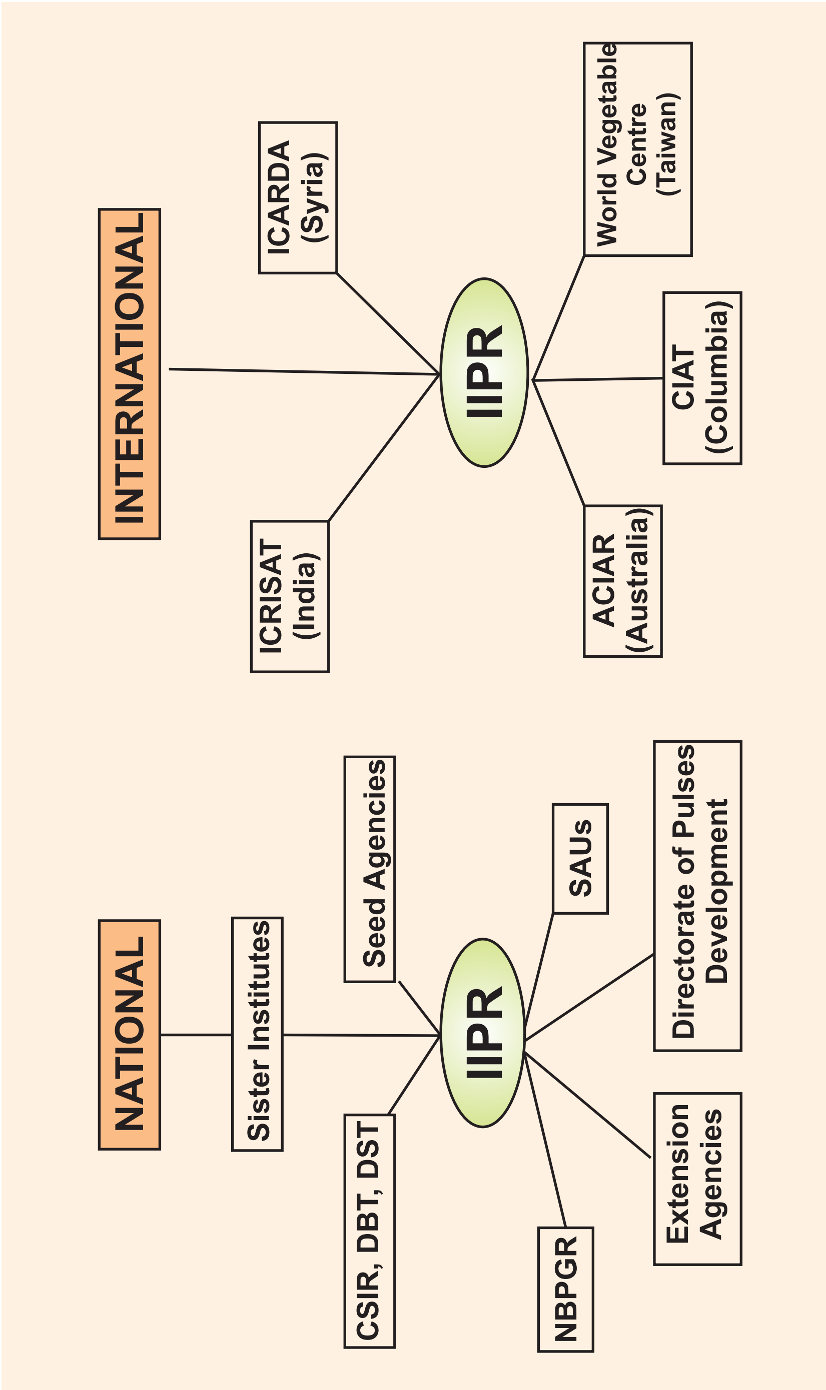
Mandate

- Basic and strategic research on pulses to improve productivity and quality
- To provide equitable access to information, knowledge and genetic material to develop improved technology and enhance pulse production
- Planning, coordination and monitoring of applied research on national and regional issues through All India Coordinated Research Projects
- Dissemination of technology and capacity building

Major Research Programmes

- Genetic Enhancement for Yield and Quality
- Biotechnological Interventions
- Plant Genetic Resources : Collection, Evaluation and Conservation
- Cropping Systems Research
- Integrated Nutrients Management
- Integrated Pests Management
- Physiological Studies
- On-farm Research and Informatics
- Post-harvest Technology

Linkage and Collaborations



Financial Statement

Statement of Receipt and Expenditure for the Financial Year 2019-20

(As on 31.12.2019)

			₹ in lakh
A.	**Receipt**		3374.46
B.	**Expenditure**		
	Plan		3096.70
C.	**Pension and other retirement benefits**		143.68
D.	**AICRP**		
	Chickpea		
	a.	Coordination Unit	58.80
	b.	Grant-in-aid	743.74
	Pigeonpea		
	a.	Coordination Unit	43.40
	b	Grant-in-aid	670.55
	MULLaRP		
	a.	Coordination Unit	9.93
	b.	Grant-in-aid	883.56
	AINPAL		
	a.	Coordination Unit	3.92
	b.	Grant-in-aid	208.74

Status of Implementation of SFC 2017-20 Three Year Plan (Upto 31.12.2019)

(₹ in lakh)

Head	Approvd outlay (R.E.)	Expenditure 2019
A. Recurring		
Pay & Allowances/Wages & Pension	2804.28	1911.47
TA	40.00	24.92
HRD	12.00	11.70
Contingency	893.00	510.01
Total	**3714.28**	**2458.10**
B. Non-Recurring		
Equipment, Information Technology & Furniture & Fixture	145.00	69.00
Works	396.22	372.95
Library	13.78	0.00
Total	**555.00**	**441.95**
C. TSP	**35.00**	**34.65**
TOTAL (A+B+C)	**4304.28**	**2934.60**

Crop Improvement

A. Institute Funded Projects

1. Genetic enhancement of pulses for grain yield, quality and multiple stress resistance in pulses

Chickpea

Breeding for yield enhancement

Varieties developed: Four chickpea varieties have been released and notified during 2019 for enhancing productivity of chickpea in Central India and Uttar Pradesh.

IPC 2006-77 (IC 616402): A *desi* chickpea variety derived from DCP 92-3 x T 39-1 cross, which was released and notified in 2019 by CVRC for cultivation in Central Zone of India comprising Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, Southern parts of Rajasthan and Bundelkhand tracts of Uttar Pradesh and suitable for late sown conditions. It recorded an average grain yield of 2065 kg/ha and registered 22.7% and 13.5% yield superiority over national check BG 372 (1683 kg/ha) and zonal check JG 14 (1819 kg/ha), respectively. It matures in 115-120 days and has resistance against wilt, stunt and collar rot and moderate resistance to dry root rot (DRR) and higher grain protein content. It has small seeds (16.5 g/100 seed weight) with attractive light yellow seed coat colour. It is medium tall, semi-erect growth habit, small leaves with dark foliage.

IPC 2005-62 (IC 612174): A *desi* chickpea variety derived from DCP 92-3 x T 39-1 cross, which was released and notified in 2019 and suitable for late sown condition of Uttar Pradesh. It recorded an average grain yield of 1018 kg/ha over the Uttar Pradesh State. It has registered 7.2% and 3.4% yield superiority over check varieties, KPG 59 and BG 372, respectively. It matures in 120 days and resistant against *Fusarium* wilt disease. It has small seed (15.2 g/100 seed wt.) with brown seed coat colour. It is medium and semi-erect growth habit with green foliage.

IPC 2004-98 (IC 612175): It is a *desi* chickpea variety derived from Phule G-5 x DCP 92-3 cross, which was released and notified in 2019 and suitable for timely sown condition of Uttar Pradesh. It recorded mean yield of 1429 kg/ha and registered 11.6% yield superiority over best check KWR 108. It matures in 135-140 days and resistant against *Fusarium* wilt. It has large seed (25.8 g/100 seed wt.) with attractive seed colour. It has medium tall and semi-erect growth habit.

IPC 2011-112 (IC 631260): It is a *desi* chickpea variety derived from IPC 94-94 x IPC 2002-120 cross, which was released by the SVRC UP for the State in 2019. It has recorded an average yield of 1296 kg/ha. It has registered 11.0%, 11.8% and 12.1% yield superiority over the check DCP 92-3, Avrodhi and KWR108, respectively in UP. It matures in 122 days and resistant against wilt. It has large seed (22g/100 seed wt.) with brown seed coat colour. It is medium tall (45-50 cm plant height) with semi-erect growth habit and suitable under timely sown condition.

Varieties identified for release

IPC 2010-62 (late sown): This line has been derived from KWR 108 (*C. arietinum*)/ EC 556270 (*C. reticulatum*) and identified by the *Rajya Beej Vimochan Samiti*, Uttar Pradesh for release in the State under late sown condition. This is a high yielding *desi* chickpea line and recorded an average grain yield of 1324 kg/ha and registered 21.1% yield superiority over check variety KPG 59 over the State. It matures in 115-120 days and moderately resistant to *Fusarium* wilt, BGM, stunt and DRR diseases. It has medium large seed (25.7 g per 100 seed weight) with brown seed coat colour. It is medium tall (45-55 cm) with semi-erect growth habit.

IPC 2010-134 (timely sown): This line is derived from GNG 469 x FG 711 cross, and identified by the *Rajya Beej Vimochan Samiti*, U.P. for release in the State under late sown condition. This is a high yielding *desi* chickpea line and recorded an average grain yield of 1670 kg/ha and registered 15.3% yield superiority over check KPG 59 in UP. It matures in 130-135 days and resistant to *Fusarium* wilt, DRR and collar rot diseases. It has medium seed size (22.5 g per 100 seed weight) with brown seed coat colour. It has medium tall with semi-erect growth habit.

IPC 2010-142 (timely sown): It is derived from RSG 143-1/IPC 94-94 cross and identified by the *Rajya Beej Vimochan Samiti*, Uttar Pradesh for release in the State under timely sown condition. This is a high yielding *desi* chickpea line and recorded an average grain yield of 1730 kg/ha and registered 19.5% yield superiority over check variety KPG. It matures in 135-140 days and resistant to *Fusarium* wilt disease. It has medium seed size (20.7g per 100 seed weight) with brown seed coat colour. It is tall (65-75 cm plant height) with erect growth habit and suitable for mechanical harvesting.

IPCK 11-179 (*kabuli*, timely sown): This line has been derived from IPCK 305 x ICC 16144 cross, and identified by the *Rajya Beej Vimochan Samiti*, Uttar Pradesh for release in the State under timely sown condition. This is a high yielding *kabuli* line and observed an average yield of 1354 kg/ha and registered 5.70% yield superiority over check variety K 3256 in Uttar Pradesh. It matures in 130-135 days and resistant to *Fusarium* wilt disease. It has large seed (27.5 g per 100 seed weight) with white seed coat colour. It is medium tall with semi-erect growth habit.

IPC 2010-72 (*Atal*): It is a *desi* chickpea elite breeding line derived from BG 256 x GNG 469 cross, and identified by the *Rajya Beej Vimochan Samiti*, Uttar Pradesh for release in the State under timely sown condition. This is a high yielding *desi* chickpea line and produced an average grain yield of 1170 kg/ha over the state. It has registered 6.3%, 6.6% and 6.8% yield superiority over check varieties KWR 108, DCP 92-3 and Avrodhi, respectively in Uttar Pradesh. It matures in 120 days and resistant against *Fusarium* wilt disease. It has large seed (28.7 g per 100 seed weight) with brown seed coat colour. It is tall (60-65 cm) with semi-erect growth habit.

Performance of breeding lines in AICRP trials

Two *kabuli* elite breeding lines IPCK 13-163 (NWPZ and WCZ), IPCK 11-37 (WCZ) and one *desi* IPC 15-116 (SZ) are being evaluated in AVT-1 trial under timely sown condition. A fifteen IPC elite breeding lines namely, IPC 16-107, IPC 15-12, IPCD 16-44 (Timely Sown); IPC 12-31, IPC 15-123, IPCB 15-165 (Late Sown); IPC 15-116, IPC 15-267, IPCB 16-222 (Rainfed);IPC 14-10, IPC 15-17, IPCB 15-133 (Mechanical Harvesting); IPCK 14-98, IPCK 16-12, IPCKB 16-149 (*Kabuli*) are being evaluated in IVTs under AICRP during 2019-20.

Performance of breeding lines in State Adaptive Trials (UP)

Fifteen elite breeding lines of chickpea including 13 *Desi* and 2 *Kabuli* entries (Timely Sown: IPC 10-217, IPC 12-108, IPC 13-70, IPC 13-74, IPC 14-28; Late Sown: IPC 13-33, IPC 12-49, IPC 07-28, IPC 07-100; Rainfed: IPC 14-120, IPC 14-51, IPC 11-30, IPC 11-28; *Kabuli*: IPCK 12-143, IPCK 09-145) are being evaluated in Uttar Pradesh State Adaptive Trials during *rabi* 2019-20 at different stages.

Generation of breeding material

Prominent donor lines of chickpea for heat tolerance (JG 14), mechanical harvesting, plant architecture (HC 5, IPC 06-11), post-emergence herbicide tolerance (ICC 1205, ICC 11101, IPC 18-186), drought tolerance (ICC 4958, RSG 888), salinity tolerance (CSG 8962), *Fusarium* wilt resistance (JSC 37, IPC 07-28, IPC 07-56, IPC 10-134, IPC 18-37, IPC 18-52, IPC 18-79, IPC 18-131, IPC 18-145, IPC 18-41), Dry root rot resistance (JG 03-14-16, IPC 10-134, IPC 05-28), collar rot resistance (RSG 888), stunt virus (IPC 04-52) were utilized in crossing program. Wild accessions (ILWC 21, ILWC 142, ILWC 257 and ILWC 263) were used to broaden genetic base of chickpea varieties (JAKI 9218, GNG 1581, JG 14, JG 16, KPG 59, KWR 108, DCP 92-3, IPC 06-77, IPC 04-98) in hybridization programme. Thirty eight crosses including 15 and 23 were developed during *Rabi* 2018-19 and *Kharif* 2019 at Kanpur and Dharwad, respectively to combine traits for grain yield, resistance against biotic and abiotic stresses. The segregating materials were duly advanced during *Kharif* 2019 at Dharwad. All the crosses have already been sown during 2019-20 at IIPR, Kanpur for generation advancement.

Advancement of breeding materials

The segregating populations were advanced during *Rabi* 2018-19 at Kanpur and *Kharif* 2019 during Off-season at RRC Dharwad. F_2 derived from 57 crosses were raised during 2018-19 at Kanpur for generation advancement. Total 951 F_2 plants harvested separately from all crosses. Altogether, 3519 SPS in various generations including F_3: 1083 SPS, F_4: 602 SPS, F_5: 721 SPS, F_6: 1071 SPS, F_7: 18 SPS and F_8: 33 SPS from 34, 38, 49, 78, 5 and 6 populations, respectively were raised during 2018-19 for further advancement. 2208 SPS including F_3: 733 SPS, F_4:485 SPS, F_5:573 SPS, F_6: 417 SPS were harvested separately. 42 single plant progenies including 18 and 24 from 5 and 8 crosses were harvested from F_7 and F_8 populations, 188 line bulks were harvested from different generations for sharing with NARS partners.

Evaluation of elite breeding lines

More than 450 lines including existing and new breeding lines of chickpea were evaluated under timely and late sown condition. Seven station trials including were evaluated at Kanpur, Bhopal and Dharwad during 2018-19. Nine PYTs including were evaluated along with checks (two) ICVTs were evaluated during 2018-19. Besides, 65 and 30 elite breeding lines were also evaluated at RRS, Phanda (ST-4-Rainfed and ST-2-Pre-breeding) and Dharwad, respectively during 2018-19. The trials-wise details are given below:

Station Trial-1 (Mechanical harvesting): Thirty entries and three checks were tested during 2018-19. IPC 16-127 (3429 kg/ha) was identified significantly superior in yield with respect to the best check followed by entry IPC 17-253 (3133 kg/ha), IPC 17-207 (3132 kg/ha), IPC 17-351 (3071 kg/ha), IPC 16-184 (3022 kg/ha), IPC 14-10 (3021 kg/ha) and checks

HC5 (2751 kg/ha), NBeG47(2612 kg/ha) and DCP 92-3 (2452 kg/ha). Entry IPC 16-127produced 24.6%, 31.3% and 39.8% more yield than HC 5, NBeG 47 andDCP92-3, respectively. All of these genotypes were tall, erect and free from lodging.

Station Trial-2 (Pre-breeding): Thirty entries developed from pre-breeding and three checks were tested during 2018-19. IPC 17-93 (3394 kg/ha) was found top yielder followed by IPC 16-52 (3214 kg/ha), IPC 16-150 (3048 kg/ha), IPC 16-148 (3018 kg/ha), IPC 17-110 (2991 kg/ha), IPC 16-39 (2968 kg/ha), IPC 14-133 (2938 kg/ha), IPC 16-15 (2902 kg/ha), IPC 15-202 (2887 kg/ha), IPC 16-231 (2857 kg/ha), IPC 17-308 (2849 kg/ha), IPC 16-57 (2747 kg/ha) and checks GNG 1581 (2387 kg/ha), DCP 92-3 (2093 kg/ha) and JAKI 9218 (1750 kg/ha). Entry IPC 17-93 produced 42.2%, 62.2% and 93.9% higher yield than GNG 1581, DCP 92-3 and JAKI 9218, respectively.

Station Trial-3A (Timely Sown): Thirty chickpea breeding lines and 3 checks were evaluated during *Rabi* 2018-19. IPC 15-154 (2643 kg/ha) was found top yielder followed by IPC 16-127 (2549 kg/ha), IPC 15-146 (2544 kg/ha), IPC 16-166 (2488 kg/ha), IPC 15-48 (2482 kg/ha), IPC 16-25 (2479 kg/ha), IPC 15-267 (2335 kg/ha), IPC 16-184 (2284 kg/ha), and checks DCP 92-3 (2068 kg/ha), K 850 (1886 kg/ha) and BG 256 (1777 kg/ha). Entry IPC 15-154 recorded 27.8%, 40.1% and 48.7% higher yield than DCP 92-3, K 850 and BG 256, respectively.

Station Trial-3B (Timely Sown): Total of 30 entries with three checks were tested during 2018-19. The entry IPC 17-04 (2817 kg/ha) was found top yielder followed by IPC 17-238 (2523 kg/ha), IPC 17-303 (2508kg/ha), IPC15-39(2441 kg/ha), IPC17-21 (2423 kg/ha), IPC 15-116 (2421 kg/ha), IPC 16-222 (2413 kg/ha) and GNG 1581(2096 kg/ha),JG 16 (1961 kg/ha), JAKI 9218 (1336 kg/ha). Entry IPC 17-04 recorded 34.4%, 43.7%, 110.9% higher yield than GNG 1581, JG 16, JAKI 9218, respectively.

Station Trial-4 (Rainfed): Thirty two entries with 3 checks were evaluated under timely sown rainfed conditions in both the locations (Kanpur and Bhopal) for yield and yield attributing traits during *Rabi* 2018-19. Entry IPC17-03 (2168 kg/ha) was found top yielder followed by IPC 17-361 (2150 kg/ha), IPC 17-174 (2008kg/ha), IPC 17-376 (1990 kg/ha), IPC 17-46 (2056 kg/ha), IPC 17-05 (1956 kg/ha), IPC 17-49 (1948 kg/ha), IPC 17-47 (1924 kg/ha), and checks JG 16 (1708 kg/ha), JAKI 9218 (1543 kg/ha) and JG 14 (1451 kg/ha) in above both locations. The entry IPC 17-03 recorded 26.9%, 40.5% and 49.4% higher seed yield than the check JG 16, JAKI 9218 and JG 14, respectively.

Station Trial-5 (Late sown): Twenty six entries with two checks were evaluated during *Rabi* 2018-19 under late sown condition (10.12.2018). Entry IPC 15-185 (2138 kg/ha) was found top yielder followed by IPC 15-39 (2122 kg/ha), IPC 15-146 (1987 kg/ha), IPC 15-149 (1918 kg/ha), IPC 15-132 (1792 kg/ha), IPC 15-16 (1776 kg/ha) and checks BG 372 (1617 kg/ha) and JG 14 (1567 kg/ha). The entry IPC 17-03 produced 32.2% and 36.4% more yield than the check BG 372 and JG 14, respectively.

Phenotyping against biotic and abiotic stresses

***Fusarium* wilt disease:** 112 chickpea advanced breeding lines were screened against *Fusarium* wilt and six lines (IPC 18-37, IPC 18-52, IPC 18-79, IPC 18-131, IPC 18-145, IPC 18-41) showed resistant reaction and 14 showed (IPC 18-127, IPC 18-17, IPC 18-24, IPC 18-29, IPC 18-24, IPC 18-41, IPC 18-109, IPC 18-67, IPC 18-71, IPC 18-109, IPC 18-130, IPC 18-135, IPC 18-140, IPC 18-132) moderately resistant reaction against *Fusarium oxysporum* f.sp. *ciceris* in wilt sick plot which was predominantly developed for race 2 pathogen. Under AICRP programme, 8 breeding lines (3 *Kabuli*: IPCK 12-29, IPCK 06-56, IPCK 09-165 and 6 *Desi*: IPC 10-134, IPC 12-98, IPC 08-69, IPC 13-33, IPC 08-11, IPC 07-28) exhibited resistance against different chickpea diseases. Out of these, IPCK 10-134 and IPC 07-28 and IPC 08-69 exhibited stable resistance over two years in AICRP screening.

***Ascochyta* blight:** The same set of above mentioned breeding lines were also screened against *Ascochyta* blight (*Ascochyta rabiei*). Among them, entry IPC 18-03 and a germplasm lines ICC 1708 showed resistance reaction and rest were susceptible to A.*rabi*ei fungus.

Dry root rot: Against dry root rot, elite breeding lines viz., IPC 12-98, IPC 13-33, IPC 11-85 and IPC 10-219 exhibited moderate resistance in first year screening under AICRP-Chickpea.

Screening against post-emergence herbicide: Thirty breeding lines/genotypes with four checks (ICC 1205, IPC 18-186, JSC 37, JG 16) were phenotyped using post-emergence herbicide Imazethapyr @100 g/ha. Three lines (ICC 3735, GL 12003, GL 10006) exhibited tolerance against targeted herbicide. The stable reaction against Imazethapyr during 2018-19, indicated genetic control of herbicide tolerance and their potential for utilization in breeding programme.

Development of heat tolerant chickpea genotypes: Forty advanced breeding lines were sown under late sown (15th Jan 2019) condition for screening against heat. Variations were observed for seed setting efficiency under heat stress period

(>35°C Tmax) and plot yield. Six entries: IPC 15-146, IPC 15-115, IPC 15-54, IPC 15-41, IPC 15-246, IPC 15-147 have been identified possessing heat tolerance and produced more grain yield than the check variety JG 14.

International *desi* chickpea nurseries / trials evaluated: Two ICVTs (*Desi* and MH) were evaluated for their yield and other traits during *Rabi* 2018-19. In ICVT (*desi*), entry ICCV181106 was found top yielder (2058 kg/ha) followed by ICCV 181107 (2053 kg/ha), ICCV 181116 (1924 kg/ha) and checks JG16 (1907 kg/ha) and DCP 92-3 (1596 kg/ha). Entry ICCV 181106 produced 7.9% and 28.9% higher yield than check JG 16 and DCP 92-3, respectively. In ICVT (MH), entry ICCV 181602 was found top yielder (2823 kg/ha) followed by ICCV 181605 (2617 kg/ha), ICCV 181607 (2432 kg/ha) and checks HC 5 (2431 kg/ha) and NBeG 47 (1019 kg/ha).

2. Genetic enhancement of *kabuli* chickpea for grain yield and seed size

Generation of breeding material

Kabuli chickpea germplasm including prominent donor lines were raised for attempting crosses to develop large seeded *kabuli* genotypes with higher grain yield and disease resistance. Eight crosses including 6 (KAK 2/IPCK 11-179, IPCK 02/IPCK 11-179, PG 0517/IPCK 06-78, JGK 3/IPCK 02, KAK 2/IPCK 09-165, IPCK 02/IPCK 09-165) during *Rabi* 2018-19 at Kanpur and two crosses (IPCK 11-179/IPCK 02, PG 0517/IPCK 02) during *Kharif* 2019 at IIPR-RC Dharwad were made to create genetic variability with regards of grain yield and seed size.

Generation advancement

The segregating populations were advanced during 2018-19 *Rabi* and *Kharif* 2019 and at Kanpur and Dharwad, respectively. Total 7F_1s' derived from different crosses (IPCK 02-29/RVGK 101, IPCK 02-29/L 550, IPCK 02-29/PG 0517, IPCK 02-29/JGK 3, IPCK 09-165/IPCK 11-179, IPCK 09-165/ILC 3279, IPCK 11-179/ILC 3279)were harvested separately during 2018-19. The F_2 population from 8 crosses (IPCK 02/IPCK 09-165, IPCK 02/JGK1, IPCK 02-29/JGK3, IPCK 02-29/PG 0517, IPCK 02-29/RVGK 101, IPCK 09-165/MNK1, JGK3/IPCK 09-165) has already been raised during *Rabi* 2019-20 for generation advancement.

Station Trial-*Kabuli* (Timely sown): Twenty five *kabuli* entries and 3 checks were tested during 2018-19. Entry IPCK 10-124 (2673 kg/ha and 42.5g 100 seed weight) was found top yielder followed by IPCK 14-125 (2551 kg/ha and 37.0g 100 seed weight), IPCK 16-88 (2463 kg/ha and 47.2g 100 seed weight), IPCK 18-177 (2283 kg/ha and 46.1g 100 seed weight), IPCK 16-133 (2249 kg/ha and 44.2g 100 seed weight), IPCK 18-174 (2212 kg/ha and 37.9g 100 seed weight), and checks Shubhra (2179 kg/ha and 35.3g 100 seed weight), KAK 2 (2117 kg/ha and 41.5g 100 seed weight) and PG0517 (1084 kg/ha and 46.5g 100 seed weight). Entry IPC10-124 produced 22.7%, 26.3% and 146.6% higher grain yield than check varieties Shubhra, KAK 2 and PG0517, respectively.

International *kabuli* chickpea nurseries / trials: Twenty entries of *Kabuli* types with 2 checks (Shubhra, Vihar) received from ICRISAT, were raised with two replications during *Rabi* 2018-90 at Kanpur. Entry ICCV 181317 (1771 kg/ha and 40.0g 100 seed weight) was found top yielder followed by entry ICCV 181306 (1431 kg/ha and 38.0g 100 seed weight), checks Shubhra (1368 kg/ha and 37.5g 100 seed weight) and Vihar (1258 kg/ha and 41.4g 100 seed weight). Entry ICCV 181317 produced 29.5% and 40.8% more yield than check Shubhra and Vihar, respectively.

40 *Kabuli* type entries with check (ILC 3279) of chickpea International drought tolerance nursery (CIDTN) received from ICRISAT, were raised with two replications during *Rabi* 2018-90 at Kanpur. Entry FLIP 12-96C (2157 kg/ha and 30.1 g 100 seed weight) was found top yielder followed by entry FLIP 12-264C (1922 kg/ha and 35.6g 100 seed weight), FLIP 12-277C (1827 kg/ha and 34.9g 100 seed weight), FLIP 12-189C (1818 kg/ha and 35.9g 100 seed weight) and check ILC 3279 (1660 kg/ha and 35.9g 100 seed weight). Entry FLIP 12-96C was produced 29.9% more yield than check ILC 3279.

Another chickpea adaptation trial (ICARDA) with 36 entries with two checks (Shubhra and ILC 482) was raised in two replications during *Rabi* 2018-19. Entry FLIP 12-139C (2547 kg/ha and 35.2g 100 seed weight) was found top yielder followed by entry FLIP 12-278 C (2497 kg/ha and 40.6g 100 seed weight), FLIP 12-53 C (2175 kg/ha and 35.2g 100 seed weight), FLIP 12-146 C (1810 kg/ha and 35.5g 100 seed weight), FLIP 12-169C (1760 kg/ha and 40.2g 100 seed weight), FLIP 12-138C (1624 kg/ha and 34.2g 100 seed weight), checks Shubhra (1578 kg/ha and 34.2g 100 seed weight) and ILC 482 (1397 kg/ha and 36.6g 100 seed weight). Entry FLIP 12-139C produced 61.49% and 82.3% more yield than check Shubhra and ILC 482, respectively.

3. Breeding for high yield and enhanced resistance against abiotic stress tolerance (heat and drought) in chickpea

Generation of breeding material: Twenty four crosses namely, JG 11/RVG 203, DCP 92-3/ICC 15894, ICC 15894/ILWC 133, ICC 4958/RVG 203, ICCV 07110/RVG 203, JG 62/RVG 203, JG 16/ICC 15925, GG 2/ICC 4958, BG 362/ICC 15925, JG 315/ICC 15925, ICC 96030/RVG 203, JGM 7/RVG 203, ICC 96029/ICC 92944, RSG 888/ICC 96030, ICC 4958/JAKI 9218, JAKI 9218/ICC 15925, JG 11/ICC 15925, JG 16/RVG 203, ICC 1356/ICC 07110, ICC 92944/RVG 203, JG 130/RVG 203, ICC 1205/RVG 203, VISWAS/JG 11 and ICC 4958/RSG 888 were developed during 2018-19 for developing breeding lines tolerant against various abiotic stresses (drought, heat etc). '3-way' crosses [(KWR 108/ILC 3518)//JG 130, (KWR 108/ILC 5498)//JG 130, (KWR 108/ICC 4958)//KWR 108] and two four way crosses [(JG 130/ICC 92944)//(JG 11/ICC 96029)], (JG 11/ICC 96029)//(JG 130 x ICC 92944) were also made to develop resistant and tolerant breeding lines against major biotic and abiotic stresses, respectively. The F_1s' of all crosses has already been sown during *Rabi* 2019-20 at ICAR-IIPR, Kanpur

Generation advancement for heat tolerance: F_2 population derived of 21 crosses(JG 11/JG 62, JG 62/JG 11, ICC 92944/JG 11, HC 5/ICC 92944, ICC 1205/JG 16, ICC 96030/JG 11, ICC 1356/ICC 92944, JG 11/ICC 96029, DCP 92-3/HC 5, ICC 96030/JG 11, JG 16/ILC 583, KWR 108/ILC 583, ICC 07110/ILC 3518, ICC 92944/ILWC 181, K 850/ILWC 133, ICC 92944/ILWC 114, ICC 1356/ILWC 21, ICC 92944/ILWC 120, JG 11/ILWC 46, JG 16/ILWC 181, ICC 14262/ILWC 181) were raised during *Rabi* 2018-19 and harvested separately. Similarly, F_3 population derived from 6 crosses (KWR 108/JG 11, JG 315/ICC 92944, KWR 108/ICC 1205, JG 11/ICC 1205, JG 130/ICC 1205, KWR 108/JG 315), F_4 from 4 crosses (ICC 1205/ICC 96030, KWR 108/ICC 4958, ICC 4958/ICC 96030, ICC 96030/ICC 4958), F_5 of ICC 92944/JG 16 cross, F_6 from 4 crosses (JG 16/ICC 4958, ICC 92944/ILC 3279, KWR 108/ICC 96030, DP 92-3/ILC 3279) and F_7 from 10 crosses (JG 11/ICC 4958, JG 16/ICC 4958, JG 16/IPC 04-98, JGK1/ICC 4958, FLIP 03-100/ICC 4958, GNG 1581/ICC 4958, JAKI 9218/IPC 04-52, ICC 1205/JG 03-14-16, ICC 15164/JG 03-14-16, IPC 06-11/ICC 96030) were advanced during *Rabi* 2018-19. The single plants were selected from F3 to F_7 populations and harvested separately. The single plants of 21, 6, 4, 1, 4 and 10 crosses from F_3, F_4, F_5, F_6 and F_7 populations have already been raised during *Rabi* 2019-20 for generation advancement.

Evaluation of elite breeding lines tolerant against drought and heat: Altogether, 14 elite breeding lines of PYT with checks (IPC 11-29, IPC 10-69, IPC 13-8, IPC 12-59, IPC 14-39, IPC 14-89, IPC 11-49) were evaluated during *Rabi* 2019-20 at main Farm and NRF at IIPR, Kanpur under normal and late sown condition. Entry IPC 11-29, IPC 12-59, IPC 14-89, IPC 11-49 and ICC 15925 were observed significantly superior with regards of grain yield in comparison to the check varieties (JG 14, RSG 888, ICC 4958 and JAKI 9218).Advanced breeding lines derived from 17 different crosses (JG 11 / ICC 4958, JG 16 / ICC 4958, KWR 108 / ILC 3279, ICC 92944/ILC 3279, KWR 108/ICC 96030, DP 92-3 / ILC 3279, JGK 1 / ICC 4958, FLIP 03-100 / ICC 4958, GNG 1581 / ICC 4958, JG 16 / ICC 4958, JG 16 / IPC 04-98, JAKI 9218 / IPC 04-52, ICC 1205/JG 03-14-16, ICC 15164 / JG 03-14-16, IPC 06-11 / ICC 96030, IPC 09-50 / BPM, IPC 09-50 / IPC 09-88) were also raised during *Rabi* 2018-19 at IIPR Kanpur. The single plant selections were done based on heat and drought tolerance from the population and harvested separately. Physiological (cell membrane stability, NDVI, chlorophyll content etc) and biochemical (SOD, POD and proline content) characterization has been done in DCP92-3, ILWC21, ICC 10685, KWR 108, ICC 15925 and ICC 92944 genotypes in context of heat stress tolerance.

Development of mapping populations for heat tolerance: Seven mapping populations having contrasting traits were developed through single seed descent method (SSD) as these are in different stages as indicated [DCP 92-3/ICC 92944 (F_7 206), DCP 92-3/ICC 1205 (F_6 215), DCP 92-3/ICC 96030 (F_6 263), DCP 92-3/ICC 4958 (F_6 245), ICC 4958/ICC 92944 (F_6 195), ICC 92944/JG 315 (F_5 181), JG 11/ICC 1205 (F_4)]. Three mapping population for flowering behaviour [JG 11 / ICC 1205 (F_5), JG 11 / JG 62 (F_2) and JG 11 / ICC 96029 (F_2) were grown during *rabi* 2019-20 and harvested single plant basis. First QTLs for primary branches and chlorophyll content QTL were elucidated from DCP 92/ ICC 92944 mapping population evaluated under late sown condition. Further, characterization of mapping population DCP 92/ICC 92944 (RIL) based on various heat relevant traits under normal and late sown condition has been done.

4. Breeding for high yield and enhanced resistance against biotic stresses in chickpea

Breeding material generated: Eleven fresh crosses among parents possessing stable resistance against dry root rot and *Fusarium* wilt viz. GL 13001/

DKG 964, GNG 2264/ IPC 08-69, GNG 2299/ IPC 10-134, JG 37/ IPC 08-69, GL 13001/ IPC 08-69, GNG 2299/ IPC 07-28, GNG 2171/ CSJ 515, GNG 2207/ IPC 12-98, JG 16/ DKG 964, PhuleG 0405/ GJG 0921 and GL 13001/ IP 12-98 were made.

Generation advancement: Ten crosses (IPC10-134/GNG 2226, IPC 10-134/IPC 07-28, JG 315/RSG 44, JG 315/RSG 888, JG 37//(IPC 06-88/ILWC 179), IPC07-28//(IPC10-134/JG24), DKG 964//(GNG 1958/JSC 37), (IPC 10-134/JG 24)//IPC 07-28, (GNG 1958/IPC 05-28)//DKG 964 and (IPC 10-134/DKG 964)//(IPC 05-28/JSC 37) were advanced to F_2. More than 800 SPSs were done among 15 crosses (GNG 958/IPC 05-28, GNG 1958/JSC 37, GNG 1958/IPC 07-28, GNG 1958/GNG 2226, GNG 1958/DKG 964, IPC 10-134/JG 24, IPC 10-134/CSJ 556, IPC 10-134 /DKG 964, IPC 10-134 // (IPC 06-88/ILWC 179), JG 37/NBeG 47, IPCK 02-29/IPCK 06-78, JAKI 9218 / PG 5, JG 14/JSC 37, RSG 931/IPC 08-69 and JG 14/ILWC 21 for advancement to F_3. Altogether, more than 1100 SPSs were done among 22 crosses (GNG 1958/IPC 07-28, GNG 1958/IPC 08-103, GNG 1958/IPC 05-28, GNG 1958/JG 14, IPCK 02-29/IPCK 06-78, GNG 2776/JSC 37, IPC 10-134/JSC 37, JG 16/DKG 964, IPC 05-28/BG 212, IPC 05-28/JG 62, JG 35/JG 03-14-16, JG 37/Phule G 06102, JG 315/JG 03-14-16 and IPC 10-434 /JG14 for advancement to F_4. A total of 353 single plant selections were done among 6 crosses (JG 16/BG 212, JG 16/ JG 03-14-16, JG 16/IPC 05-64, JG 16/IPC 05-28, IPCK 04-29/IPCK 12-258 and JAKI 9218/IPC 05-24 for advancement to F_5.

Evaluation of elite breeding lines: Preliminary Yield Trial with 64 entries and two checks was conducted. Six entries (DR1533, DR 1502, IAPC 18-3, ICT 17-14, IAPC 18-7, DR 1518) were found promising.

Mapping population development for *Fusarium* wilt: Two crosses (IPC 05-28 / BG 212 and JSC 37/BG 212 were advanced to F_3 for developing mapping populations for dry root rot using with IPC 05-28 and JSC 37 (resistant) and BG 212 (susceptible) parents. Back cross population (BC_2F_1) of a three way cross (DCP 92-3 / ICC 92944) // DCP 92-3 were attempted. Marker trait association analyses for *Fusarium* wilt tolerance (race 2) of 75 selected chickpea accessions (tested in wilt sick plot for two years) has been done by SSR marker assay. Three candidate genes such as Ca_23618, Ca_14730 and Ca_20129 and Ca_14301 for wilt resistance (*foc2*) were elucidated based on GWAS analysis.

5. Improving seed protein content in chickpea

Generation of breeding material and generation advancement: During the off season crossing programme at IIPR-RRC, Dharwad, four new crosses were developed utilizing high protein donor T 39-1 into diverse genetic backgrounds of *Desi* chickpea.

Mapping for protein content: Mapping population developed for protein content, IPC 2004-98 × T 39-1 (n=320) has been sown for generation advancement to F_6. Parental polymorphism survey with SSR markers identified 42 informative polymorphic SSRs between IPC 2004-98 and T 39-1. The population has been phenotyped for protein content which ranges from 19-28%. Population genotyping with the identified polymorphic markers have been completed, data analysis and result compilation under process.

6. Improving quality traits in chickpea

Enhancement of greenness in mature chickpea grains (green at maturity) after cooking is a focus of this project. Green seeded varieties like Sadabahar, Hirua Chaffa *etc*,. turn black on cooking. Advanced breeding lines of the cross IPC 2008-103 (green seeded) × ICC15614 (brown seeds) have been identified which retain green seed colour after boiling (Fig. 1). Female parent of the cross, green seeded line IPC 2008-103 turn black on cooking. Ten out of twenty five promising advanced breeding lines of the above mentioned cross identified in last season for retaining greenness in seed after cooking were observed with seed traits of consumer preference. Those segregating lines were constituted into families based on seed traits and sown for field evaluation during the *Rabi* 2019-20. Off-season crosses were attempted in IIPR-RRC, Dharwad for development of F_1s to combine high protein content donor (T 39-1) with high Fe and Zn containing wild accession ILWC 257. Breeding materials (3 F2, 5 F3, 8 F_4, 10 F_5 and 5 F_6 populations) segregating for protein content have been sown for generation advancement and selection during the *rabi* season 2019-20.

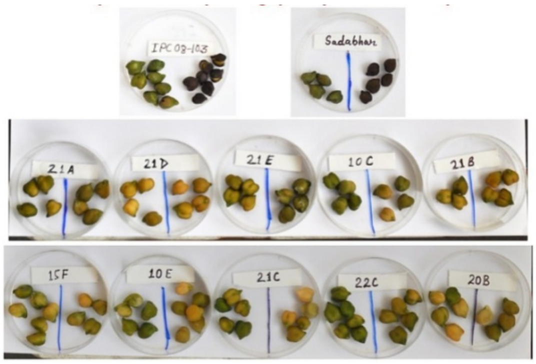


Figure 1: Variation in retention of greenness in the advanced breeding lines derived from the cross IPC 2008-103 x ICC 15614. The left quarter (reader facing the figure) of the petri dish shows the colour of the soaked seed and right quarter shows the colour of the cooked seed. Segregating lines 21 A and 21 E shows better retention of greenness after cooking. In the top of the figure, blackening of the seeds of green seeded genotypes IPC 2008-103 and Sadabahar after cooking are shown.

Pigeonpea

Breeding for yield enhancement

Identification of donor lines for dual purpose: Pigeonpea genotype IPAV 16-1 have been identified as donor for vegetable and grain purpose. This grain type has high dried and green seed weight of 23.04 and 52.00 g/100 seeds respectively. Accordingly, the line was subjected for evaluation by the germplasm identification committee of ICAR-IIPR, Kanpur. The committee recommended the registration of the line IPAV 16-1 as donor for high 100 seed weight with ICAR-NBPGR, New Delhi (Fig. 2).

Figure 2: Pod and seed of IPAV 16-1

Generation and advancement of breeding materials

During the *Kharif* 2019 cropping season F_3 progenies were generated for the four way crosses *viz*. (UPAS-120/D Dwarf)// (Ranchi Local/Asha); (UPAS-120/D Dwarf)//(DPPA-85-12/Bahar); (IPA 6-1/Azad)// (DA- 11/KPL- 44); (PH-1063/DPPA-85-12)//(DPPA- 85-12/PH- 1063); (ICPL-7035/MAL-16)//(MAL-16/ICPL- 7035); (ICPL-20124/IPA- 2014-4A)// (IPA- 2014-4A/ICPL-20124); (IPA- 2014-4A/ICPL- 20124) // (ICPL-9908/IPA- 2014-4A); (KPBR-80-2-1/IPA-38B)//(DPPA-85-12/Bahar); (KPBR-80-2-1/IPA-38B)//(DA-11/KPL-44); (IPA-203/PH-4816)//(IPA-15-20/ICPL-9908); (DA-11/Azad)//(Maruthi/IPA-6-1); (IPAV-16-10/IPA-15-19)//(Ranchi local/UPAS 120). F_3's were also being advance for the crosses namely, JBP-13/IPAV-16-17; IPAV-16-17(VKG23/50)/JBP-13; JBP-13/IPAV-16-10; IPAV-16-17/IPA-15-19. The crosses viz. UPAS 120 / Dholi dwarf; IPA 15-20 / ICPL 9908; (Type 7/Bahar) / KPL 43//KPL 43; (Bahar/IPA 6-1 / (KPL43/KPL43); Type 7 / ICPL 8863; ICPL 9908 / IPA2014-4a; (NA1/Dholi dwarf) / (KPL 43//KPL 43); Kudrat / IPA203; IPA 2014-4a / ICPL20124; Bahar / DPPA 85-12; KPBR 80-2-1 / IPA 38B; IPA 15-19 (Ranchi local/UPAS 120); IPA 14-2 (Pusa 9/Kudrat 3); IPA 203 (Bahar/AC314-314); IPAV 16-17 (Sel. of VKG23/50) are being advanced to F_4 generation. The crosses namely, IPA 8F/ Dholi Dwarf, IPA 15F/ Dholi Dwarf, IPA 16F /Dholi Dwarf, IPA 8F/Bahar, Bahar/IPA8F, KPL44/Bahar, Bahar/KPL 44, Bahar/ KPL 43, IPA 8F/NA-1, NA-1/IPA8F, NA-1/KPL 43, KPL 43/Bahar, Bahar/Banda Palera, (T7/BAHAR)/KPL 43, (NA-1/ Dholi.Dwarf/KPL 43, (Bahar/IPA6-1)/KPL 43 have reached F_5 generation. The crosses *viz*. MAL 13 / IPA 203, IPA 203/MAL 13, Bahar/ IPA 203, Bahar/IPAC 68, NA 1/KPL 44, Bahar/KPL 44, IPAC 68/Bahar are in F_6 stage. Fifty advance lines emanating from crosses namely, KPBR 80-2-1 / IPAC 79, BAHAR / KPL-43 , Bahar / KPBR 80-2-1, NA 1/ KPL 44, NA 1/KPBR 80-2-1 , NA 1/KPL 43 , IPA 203/KPBR 80-2-1 IPA 203/KPL 44, IPA 203/KPL 43, SGBS3/ ICPL 5028, ICPL 5028/ICPL 87051, IPAC 8/IPAC 3, IPAC 8/IPAC 4, IPAC 8/IPAC 5, IPAC 8/IPAC 6 are in F_7 generation.

Breeding materials: short duration pigeonpea

The F_1's of the cosses *viz*., ICPL 11298 / ICP 6992, ICPL 11298 / ICP 7130, ICPL 11285 / ICP 14459, ICPL 11285 / ICP 7148, ICPL 11279 / ICP 13193, ICPL 11279 / ICP 14440, ICPL 20325 / ICP 709, ICPL 20325 / ICP 13193, ICPL 11301 / ICP 10905, ICPL 11301 / ICP 10908 were raised for generating F_2 population. The crosses namely, AL 15 / ICPL 84023, AL 15 / D

20, AL 15 / DSLR 129, AL 15 / CORG 9701, Prabhat ICPL 91045, Prabhat / ICPL 84023, Prabhat / UPAS 120, AL 201 X D 20, AL 201 / ICPL 84023, CORG 9701 / Prabhat, CORG 9701/ ICPL 88039, CORG 9701 / AL 15, ICPL 88039/ AL 201, ICPL 88039/ AL 15, ICPL 88039/ CORG 9701, Manak / AL 15, Manak / CORG 9701, Manak/ ICPL 88039, UPAS 120 / ICPL 84023, UPAS 120 / AL 15, NA 1 / (NA 1 / ICPL 20338), are being advanced to F_3 generation. The crosses *viz*., AL 15 / ICPL 8402, AL 15 / D 20, AL 15 / DSLR 129, AL 15 / CORG 9701, Prabhat / ICPL 91045, Prabhat / ICPL 84023, Prabhat / UPAS 120, AL 201 / D 20, AL 201 / ICPL 84023, CORG 9701 / Prabhat, CORG 9701 / ICPL 88039, ICPL 88039 / AL 15,CORG 9701 / AL 15, ICPL 88039 / AL 201, ICPL 88039 / CORG 9701, Manak / AL 15, Manak / CORG 9701, Manak / ICPL 88039, UPAS 120 / ICPL 84023, UPAS 120 / AL 15, NA 1 / (NA 1 / ICPL 20338) are being advanced to F_4 generation. The crosses namely, CORG 9701 Pusa 992, CORG 9701 / ICPL 88039, CORG 9701 / AL201, UPAS 120 / Pusa 992, PUSA 2002-2 / UPAS 120, Pusa 2002-2 MN 5, Pusa 2002-2 / ICPL 88039, MN 5 / AL 201, MN 5 / UPAS 120, MN 5 / Pusa 992, ICPL 88039 / Pusa 992, AL 201 / ICPL 88039, AL 201 / UPAS 120 ,AL 201 / Pusa 992, Pusa 992 / ICPL 87154, ICPL 7124 / Pusa 992 Prabhat / ICPL 87154 are being advanced to F_5 generation. The crosses *viz*. ICPL 87154 / ICPL 88039, ICPL 88039 / UPAS 120, ICPL 20335 / ICPL 87154, 67 B / UPAS 120, ICPL 87154 / PUSA 992, ICPL 20330 / Pusa 992, CORG 9701 X Pusa 992, Pusa 992 X CORG 9701 are being advanced to F_6 generation. The crosses namely, UPAS 120 / ICPL 87154, ICPL 87154 / CORG 9701, CORG 9701 / UPAS 12, UPAS 120 / CORG9701 are in F_7 stage.

Forty advance lines namely, IPA 19-1, IPA 19-2, IPA 19-3, IPA 19-4, IPA 19-5, IPA 19-6, IPA 19-7, IPA 19-8, IPA 19-9, IPA 19-10, IPA 19-11, IPA 19-12, IPA 19-13, IPA 19-14, IPA 19-15, IPA 19-16, IPA 19-17, IPA 19-18, IPA 19-19, IPA 19-20, IPA 19-21, IPA 19-22, IPA 19-23, IPA 19-24, IPA 19-25, IPA 19-26, IPA 19-27, IPA 19-28, IPA 19-29, IPA 19-30, IPA 19-31, IPA 19-32, IPA 19-33, IPA 19-34, IPA 19-35, IPA 19-36, IPA 19-37, IPA 19-38, IPA 19-39, IPA 19-40 along with national checks were sown in replicated trial for their evaluation and promotion to AICRP. In addition, 28 advance generation lines emanating from crosses *viz*. IPAC 64/ IPAC 15625, UPAS 120/NA-1, Prabhat / IPAC 64, ICP 12195/VKS 11\24-2, NA -1 / IPA 8F are being evaluated in preliminary yield trial.

Two station trials are being conducted for evaluation of short duration pigeonpea each comprising of 10 test entries. Eleven advance cleistogamous lines derived from cross between IPA 203/ICPL 87154 are being evaluated for agronomic traits. Ninety three genotypes are being maintained in the crossing block.

Screening for *Phytophthora* stem blight resistance

Phytophthora stem blight (PSB) incidence was recorded on a set of 210 pigeonpea genotypes comprising 69 extra large seeded vegetable types, 69 advance generation breeding lines, 61 parental lines and 11 cliestogamous lines grown at IIPR, Kanpur. Result revealed that the intensity of susceptibility during the period was up to 76.47 % in the genotype BRG 2-9-1. Nevertheless, 131 genotypes recorded resistance reaction with less than 10% of disease incidence while, 44, 14 and 21 genotypes showed moderately resistant, moderately susceptible and susceptible reaction against PSB. At our Institute several resistant lines have already been used in the breeding programme. Interestingly, the extra large seeded vegetable type genotypes (BRG 2-3, BRG 2-9-2, BRG 3, BRG 4-2-4, BS 2, BS 4, IPAV 16-1, IPAV 16-10-1, IPAV 16-10-2, IPAV 16-10a, IPAV 16-11, IPAV 16-12-1, IPAV 16-12-2, IPAV 16-12-2b, IPAV 16-12A-1, IPAV 16-12A-2, IPAV 16-12B, IPAV 16-15B, IPAV 16-16, IPAV 16-16B-1, IPAV 16-17B-1, IPAV 16-17B-2, IPAV 16-17C, IPAV 16-18, IPAV 16-18A, IPAV 16-19-2, IPAV 16-19B-2, IPAV 16-20, IPAV 16-3A-1IPAV 16-21, IPAV 16-21 B, IPAV 16-22, IPAV 16-22-1, IPAV 16-22C, IPAV 16-24-1, IPAV 16-24-2, IPAV 16-2B, IPAV 16-3, IPAV 16-3A-1, IPAV 16-4, IPAV 16-9, IPAV 16-9-1, JBP 13C-1) and cleistogamous derived breeding lines (IPA cleisto 19-3, IPA cleisto 19-4, IPA cleisto 19-5, IPA cleisto 19-7, IPA cleisto 19-10, IPA cleisto 19-11), resistant under natural epiphytotic condition are useful in further strengthening of our pigeonpea disease resistance breeding programme.

Lentil

Varieties developed

IPL 225: The lentil variety (IPL 225) has been released by UP State Seed Release Sub-Committee for cultivation in Uttar Pradesh (Fig. 3). It has been developed through hybridization from three way cross [(DPL 44 X DPL 62) x DPL 58]. IPL 225 has yield superiority of 8.86% over the check variety KLS 218 in Uttar Pradesh under the normal sown conditions. It has average yield 1032 kg/ha and matures 124 days. This small seeded variety has brown dotted seed coat and red cotyledons and higher level of resistance to rust and *Fusarium* wilt diseases is another advantage with this variety.

IPL 329: The lentil variety (IPL 329) has been released by UP State Seed Release Sub-Committee for cultivation in Uttar Pradesh (Fig. 4). This variety has been developed through hybridization from a single way cross (KL 178 X DPL 62). IPL 329 has yield superiority of 9.03 % over the check variety DPL 62 in Uttar Pradesh under the normal sown conditions. It has average yield 1012 kg/ha and matures 124 days. This proposed variety has large seeds with brown dotted seed coat and red cotyledons, which are farmers' preferred attributes. It has resistance to rust and *Fusarium* wilt diseases is another advantage with this variety.


Figure 3: IPL 225


Figure 4: IPL 329

Performance of breeding lines in AICRP trials

Total 13 entries were evaluated in AICRP trials during 2018-19. One entry IPL 237 having average yield 1189 kg/ha and 7.6% yield superiority over the best check VL 126 has been promoted to AVT -1 for NHZ. Six new entries (IPL 239, IPL 240, IPL 345, IPL 346, IPL 542 and IPL 543) are being evaluated in AICRP during current *Rabi* season 2019-20.

Performance of breeding lines in UP State Adaptive trials

Two small seeded lentil variety IPLS 231 and IPLS 232 and one large seeded lentil varieties IPLB 338 have performed well over three years in Uttar Pradesh Adaptive Trials and recommended for identification and release for cultivation in Uttar Pradesh.

Evaluation of promising breeding lines

During 2018-19, two station trials with 15 entries each and one preliminary yield trial with 60 entries were evaluated at main and new research farm in order to evaluation of their performance for yield. At main farm, in ST-I, IPL-10820, IPL-10800, IPL-161441, IPL-8639, IPL-161502, IPL-161464 had high yield (23.7 q/ha to 27.1 q/ha) over the check IPL 316. The entry IPL-161464 had the highest yield (27.1q/ha) with 15.8% yield advantage over best check variety IPL 316. This small seeded entry showed the highest yield over the years and locations. Another entry, IPL 161441 had the highest yield over locations and had early flowering (71 day) among the tested entries. In ST-II, IPL-151287, IPL-141595, IPL-161426, IPL-131242, IPL-161428, IPL-141643, IPL-151302 entries had higher yield (21.3 q/ha to 23.3 q/ha) over the best check IPL 220. The entry IPL-151302 had the highest yield (23.3 q/ha) with 15.4% yield advantage over best check IPL 220. This entry also showed high yield during last year evaluation. In PYT, seven entries (IPL-171395, IPL-11718, IPL-141657, IPL-181655, IPL-14977, IPL-1413338, and IPL-181635) were identified promising over the checks for further evaluation in station trial. These entries yielded 26.3 – 31.0 q /ha. However, IPL-161450 was earliest flowering having 50% flowering in 69 days and has high biomass along with early growth vigor. This entry yielded 23.5 q/ha and had large seed size (3.4 g/100 seeds). This entry can be suitable for cultivation in central zone of India.

A station trid of 15 entries having large seed size (>2.5g/ 100 seeds) along with the checks IPL 316 and DPL 62 was conducted at RS-IIPR, Bhopal. One large seeded entry IPL 161441 had the highest yield (1783 kg/ha) over the best check variety, IPL 316.

Generation of breeding materials

During *Rabi* 2018-19, 28 crosses (IPL534 × IPL 321, IPL 225 × IPL 220, IPL 321× IPL 220, IPL 539 × IPL 534, IPL 316 × IPL 534, IPL 316 × L 4710, IPL 316 × IG 131607, IPL 534 × L 4710, IPL 316 × IPL 10820, IPL 11702 × IPL 10820, IPL 11702 × IPL 321, IPL 220 x SLLOPFL, IPL 232 × SLLOPFL, IPL 321 × Kalamasara, IPL 220 × Tal-9, JL 3 × EC 520204, IPL 316 × L 4714, DPL 62 × IPL 406, IPL 220 × IG 4686, JL 1 × Kalamarara, IPL 181660 × SLLOPFL, IPL 316 × IPL 321, IPL 406 × IPL 316, IPL 10820 × IPL 161485, IPL 10800 × IPL 161485, IPL 316 × IG 13, B-77 × SLLOPFL) were attempted among the elite breeding lines having earliness, high biomass and wider adaptability. The F_1 seeds harvested from these crosses have been grown during current *Rabi*-season 2019-20 for raising F_1 generation.

F_1s seeds were grown from 29 crosses (IPL 316 × IPL 321, IPL 316 x LL 1114, IPL 316 × ILWL 118, IPL 316 × ILL 7663, IPL 316 × LL RVL 16-4, IPL 316 × LL 699, IPL 316 × LL 1122, IPL 316 × PL 101, IPL 316 × LL 1161, IPL 316 × LL 931, IPL 316 × DPL 62, IPL 316 × PL 02, IG 4258 × IG 39 73, DPL 62 × B-77, IPL 220 × B-77, IPL 406 × B-77, IPL 534 × B-77, DPL 62 × 2k/303, IPL 406 × 2k/303, IPL 534 × 2k/303 IPL 406 × SLLOPFL, IPL 316 × SLLOPFL, IPL 406 × ILWL-92, IPL 341 × IPL 538, IPL 342 × IPl 39, IPL 538 × IPL 341, IPL 39 × IPL 342). The F_2 seeds were harvested from 79 F_1 plants of these crosses. These seeds were grown during current *Rabi*-season 2019-20 for raising F_2 generation. The single plants selected from 8 F_2 (126 SPS), 22F_3 (386 SPS), 44 F_4 (597 SPS) and 16 F_5 (129 SPS) were advanced to next generation during current *Rabi*-season 2019-20. Total 120 single plant progenies from 13F_6 were bulked and improved high yielding progenies were selected for evaluation in PYT during current *Rabi* season 2019-20.

Development and maintenance of mapping populations

Trait specific AB QTL mapping populations comprising >500 BC_2F_3 individual plants for yield traits (ILWL 118 × IPL 220) advanced to BC_2F_4 generation for developing NILs. While AB QTL mapping populations for early vigour from a cross ILL 6002 x IPL 220 was advanced from BC_2F_2 to BC_2 F_3 generation. These progenies have been grown during current *Rabi* season 2019-20.

ICARDA nurseries

Three ICARDA nursery of small seeded (LIEN-S-2019), pre-breeding (LIPBN-2019) and earliness (LIEN-E-2019) comprising 25, 7 and 25 entries respectively were evaluated at IIPR, New Research Farm. However, none of entries was identified promising. During current *Rabi* season 2019-20, two ICARDA nurseries have also been grown for identification of useful genetic materials.

Mungbean

Varieties developed

IPM 512-1 (Soorya)

This variety has been developed from the segregating materials of a cross between 'IPM 99-125 and 'Co 5' and identified for cultivation in the North East Plain Zone (Eastern Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal) during spring season (Fig. 5). IPM 512-1 exhibited an average yield potential of 1255 kg/ha. in All India Coordinated Trials with a very high yield potential (up to 2.0 tons/ha). It has portrayed a yield advantage of 15.83% over Pusa Vishal and 13.57% over Pant Mung 5. This variety is highly resistant to Mungbean Yellow Mosaic disease and anthracnose and moderately resistant to *Cercospora* leaf spot. Besides this, it also observed very less pod damage due to thrips. It has green, shining, attractive and medium large seeds (3.9 g/100 seed) with 21.53% protein content and will be a suitable choice to farmers for cultivation during spring season. This variety will provide a superior alternative to IPM 99-125 (Meha).

In addition to above, two varieties *viz*., IPM 409-4 (Heera) and IPM 312-20 (Vasudha) were recommended for release in Uttar Pradesh.

Figure 5: Mungbean variety IPM 512-1 (*Soorya*)

Advancement of breeding

Generation	Families	Crosses	SPS made
F_6	20	20	200 +20 bulks
F_5	45	09	140+09 bulks
F_4	79	13	200+ 13 bulks
F_3	-	20	209+20 bulks
F_2	-	24	24 bulks

Inheritance of seed traits and MYMIV resistance in black gram (*Vigna mungo*)

To benefit crop improvement programme inheritance of seed traits like seed lusture, seed colour and YMV resistance were worked out in a biparental F_2 and $F_{2:3}$ populations. The population was generated with the cross between two contrasting parents: DPU 88-31 and a mutant line of LBG 685. DPU 88-31 is an advanced breeding line of blackgram developed from the cross PLU 131 x T9, which is a dull black seeded and Mungbean Yellow Mosaic India Virus (MYMIV) resistant. Another parent, a spontaneous mutant line of LBG 685 which is a state released variety from ARS, Lam, Andhra Pradesh, and is derived from a cross LBG 402 x (NM/CKM). This mutant line of LBG 685 has Shiny Mottled Green seed in contrast to Dull Brown seed of LBG 685 and is susceptible to MYMIV. Six F_1 seeds were grown along with their parents and advanced to F_2. One segregating F_2 population with size of 346 plants was chosen for study of inheritance of seed traits and MYMIV resistance and after recording phenotypic data population was advanced to $F_{2:3}$. MYMIV data was recorded in F_2 plants and seed traits were recorded in F_2 seeds. Based on the analysis of F_2 phenotypic data, it was found that shiny trait is dominant over dull trait. MYMIV resistance was dominant over MYMIV susceptibility. Mottled green seed colour was dominant over Black seed colour. In all of these cases single gene was found to be operative which was further confirmed in 346 $F_{2:3}$ families.

Station trial and field evaluation for early and MYMIV resistant lines: In this trial, twenty one blackgram genotypes (14 advanced breeding lines, 7 released varieties) (IPU 19-27, IPU 19-11, IPU 19-5, IPU 19-6, IPU 19-7, IPU 19-8, IPU 19-20, IPU 19-24, IPU 19-31, IPU 19-44, IPU 19-46, IPU 19-51, IPU 19-53, IPU 19-55, IPU 02-43, IPU 11-02, IPU 94-1, KUG 479, WBU 108, Shekhar 3, WBU 109) were grown following Randomized Complete Block Design with three replications. Starting from the germination upto maturity stage, various qualitative and qualitative traits were recorded as following: days to first flower, days to 50% flowering, days to first branch, days to first pod, plant height 30 days after sowing, plant height 45 days after sowing, number of pods per plant, number of seeds per pod, number of clusters per plant, days to physiological maturity. Significant variation was observed for test entries as compared to released checks for these traits. One urdbean genotype, IPU 19-27, was developed at ICAR- Indian Institute of Pulses Research, Kanpur which mature significantly early (60-65 days) during summer as well as rainy seasons as compared to other released urdbean varieties (70-80 days) in North Eastern Plain Zone (NEPZ). This genotype was developed from the cross 'SPS 5 x IPU 02-33' following the pedigree method of selection. This urdbean genotype showed resistance to mungbean yellow mosaic India virus (MYMIV) under high natural disease pressure conditions as evidenced in susceptible genotypes of urdbean. The major morphological characteristics of this newly developed genotype are medium height and erect plant type, light green lanceolate leaves, bright yellow flowers, medium length black pods on maturity with pubescence, and dull black seeds. This genotype has the potential to be released as a cultivar after multi-location testing and can also be a useful donor for earliness and MYMIV resistance.

Genetic improvement of urdbean (*Vigna mungo* L. Hepper) for abiotic stresses

Screening of urdbean germplasm lines for abiotic stresses: A set of 310 urdbean germplasm lines were evaluated during *Kharif* 2019 for screening and evaluation for heat and drought, photo-thermo insensitivity and yield attributing traits. Observations were recorded on reproductive phenology, seeds per pod, pods per plant, 100-seed weight and yield per plant under field conditions. Five plants were randomly selected from each line. Under field conditions, 22 genotypes namely, PLU 158, PLU 570, PLU 250, PLU 277, PLU 9910, PLU 543, PLU 302, IPU 99-79, NP 16, IC 10703, IC 43647, IC 2K-226, UH 81-89, IC 106066, UH 87-7, UH 82-14, UH 86-17, DU 519, IPU 90-32, IPU 99-168, IPU 99-60 and PLU 25 were identified as the promising germplasm lines indicating the existence of significant genetic variability for yield and yield attributing traits among the genotypes and identified as the promising lines for both abiotic stresses.

Generation of breeding materials for abiotic stresses: For development of genetically improved breeding lines of urdbean for heat & drought tolerance and photo-thermo insensitivity coupled with new plant type, a new set of 52 crosses were attempted involving diverse breeding lines or parents for heat and drought tolerance and photo-thermo insensitivity during *Kharif* 2019. However, seeds could be obtained from 39 crosses. The list seeds obtained from new crosses are as follows;

	Heat tolerance		*Drought tolerance*
1	IPU 94-1 x GU-1	1	IPU 94-1 x IC 106068
2	IPU 94-1 x PDU-1	2	IPU 94-1 x PDU-1
3	IPU 94-1 x PU-19	3	IPU 94-1 x PU-19
4	IPU 94-1 x Mahoba Local-1	4	IPU 94-1 x STY 2289
5	IPU 02-43 x GU-1	5	IPU 94-1 x UH 85-5
6	IPU 02-43 x PDU-1	6	IPU 94-1 x Mahoba Local-1
7	IPU 02-43 x PU-19	7	IPU 02-43 x IC 106068
8	IPU 02 -43 x Mahoba Local-1	8	IPU 02-43 x PDU-1
9	PDU-1 x IC 106068	9	IPU 02-43 x PU-19
10	PDU-1 x IPU 94-1	10	IPU 02-43 x STY 2289
11	PDU-1 x IPU 02-43	11	IPU 02-43 x UH 85-5
12	PDU-1 x GU -1	12	IPU 02-43 x Mahoba Local-1
	Photo-thermo insensitivity	13	PDU-1 x PGRU 95016
1	IPU 94-1 x LBG-17	14	PDU-1 x IC 106068
2	IPU 94-1 x PDU-1	15	PDU-1 x IPU 94-1
3	IPU 94-1 x PU-19	16	PDU-1 x IPU 02-43
4	IPU 94-1 x IPU-99218	17	PDU-1 x Mahoba Local -1
5	IPU 02-43 x LBG-17	18	PDU-1 x PU 19
6	IPU 02-43 x PDU-1	19	PDU-1 x Pratap Urd -1
7	IPU 02-43 x PU-19		
8	IPU 02-43 x PGRU 95016		

Evaluation and advancement of segregating generations for abiotic stresses: The generations (F_1's and F_2's) advanced during Rabi 2019 and kharif 2019 at ICAR-IIPR, RC Dharwad and ICAR-IIPR, Kanpur, respectively. A total of 27 F_1's (6 F_1's for heat tolerance, 13 F_1's for drought tolerance and 9 F_1's for photo-thermo insensitivity are being raised at ICAR-IIPR Main campus, Kanpur during spring/ summer 2019 for generation advancement to F_2 generation. During *Kharif* 2019, a total of 31 F_1's (6 F_1's for heat tolerance, 15 F_1's for drought tolerance and 10 F_1's for photo-thermo insensitivity), while, a total of 28 F_2's (6 F_2's for heat tolerance, 14 F_2's for drought tolerance and 8 F_2's for photo-thermo insensitivity). A total of 680 single plant selections were taken from different segregating generations (166 SPS for heat tolerance, 308 SPS for drought tolerance and 206 SPS for photo-thermo insensitivity). All segregating generations were advanced through single plant selections.

Biofortification for quality traits in urdbean (*Vigna mungo* L. Hepper) and Fe metabolism related genes' expression analysis in lentil (*Lens culinaris* Medik.)

A set of 20 urdbean genotypes grown in following randomized complete design in NRF and Main Farm of IIPR were harvested and grounded into seed powder and will be tested for seed iron and zinc concentrations using atomic absorption spectrophotometer (AAS).

Germplasm resources and wild accessions: During *Kharif* 2019, 1111 germplasm accessions were rejuvenated (Table 1). This included 289 active germplasm collections, 35 accessions including landraces and farmers' materials, IMIN minicore set comprising 296 accessions, 90 AVMU lines supplied by World Vegetable Centre (advanced breeding materials as well released cultivars of Australia, Myanmar and Bangladesh) and 183 germplasm lines from medium-term storage. The 296 minicore accessions were raised in two replications during Summer as well as *Kharif* seasons at ICAR-IIPR, Kanpur and during *Kharif* season at RS, Dharwad. Data were recorded on 24 morpho-physiological parameters besides disease incidence at IIPR main campus.

Table 1: Germplasm maintenance during 2019 at ICAR-IIPR in mungbean

S. No.	Germplasm Set	No. of accessions
1.	Active germplasm collection	289
2.	Landraces and Farmers' materials	35
3.	Miniore set	296
4.	AVMU advanced lines	90
5.	Germplasm lines	183
6.	Wild accessions	218
	Total	1111

Among wild genetic resources, 218 *Vigna* accessions of 19 species were maintained during *Kharif* 2019 (Table 2). These were also evaluated for morpho-physiological traits following IBPGR descriptors.

Generation and advancement of breeding materials: During *Kharif* 2019, 36 intra-specific crosses were attempted between elite mungbean cultivars (IPM 02-3, IPM 02-14, PDM 139, IPM 302-2, Varsha, IPM 312-20 and IPM 2K14-9) and 11 donor lines (EC 398889, MH 421, LRM 13-11, ICC 550520, LRM 13-44, RBL-50, RMG 1028, BWMCD 31, LGG 460, ML 2479, AVRDC 292). Likewise 19 two-way cross combinations were also attempted in an order to develop more diverse genetic material. However, seed could not be obtained in any of the crosses due to a long spell of rains (>20 days) during the reproductive phase of the crop. In advanced breeding material, superior fixed lines were not isolated due to significant loss of materials as a result of incessant rains. Nonetheless, all 591 single plant selections isolated during 2018-19 were advanced further. These included 53 SPS in F_6, 85 in F_5, 139 in F_4, 75 in F_3, and 239 in F_2 generation.

Table 2: Maintenance and evaluation of wild *Vigna* accessions during 2019

S. No.	Name of species	No. of accessions	S. No.	Name of species	No. of accessions
1.	*Vigna radiata*	7	11.	*V. hainiana*	4
2.	*V. radiata* var. *radiata*	8	12.	*V. trinernia* var. *bournei*	3
3.	*V. trilobata*	100	13.	*V. glabrescens*	1
4.	*V. mungo*	10	14.	*V. pilosa*	3
5.	*V. umbellata*	17	15.	*V. trinernia*	1
6.	*V. sublobata*	5	16.	*V. dalzelliana*	3
7.	*V. aconitifolia*	8	17.	*V. unguiculata*	3
8.	*V. sylvestris*	7	18.	*V. vexillata*	2
9.	*V. stipulaceae*	31	19.	*V. khandalensis*	1
10.	*V. radiata* var. *setulosa*	2	20.	Other	2
				Total	218

Fieldpea

Varieties developed

IPF 16-13 (Harit): This variety is tall, green seeded and leafy type. This variety has been developed from the segregating materials of cross between fieldpea and vegetable type genotypes 'IPF 99-25 and 'VRP-22, respectively. It portrayed >12.45 % yield superiority over the best check VL 42 based on three year performance in NEPZ. In addition, it exhibited 28.53% yield advantage over the ruling check variety 'HUDP-15' in proposed zone. It gave average grain yield of 1752 kg/ha across different locations of NEPZ highest yield of 3146 kg/ha. Moreover, it is resistant to powdery mildew and moderately tolerant to rust. It has been identified, released and notified for NEPZ.

IPFD 12-8 (Aakash): This variety is white seeded, dwarf and leafy type. It has been developed using IPFD 1-10 x DDR 27 as parents. It has portrayed more than 15 % yield superiority over the best check KPMR 522 in State Adaptive Trials over 3 years (2014-

17). It showed average grain yield potential of 1158 kg/ha across different locations of Uttar Pradesh, the highest at 2568 kg /ha. It is resistant to powdery mildew and rust disease. It has medium seed size with round, smooth and white colour and yellow cotyledon. Hence, it has been released for whole Uttar Pradesh.

IPFD 13-2 (Anant): This is a dwarf and leafy type variety of fieldpea. It portrayed more than 24 % yield superiority over the best check KPMR 522 in State Adaptive Trials over 3 years (2015-18) in Uttar Pradesh. The average grain yield of variety is 1409 kg/ha across different locations of Uttar Pradesh. It is resistant to powdery & downey mildew and rust disease. It has medium seed size with round, smooth and white colour and yellow cotyledon. It has been released for Uttar Pradesh.

Genetic stock registered: One genetic stock *i.e.* P-637 (INGR19075) has been registered at NBPGR, New Delhi for tolerance to post emergence herbicide (metribuzin).

Promising entries in AICRP trials: Based on *rabi* 2018-19 AICRP results three entries *i.e.* IPF 18-17, IPF 18-14 and IPF 18-20 of tall type have been promoted from IVT to AVT-1 in NEPZ. Similarly, one entry IPFD 18-2(dwarf type) has been promoted from IVT to AVT-1 in NHZ. This year, total six entries such as IPF 19-11, IPF 19-15. IPF 19-18, IPFD 19-9, IPFD 19-1, IPFD 19-3 are being evaluated in IVT of tall and dwarf trials of AICRP. In addition, four entries *viz.*, IPFD 17-2, IPFD 18-8, IPF 17-19 and IPF 18-20 are being evaluated in Uttar Pradesh state coordination trials. Presently, total nine entries are being tested in UP State Adaptive Trials.

Generation of breeding material: During *Rabi* season *2018-19* total 40 crosses were successfully made using different donor possessing specific traits like large seed size, no. of seeds per pods, pod length, no. of pods, earliness, powdery mildew resistant and rust tolerant. Similarly, during *Rabi* 2019-20 crosses are being attempted using trait specific donors.

Evaluation of advance breeding lines: In station trial for dwarf, 10 genotypes were evaluated along with three checks among these IPFD 19-9 (4206 kg/ha) and IPFD 19-3(3869 kg/ha) were found promising as compared to the best check IPFD 10-12 (3822 kg/ha). In another station trial, 12 tall genotypes were evaluated along with three checks among these none of the genotypes found superior as compared to best check IPFD 10-12. In preliminary yield trial (PYT), total 36 lines including tall and dwarf entries were evaluated with three checks. During *Rabi* 2019-20 in station trial for dwarf 10 genotypes with three checks and in tall, 12 genotypes with three checks are being evaluated. In case of PYT(dwarf), 25 genotypes and PYT(tall) 38 genotypes are being evaluated with three checks.

Selection of promising genotypes from segregating population: 35 crosses were harvested in $_{F1}$ generation. In the segregating generations, single plants were selected based on the desirable traits *i.e.* earliness, seed size, pod length, resistant to powdery mildew, rust and yield/plant. In total 240 single plants from 24 crosses in F_2, 250 single plants from the progenies of 24 crosses in F_3 and 220 single plants from the 22 F_4 generations were selected. In F_5, F_6 and F_7 generation 660, 222 and 47 single lines were evaluated, respectively. During *Rabi* 2019-20 total 40 F_1 raised. In case of segregating population in F_2 (35 crosses), F_3 (63 crosses), F_4 (46 crosses), F_5 (226 single lines) and F_6, (160 bulk lines) have been planted for advancement.

Extra early flowering genotypes in fieldpea: To develop an extra early genotype, efforts have been made using already available early type materials. Accordingly, two crosses were synthesized between DDR 23 (grain type) x VRP 22 (Vegetable type) and DDR 30 (grain type) x VRP 22 (Vegetable) early type parents in *Rabi* season of 2011-12. In succeeding generations, required selections were made based on earliness. Consequently, total 200 single plants were selected based on earliness during 2015-16 in F_4's generations of both crosses; and subsequently single plant progenies of the same were evaluated in *rabi* 2016-17 along with available early type materials. Of them, 50 promising single plant progenies/lines comprising of 35 single plant progeny of DDR 23 x VRP 22 and 15 single plant progeny of DDR 30 x VRP 22 were planted with existing early type materials (Arkel, VRP 6 and AGETA 6) and parents (DDR 30, DDR 23 & VRP 22), and evaluated consecutively for two years *viz.* 2017-18 and 2018-2019 in winter season for earliness. Staggered planting **(04/11/18; 29/12/18; 12/01/19)** of the same set was also done during winter 2018-19. Over the years and staggered planting, the results revealed that one line IPFD 18-14 (DDR 23 x VRP 22) was extra early type. This genotype had flowered and matured in less than 36 days and 75 days, respectively.

Screening for high temperature

For validation purpose, the same set of 151 genotypes including advanced breeding lines, released varieties and germplasm accessions was constituted and staggered planting was done at normal sowing(E1):- 04.11.18, late sowing (E2):- 01.12.18 and very late sowing (E3):- 28.12.18 to expose the fieldpea different growth stages to different temperatures regimes. The observations for various yield attributes such as first flower, days to 50% flowering, days to maturity, first pod bearing node (FPBN), pods/plant, pod length, ovules/pod, seeds/pod, seed set(%), last pod bearing node (LPBN), plant height, 100-seed weight, biological yield and grain yield were recorded. The major objectives were:

(1) **Estimating fieldpea performance under high temperature:** The results revealed that the maximum decline in grain yield was noticed in second date of sowing (E2) which was 51.87% followed by third date of sowing (E3) 49.0 per cent (Fig. 6). The yield reduction was due to exposure of different phases of E-II and E-III to high temperature regimes during cropping season. The decreased grain yield was the collective output of reduction in most of the yield attributes namely, days to maturity, last pod bearing node (LPBN), pods/plant, pods length, seeds/pods, 100-seed weight, biological yield and grain yield. No considerable reduction has recorded in first pod bearing node (FPBN) due to high temperature exposure at any stage of crop growth.

(2) Validation of stable and high temperature tolerant genotypes of fieldpea: GGE biplot is an effective and efficient graphical tool to assess genotype and their interactions effect along with identification of stable and high yielding genotypes. Based on two years data, the GGE biplot analysis revealed that PC1 and PC2 accounted for 71.52 per cent of the total grain yield variations. Similarly, based on GGE biplot 'mean vs. stability' analysis the

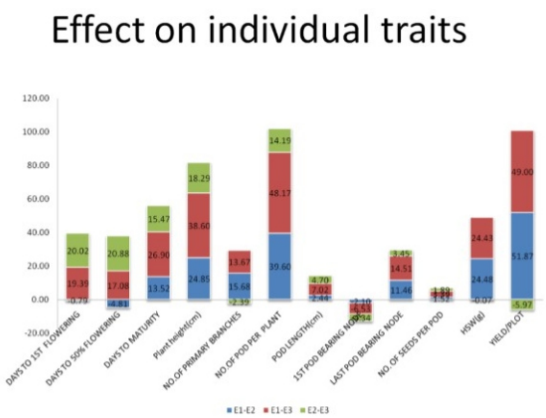


Figure 6: Effects of high temperature exposure on different yield attributes of fieldpea

stable and high yielding genotypes for grain yield were DMR-7, IPF 6-16, IPF 12-17 and IPF 11-15 (Fig. 2). In addition, based on discriminating ability and representativeness, first planting was found to offer near ideal environmental conditions for good fieldpea crop performance followed by second date of sowing. Thus, the aforesaid genotypes can be used as stable/durable sources for future breeding programme to develop high temperature tolerance cultivars with high yield. Since the crop is grown in diverse environments/ecologies, the stable and high temperature tolerant cultivar will be more successful in all production systems which lead to improved productivity of the fieldpea.

Development of mapping population: $F_{6'S}$ harvested (220) derived from HFP 4 (S) x FC1 (R) for rust resistance has been harvested for advancement. During *Rabi* 2019-20, the same mapping is being advanced.

Evaluation of Advanced Breeding Lines of Pulses at Rs Dharwad

Mungbean: Total 24 advance breeding lines of mungbean were evaluated during summer season. The entries such as IPM 14-9 (60 days) and IPM 9901-13 (62 days) were the earliest to mature. The genotypes such as IPM-14-6 (1240 Kg/ha), IPM 14-10 (1090 kg/ha) and IPM 604-1-6 (1008 kg/ha) were found to be promising for summer cultivation in Karnataka.

Chickpea: Two station trials of chickpea (Total 52 advance breeding lines) were evaluated for seed yield and component traits during *Rabi* season. About 16 genotypes (DTIL-trial) were evaluated for drought tolerance traits under rain out shelter during *Rabi*-2018-19.

Generation of breeding materials: Fresh crosses (17 crosses) were made in cowpea and horsegram involving donor lines for yellow mosaic disease resistance, heat tolerant, photo-thermo insensitivity and bruchid tolerance. Segregating materials of cowpea, horsegram, chickpea and urdbean were advanced during *Kharif*/summer season.

Off-season generation advancement of pulses: During 2019-20, segregating materials for generation advancement were received from 8 centres of AICRP on Chickpea such as Rahuri, Sehore Jabalpur Sriganganagar Junagadh, Coimbatore Ludhiana and Bijapur. Chickpea and lentil breeding materials generated at IIPR were advanced during the *Kharif* season at IIPR RRC, Dharwad and advanced breeding materials were sent to the respective centers.

2. **Germplasm management, evaluation and rejuvenation (Plant genetic resource management and its utilization through pre-breeding)**

Chickpea

Maintenance of wild *Cicer* species (Pre-breeding): 113 wild accessions of chickpea belonging to six *Cicer* species, viz., 42 *Cicer reticulatum* accessions, 32 *C. judaicum,* 27 *C. pinnatifidum*, 6 *C. echinospermum*, 3 *C. cuneatum*, 2 *C. yamashitae*, and 1 *C. bijugum* accessions were maintained in the wide hybridization garden as ICAR-IIPR, Kanpur (Fig. 7). Segregating generations of populations derived from pre-breeding hybridization utilizing landraces, *C. reticulatum* and *C. pinnatifidum* are being maintained and also using these lines as donors to enhance traits like, drought, heat tolerance, yield, plant architecture, seed/pod, seed protein content. A station trial has been constituted comprising of the advanced breeding lines derived from the pre-breeding hybridization during *Rabi* 2018-19.

Figure 7: View of the chickpea wide hybridization garden ICAR-IIPR, Kanpur with 113 wild accessions from six different wild species and 97 trait specific donor germplasm accessions

A diverse panel of 550 chickpea germplasm lines sown for evaluation and rejuvenation under field condition during 2019-20. Morphologically distinct lines were isolated from the landrace population of T39-1 (donor for high protein content) through pre-breeding and acclimatization, distinct families were constituted from those lines based on seed characteristics. Families with improved angular type seeds with desirable grain parameters were constituted from individual single plant selections and sown in *Rabi* 2019-20 for field evaluation. The isolated lines from the land race population of high protein line T 39-1 (protein content 28%) varied in terms of protein content in seeds ranging from 24-29%.

A panel of 30 germplasm accessions with improved podding and seed setting under terminal heat stress identified in the last season were sown for field evaluation. 70 advanced breeding lines with >2 seeds/pod have been identified in a breeding population (IPC 06-88/ILWC 179) derived from *C. echinospermum* during *Rabi* 2018-19 were sown for field evaluation and study of the seed setting traits. A preliminary yield trial and a station trial were constituted with the lines derived from pre-breeding and wide hybridization and sown for field evaluation. Segregating generations developed from prebreeding hybridization have been sown for selection and genetic enhancement of the respective target traits.

Pigeonpea

Germplasm rejuvenation: The germplasm accessions were categorized on the basis of phenology and maturity and a total of 756 cultivated germplasm were planted for seed multiplication. A set of 21 wild accessions of *Cajanus albicans*, *C. lineatus*, *C. sericeus*, *C. platycarpus*, *C. scarabaeoides*, *Rhynchosia rufescens and R. bracteata* were raised in net house for crossing and rejuvenation.

Generation of pre-breeding materials: Pre-breeding in pigeonpea was initiated with an aim to broaden the genetic base of breeding population linking it with utilization of germplasm resources and wide hybridization. Crosses were attempted between *Cajanus cajan* and *C. scarabaeoides* and also among different lines of *C. cajan* for the incorporation of trait specific alleles into improved lines and for the study of inheritance of concerned traits. New wide crosses are being generated and inter-mating done among the wild derivatives to incorporate useful alleles from the wild crop relatives. *Early maturing segregants were identified from the* F_3 *progenies of* C. *cajan/C.* scarabaeoides are being advanced to the next generation. A trial is being conducted for the identification of elite line emanating from the cross of Early 3 (determinate, early and pod bearing in cluster) x *C. scarabaeoides* (ICP 15685), UPAS 120 x *C. scarabaeoides* (ICP 15731), IPAC 64 x *C. cajanifolius* (ICP 15629).

Generation advancement of pre-breeding materials: The progenies derived from wide crosses require seneral generations of selfing to fix the segregating alleles and accordingly, selection and selfing is continued up to late filial generatons. The BC_1F_8 and F_9 populations derived from crosses, Early (determinate, early and pod bearing in cluster) x *C. scarabaeoides* (ICP 15685), UPAS 120 x *C. scarabaeoides* (ICP 15731), IPAC64 x *C. cajanifolius* (ICP 15629) are being generated. The derivatives of wild crosses were advanced to F_9 generation. The selfed progenies of the cross derivatives among selected F_3's plants between the adapted lines and the F_4 derivatives of *C. scarabaeoides* namely, NDA-1 x WDN 100, Pusa 2001 x Bennur local, IPAC-79 x WD-5, Maruti x WD-5-1, Maruti x WDN 100, WDBCU-5-2 x WDBCU-5-1were advanced to the F_4 generation. Selections were made from the F_7 derivatives of *C. scarabaeoides* (IPAC 8 x WDN2-258, ICP 88039 x IPAC 3, ICP 88039 x WD 3, WDN1-95 x IPAC 3, IPAC 79 x WD 4, IPAC 79 x WD 5, IPAC 79 x WD 3, IPAC 70-1 x WDN2-288) for advancing them to F_8.

The F_7's derived through intercrossing of TTB7, IPAC 80, IPAC 79, BSMR 853, IPA 8F and JKM 189 were advanced to F_8 generation. The BC_1F_6 and F_7 generations of [IPAC 79 x IPAC 80, JAP 10-50 x IPA 203, Maruti x IPA 8F, NA1 x (ICPL 87154), IPAC 80 x (ICPL 87154), IPAC 79 x (ICPL 87154), Prabhat x IPAC 64 , LRG 30 x Dholi Local, ICP 970 x JAP 10-52, Bahar x Maruti, NDA 1 x IPA 8F, NDA 1 x IPAC 68] were advanced to the next generation.

Screening of genotypes for *Fusarium* wilt and *Phythopthora* stem blight resistance: 122 advance lines including germplasm accessions were sown in the wilt sick plot for screening against *Fusarium* wilt. In another screening trial, 26 advance lines derived from multiple crosses were evaluated for *Phythopthora* stem blight (PSB). The intensity of disease in PBS sick plot was very high which led to more than 90% mortality in the susceptible check UPAS 120. *F.* wilt disease was initiated in the susceptible checks in wilt sick plot which is dominated by race 2 of *Fusarium udum*. The final scores of disease severity will be based on the mortality of plants in the month of March. Genotypes will be classified into resistant and susceptible category based on the final score.

Evaluation for pod borer tolerance in wild derivatives: 43 advance lines derived from *C. scarabaeoides* are being screened for tolerance against *Helicoverpa armigera* and *Maruca vitrata*. This trial is being for evaluation of tolerance against insect damage.

Maintenance of wild relatives of pigeonpea: A wild pigeonpea garden has been established in the main farm of ICAR-IIPR Kanpur including the accessions *C. scarabaeoides* (ICP 15683, ICP 15685, ICP 15687, ICP 15688, ICP 15689, ICP 15690, ICP 15693, ICP 15698, ICP 15699, ICP 16950, ICP 15700, ICP 15710, ICP 15712, ICP 15711, ICP 15713, ICP 15724, ICP 15725, ICP 15727, ICP 15731, ICP 15882, ICP 15883, ICP 15922), *C. platycarpus* (ICP 15661, ICP 15662, ICP 15663, ICP 15664, ICP 15665, ICP 15666, ICP 15667, ICP 15668, ICP 15921), *C. cajanifolius* (ICP 15630, ICP 15631, ICP 15632, ICP 15873) *C. lineatus* (ICP 15642), *C. crassus* (ICP 15767, ICP 15770, ICP 15771, ICP 15772, ICP 15773, ICP 15774, ICP15775, ICP 15776), *C. sericeus* (ICP 15761), *C. albicans* (ICP 15616, ICP 15617, ICP 15618, ICP 15621, ICP 15625, ICP 15627, ICP 15628) *Rhynchosia minima* (ICP 15923), *R. bracteata* (ICP), *R. suaveolens* (ICP 15866), *R. rufescens* (ICP 15861). Seedling vigour showed range of variation among the species as well as accessions. *C. scarabaeoides* and *C. platycarpus* easily germinated. In the secondary gene pool C. sericius and *C. lineatus* were difficult to establish due to very poor initial vigour. Morphological and phonological data is being generated. *C. platycarpus* showed no sensitivity towards photoperiod and temperature. A set of wild accessions are being evaluated for resistance against *Fusarium* wilt in the wilt sick plot. *R. rufescens* showed lack of autogamy and did not set pod in the absence of hand aided pollination.

Lentil

During *Rabi* 2019-20, 450 accessions of active germplasm, a diverse set of 94 accessions; a population of 96 accessions received from Kota were maintained. In addition to this, 206 single plant progenies from 37 F_6 wild x cultivated crosses were evaluated for identification of improved breeding lines. Total 225 accessions of wild species were grown for maintenance. >800 accessions of lentil germplasm are being grown for evaluation at RRS Bhopal.

Urdbean

Rejuvenation and maintenance: 150 black gram germplasm accessions were rejuvenated.

Prebreeding and interspecific hybridization: Under the pre-breeding activity, few inter-specific crosses were made as following: IPU 13-1 x *Vigna sylvestris*, IPU 13-1 x *V. sublobata*, IPU 13-1 x *V. umbellata*, IPU 11-2 x *V. dalzhiana*, IPU 13-1x *V. pilosa*, IPU 13-1 x *V. trilobata*, IPU 13-1 *x V. aconitifolia*. However, due to excessive rainfall F_1s could not be harvested.

Performance of entries in AICRP trials: One entry IPU 11-02 is being tested in AVT 1 trial in the South Zone under Rice Fallow condition.

Fieldpea

Germplasm rejuvenation and evaluation: During *Rabi* 2018-19, total 200 accessions of fieldpea rejuvenated and evaluated for different traits like days to 50% flowering, anthocynin, leaf size, foliage color, leaf axil color, plant height, petal color, pod no./axil, pod curvature, pod beak, pod colour, pod/plant, pod length, no. of seeds/pod, days to maturity, seed colour and 100-seed weight, grain yield/plant and plot yield.

Different quantitative traits such as number of pods/plant, primary branches, plant height, pods/axil, pods length, seeds/pod, 100-seed weight, days to flowering, days to maturity and yield/plant were scored. The descriptive statistics and two ways clustering indicated that there is ample amount of variability exists in present set of germplasm accessions. The clustering represents the group of genotypes based on similarity in different traits. The colour intensity showed the trait value magnitude.

Identification of Trait specific donors: Based on evaluation of 200 accessions of fieldpea trait specific donor has been identified. The trait specific donors are mentioned below in Table 3.

Table 3: Trait specific donors of fieldpea

Character	Accessions
Days to flowering (<50)	EC-598648, EC-598666, IC-310-833-A, EC-598511, IC-291544, EC-598650, EC-598651, EC-598658, EC-598501, EC-598523, EC-598582, EC-598640
Days to maturity (<100)	EC-598585, EC-598648, EC-598666, EC-598641, EC-598640, EC-598590, EC-414487
Pods/plant (>25)	IC-469151, IC-342023, IC-49684, IC-342022, IC-427191, IC-469139,
Pod length (>6.0cm)	EC-598646, IC-469147, IC-469139, EC-598663
HSW (>28g)	IC-106905, EC-598582, EC-598511, IC-469135, IC-342038, EC-598526
Grain yield (g)	IC-469161, IC-469151, EC-269421, IC-469156, IC-469158, IC-49689

Cowpea

Generation of breeding materials: During *Kharif* 2019, 20 crosses were made using different trait specific donors like determinate plant type, Yellow mosaic disease, powdery mildew, bruchid tolerance, pod length, number of pods, grain size and colour.

Generation advancement: Total 15 F_1,s were raised during *Kharif* 2019 for generation advancement.

Germplasm evaluation and rejuvenation: During spring season-2019, a set of 119 genotypes rejuvenated and evaluated for different qualitative and quantitative traits. Genotypes like EC-738206, VBN-1, GC-4, PL-4, GC-5, GC-6 and EC-738156 flowered in less than 49 days. On the basis of pods per plant, the best genotypes were EC-725978, EC-723774 and EC-723996 with > 15 pods/plant. Based on pod length, best performing genotypes were EC-738125, EC-723989 and Ec-458480 with more than 11.0 cm length. In case of days to maturity, the best performing genotypes were PL-4, EC-738206, GC-4, GC-5 and GC-6. The same set of genotypes also evaluated in summer 2019 for different quantitative and qualitative traits. On the basis of days to flowering, the promising genotypes were PL-4, Co-4, EC-366776, EC-738156 and EC-738181 flowered in 37 days. The best performing genotype for pod length were EC-738156, EC-738125 and EC-728206 (>12.0 cm). In case of maturity the best genotypes were EC-738206, EC-738156 and PL-4 (<53 days). Likewise in Kharif 2019 around 200 genotypes rejuvenated and evaluated for different quantitative and qualitative traits. Ample amount of variability was recorded for all the studied traits. Based on flowering the earliest genotypes were EC-723909 followed by EC-528393 (<31 days). Similarly in case of days to maturity the earliest genotypes were EC-528393, EC-724601, EC-723909 and EC-723807 (< 58 days). On the basis of pod length, the promising genotypes were EC-724780, EC-738125 and EC-724615>15.00 cm). In case of no. of pods per plant, the best genotype was IT-83-5-22-13 followed by EC-724774>18.33). Total 25 accessions of wild *Vigna* species of cowpea were maintained in *Vigna* garden of IIPR.

Cowpea germplasm evaluation for different traits at IIPR RS, Dharwad: Total 190 accessions of cowpea germplasm were rejuvenated and evaluated for different morphological traits during *Rabi* season 2018-19. Wide range of variations were observed for different morphological traits such as days to maturity, seed size, pod length, seed coat colour *etc*. The entries such as IC-402180 (73 days) and IC-198355 (73 days) were the earliest to mature followed by GP-37 (74 days) and EC-472252 (75 days). The accessions such as MP-2 (90 days), IT-97-1-499-38 (89 days) and IC-402172 (88 days) took more number of days to mature.

Rajmash

Germplasm management: More than 1800 germplasm accessions have been procured from National Gene Bank unit, NBPGR, Regional Station, Shimla (Himachal Pradesh) and Bhowali. In addition to this, during 2019-20, imported 570 lines of biofortified Common Bean from CGIAR institute CIAT (International Centre for Tropical Agriculture), Colombia through proper means. Evaluation, multiplication and characterization of 1000 accessions of common bean gene bank has been carried out and evaluation and characterization of recently received germplasm accessions will be accomplished in succeeding years.

Table 4. Common bean Genetic Resource Maintained at ICAR-IIPR, Kanpur

Time line	Germplasm collection	Botanical name	Source of Collection
---	52	*Phaseolus vulgaris*	IIPR, Kanpur
2016	270	*Phaseolus vulgaris*	NBPGR-RS, Bhowali
2017	9	*Phaseolus vulgaris*	SeKU, Jammu
2017	176	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2018	73	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2019	113	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2019	1200	*Phaseolus vulgaris*	CIAT, Colombia
2019	3 wild	*Phaseolus lunatus*	NBPGR-RS, Shimla
2019	3 wild	*Phaseolus coccineus*	NBPGR-RS, Shimla
Total	**1899**		

Maintenance of released varieties = 21
Breeding material handled at Institute =19 F_1 Hybrids, 3 F_3 and 3 F_4 progenies
Active germplasm used in study =350

Table 5. Identification of trait specific germplasm accessions

Character	Promising accessions
Early flowering (< 50 days)	EC 931101, EC 931102, EC 93110 8, EC 931122 & EC 931119
Early maturity(<90-100days)	EC 931159, EC 931104, EC 931108, EC 931110, EC 931185, EC 931162, EC 931179 & EC 931203
Pod length (>12 cm)	EC 931535, EC 931530, EC 931137, EC 931139, EC 931366
No. of pods/plant (>20)	EC 931106, EC 931109 & EC 931149
No. of seeds per pod (> 5)	EC 931366, EC 931572, & EC 931413
Resistan to BCMV	EC 931572, EC 931324, EC 931371, IC 340947, IC 360831, IC 417350
Resistant to Anthracnose	IC 340947
Upright branching	IC 340947, GPR 203, EC 931433 & EC 931435
Large seed type	EC 9 31102, EC 931110, EC 931111, EC 931119, & EC 931156
Extra small seeded type	EC 931132, EC 931415, EC 931439, EC 931342, EC 931312
Purple Stem anthocyanin	EC 931106, EC 931107, EC 931108, EC 931115
Circular seed type	EC 931168, EC 931314, EC 931186, EC 931202, EC 931204, EC 931298, EC 931293 & EC 931262

Breeding materials generated: During *rabi* 2018-19, fresh crosses were attempted and total 19 F_1 hybrids successfully produced for desired traits *viz.*, BCMV resistance, bush plant types, anthracnose disease resistance and cold tolerance. In *Kharif* 2019, out of nineteen F_1 hybrids, 11 hybrids were advanced to F_2 segregating generation and they are BLF101 × Uday, Amber × BLF101, Arka Bold × Amber, Amber × Jawala, Amber × Uday, Amber × Kailash, BLF101 × Amber, Utkarsh × HUR15, Amber × Arun, BLF101 × HUR15, & HUR137 × Arun and including other advanced breeding material like 215 SPS of 3 F_3 and 150 SPS of 3 F_4 were advanced at NBPGR, regional station, Shimla, Himachal Pradesh.

Germplasm maintenance at IIPR-RRC, Dharwad

Mungbean-mini-core: 296 accessions of mungbean-mini-core received from world vegetable centre, Hyderabad were rejuvenated and characterized for qualitative and quantitative traits during kharif season at Dharwad centre. The genotypes such as VI001408BG, VI001419BG, VI001509AG and VI002529 B-BL were found to be resistant to MYMV, Anthracnose, powdery mildew and Cercospora leaf spot disease.

Urdbean: About 150 accessions of urdbean germplasm were maintained and evaluated for different quantitative traits during *Kharif* season. The entries PU-519 (64 days) and IPU-99-18 (65 days) were the earliest to mature followed by IPU 90-32 (67 days) and PLU-13-69 (70 days).

Cowpea: About 100 accessions of cowpea received from NBPGR, were rejuvenated and evaluated for different quantitative traits during summer season. EC-738107 (68 days) and EC-109174 (71 days) were found to be the earliest maturing genotypes followed by the IC-20482 (72 days) and IC-8966 (73 days).

Horsegram: Total 200 accessions of horsegram were being rejuvenated and evaluated for different traits during *Rabi* season (Fig. 8).

Figure 8: Horsegram germplasm maintained at IIPR-RRC Dharwad

Maintenance of wild species of pulses: Wild *Vigna* species such as *V.umbellata* (IC-251442), *V. aconitifolia* (LRM-2013-01), *V.trilobata* (LRM-2013-30, LRM-2013-34) and *V.stipulacea* (LRM-2013-36, LRM-2013-37) and wild chickpea accessions (25) were being rejuvenated and evaluated for different traits during rabi season.

Seed quality enhancement

Nucleus Seed Production and Maintenance Breeding:

Chickpea: 653 kg nucleus seed produced of chickpea varieties IPC 06-77 (74.9 kg), IPC 11-112 (95.2 kg), IPC 04-01 (11.3 kg), IPC 04-98 (59.9 kg), IPC 05-62 (21.8 kg), IPC 10-62 (11.5 kg), IPCK 02-29 (130 kg), IPCK 04-29 (172 kg) and DCP 92-3 (76.4 kg) and single plant selections of 200, 100, 100, 100, 100, 100, 250, 250, 100, respectively was done during 2018-19. The nucleus seed has supplied to seed production unit for enhancing breeder seed production. The genetic purity was maintained with and single plant selection and raising progeny row.

Mungbean: During 2019, 110 kg nucleus seed of eight mungbean varieties (IPM 410-3 (Shikha), IPM 205-7 (Virat), IPM 99-125 (Meha), PDM 139 (Samrat), IPM 2-3, IPM 2-14, Kanika and Varsha) was produced.

Fieldpea: The nucleus seed production programme of institute developed fieldpea varieties was conducted during 2018-19 as per DAC indent. The variety wise nucleus seed production was such as Adarsh (50.0 kg), Aman (240.0 kg), Vikas (70.0kg), Prakash (30.0 kg), IPFD 10-12 (350.0 kg), IPF 4-9 (236.0 kg), IPFD 6-3 (75.0 kg), IPFD 11-5 (310.00 kg), IPFD 9-2 (69.0 kg), IPFD 2014-2 (117.0 kg) and IPFD 12-2 (570.0 kg). Similarly, during rabi 2019-20 nucleus seed production programme for all IIPR released varieties is being taken based on DAC indent.

A. Externally Funded Projects

1. Characterization, mapping and transcriptome analysis of seed protein, β-carotene and mineral contents in chickpea (*Cicer arietinum* L.)

High protein donors identified in the previous season from a diverse panel of 404 germplasm accessions were confirmed and T39-1, ICC 5912 and ICC 8397 were identified as the stable high protein (~28%). All the chickpea varieties in the seed chain of India were identified with protein content ranging from 17-23%. F_3 seeds of the mapping populations developed for genetic enhancement for protein content in chickpea were harvested after *Rabi* season 2018-19. Mapping population JAKI9218/T39-1 (n=200) was phenotyped for total protein content in seeds and their protein content ranged from 19-28% (dry weight) in comparison to the protein content of the parental lines (21% in JAKI9218 and 29% in T39-1). Sixty one polymorphic SSR markers were identified between the parental lines JAKI9218 and T39-1 after parental polymorphism survey with four hundred and fifty SSR markers. The polymorphic SSRs cover all the linkage groups (8 chromosomes) with lesser coverage in the LG 7. Five SSR markers were identified to be polymorphic between the parents (JAKI 9218 and T 39-1) in Linkage group (LG) 1, six in LG 2, seven in LG 3, seven in LG 4, eight in LG 5, fourteen in LG 6, three in LG 7 and eleven markers were found to be polymorphic in LG 8.Population genotyping with the polymorphic markers and data analysis are under progress and by November 2019, 42 lines have been genotyped. Breeding population developed for enhancement of protein content IPC 04-98/T39-1 was also duly advanced to next generation (F_5) during 2018-19 and seeds harvested.

2. **Association mapping of nutritional quality traits (protein, iron, zinc) in chickpea**

The project is funded by CRP-GLDC programme of ICRISAT. On the basis of performance under field conditions observed during *Rabi* 2018-19, potential chickpea genotypes identified for earliness, podding behaviour, improved source: sink relation and quality parameters are to be tested during *Rabi* 2019-20. Diverse panel comprising of 140 accessions have been sown under timely sown condition for field evaluation. Entries ICCV 96030 (Check), ICCV 8305, ICC 5362, ICC 8584, ICC 16216, ICC 5434, ICC 16641 and ICC 16343 were identified for early flowering during last season to be confirmed during the ongoing *Rabi* season. Lines are to be evaluated for nutritional quality traits as well.

3. **National Innovations on Climate Resilient Agriculture (NICRA)**

Chickpea

Regarding genome wide association mapping for heat relevant traits, phenotypic data for various heat tolerance related traits have been recorded for two years in 182 chickpea genotypes under both normal and late sown conditions. Neighbourhood joining tree analysis grouped the whole set of genotypes into two clusters. Likewise, factorial analysis grouped the all genotypes into two groups. To discern the molecular diversity genotyping of 186 genotypes with 120 SSR markers resulted in a total of 611 alleles with an average of 5.1 alleles per marker. Likewise, population structure analysis also grouped the entire genotypes into two sub populations. Thus, the genetic variability captured both at phenotypic and molecular level could be useful for developing heat stress resilient chickpea genotypes. Chickpea germplasm line ICC 15925 and ICC 15894 showed superior pods/plant and high grain yield/plant under late sown condition. Based on PYT data, ICC 15925 showed superior yield performance to the checks RSG 888, JAK I9218 and JG 14. During screening of germplasm for heat tolerance, ICC 12213 line was identified based on high podding under both normal and late sown conditions, displaying high filled pods/plant and high pollen fertility under heat stress.

Lentil

Transcriptome analysis of genotypes grown under heat stress: Heat tolerant genotype IG 4258 and heat sensitive genotype IG 3973 were also grown under late sown and leaf samples were collected at different dates at temperature below 35 ºC and above 35ºC from field. The transcriptome analysis of the heat tolerant and sensitive genotypes resulted in assembling of a total of 2,09,549 transcripts. Among these, 94,437 transcripts were annotated. This analysis also identified 21,487 genic-SSRs that can be used in molecular mapping of heat tolerant genes in lentil. The differential gene expression analysis showed up-regulation of 678 transcripts and down regulation of 680 transcripts between tolerant and susceptible genotypes at early reproductive stage. While 95 transcripts were up-regulated and 70 transcripts were down-regulated at late reproductive stage. This study identified the candidate genes for different pathways differentially expressed under heat stress conditions in lentil. A gene encoding a heat shock proteins was identified to be up-and down-regulated under heat stress condition. These findings can further be validated for identification mechanism underling the heat tolerance in lentil.

4. **Delivering more produce and income to farmers through enhancing genetic gains for chickpea and pigeonpea project**

Generation of breeding material: Six crosses (JSC 37/GNG 1581, GNG 1581/SA1, BG 212/SA1, GNG 1581/RSG 888, RSG 888/ICC 4958, JSC 37/SA1) were attempted during *Kharif* 2019 at Dharwad. Similarly, six crosses (GNG 1581/JSC 37, JAKI 9218/SA1, RSG 888/CC 4958, GNG 1581/IPC10-134, KWR 108/ICC 4958, GNG 1581/IPC 07-28) were made for developing breeding lines resistance to biotic and abiotic stresses. The F_1s' of all crosses has already been raised during 2019-20 at Kanpur.

Generation advancement: F_1 populations of five crosses (GNG 1581/IPC 07-28, JAK I9218/JG 14, JAK I9218/JSC 37, RSG 888/JG 14, JAK I9218/JG 16) and F_2 population from 3 crosses (DCP 92-3/ICC 4958, JAKI 9218/JG 14, JG 14/ICC 4958) were raised during *Rabi* 2018-19 for development of mapping population and breeding lines. F_2 plants of all crosses were harvested based on single plant. The single plant progenies of segregating materials has already been sown during 2019-20 at Kanpur.

Development of mapping population: Mapping populations (wilt, DRR, drought) from 3 crosses (DCP 92-3/ICC 4958, JAKI 9218/JG 14, JG 14/ICC 4958) has been raised during *Rabi* 2019-20.

Evaluation of elite breeding lines of Desi chickpea: Seventy elite breeding lines and checks (DCP 92-3, JAKI 9218) with three replications were evaluated during *Rabi* 2018-19. Qualitative & quantitative traits were recorded. Entry IPC 08-11

(2091 kg/ha) was found top yielder followed by entry IPC 14-112 (2054 kg/ha), PG 0913-2-11 (1987 kg/ha), IPC 10-142 (1981 kg/ha), ICCX 090020-F4-P5-BP-BP-BP (1953 kg/ha), and checks DCP 92-3 (1925 kg/ha) & JAKI 9218 (1503). Entry IPC 08-11 produced 8.6% and 39.1% more yield than DCP 92-3 & JAKI 9218, respectively.

Farmers participatory varietal selection trial (FPVS): Five chickpea varieties (JG 14, RVG 202 RVG 203, Shubhra and Ujjawal) were demonstrated in 12 targeted villages during *Rabi* 2018-19 and covered a total of 32.42 ha area in Fatehpur (10.97 ha), Mahoba (12.6 ha) and Jalaun districts (8.85 ha) of Uttar Pradesh. The crop of chickpea made male farmers to tend to their crop rather than leave the village for off-farm employment after *Kharif* season or rice crop. A total of 25.90 Qtls of quality seed including 3.90, 8.0, 2.0, 8.4 and 3.6 Qtls of chickpea varieties JG 14, RVG 202, RVG 203, Shubhra and Ujjawal, respectively were distributed among 94 farmers during Rabi 2018-19 under Genetic Gain Project. Altogether, 106 Farmer's Participatory Varietal Selection (FPVS) trials including 55, 30 and 21 were conducted in a cluster by forming groups of farmers in each village of Fatehpur, Mahoba and Jalaun district, respectively. After compilation of variety-wise grain yield performance data, the highest average yield was recorded of *Desi* chickpea variety RVG 203 (20.98 q/ha) followed by JG14 (20.77 q/ha), RVG 202 (18.63 q/ha), Shubhra (18.15 q/ha) and Ujjawal (17.34 q/ha) of FPVS trials in the project targeted districts (Fatehpur, Mahoba, Jalaun) under Genetic Gain project during *Rabi* 2018-19. The grain yield of chickpea ranged from 18.48 to 23.88 qtls/ha, 12.69 to 15.93 qtls/ha and 18.53 to 22.63 qtls/ha in Fatehpur, Mahoba and Jalaun districts, respectively.

5. Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops

This project is funded by ICAR and BMGF (Bill and Melinda Gates Foundation, USA) and IIPR (Chickpea breeding and Pigeonpea breeding) is a partner along with nine other ICAR institutes and ICRISAT. AICRP (chickpea) is also a partner in the project. Digitalization of the historical breeding data of the chickpea programme and adoption of novel approaches in the ongoing breeding programme are the major activities under the project. The pedigrees of the breeding lines subjected to different field trials (station trials and preliminary yield trials) since 2014 have been duly digitalized and certain segregating generations have been uploaded in the Breeding Management System (BMS) platform. Finalization of the donor and recipient parental panel of the breeding lines subjected to trial during *Rabi* 2018-19 and 2019-20 is under process in chickpea which will be uploaded to the BMS platform following which the digitalization and unique ID assignment process will be done online in the platform. Nineteen trials of pigeonpea have been uploaded in the BMS platform in the last season. Digitalization process of the breeding lines developed has been initiated in both chickpea and pigeonpea. Three hands on training sessions have been conducted under the project, one at ICAR-IARI, New Delhi and two in ICRISAT, Hyderabad and scientists from ICAR-IIPR has been trained in digitalization and modern breeding approaches. Two target product profiles of chickpea breeding programme has been submitted from ICAR-IIPR, Kanpur and IIPR-RRS, Bhopal respectively. An "Era Trial" of chickpea has been constituted with guidelines laid out from the AICRP (Chickpea) which will be conducted under this project with the historical varieties to estimate the genetic advance during *Rabi* 2019-20. Field trials for evaluation of advanced breeding lines under the project have been sown during the ongoing *Rabi* 2019-20.

6. Genomic data analysis to elucidate the regulatory network and candidate genes underlying cytoplasmic male sterility in pigeonpea (CABin scheme)

Small RNA and degradome sequencing to find microRNAs and their gene targets in male sterile pigeonpea: Small RNA libraries constructed from unopened flower buds of male sterile (UPAS 120A) and cognate fertile (UPAS 120B) were sequenced using Illumina platform. Analysis of the dataset with ***mirPRo***identified a total of 316 miRNAs, of which 248 were known and remaining 68 were of novel type. Known miRNAs belonged to 46 miRNA families, and maximum miRNAs were represented by miR166 family (25) followed by miR171 (20) and miR169 (17) families.

Further examination of length distribution of the identified miRNAs suggested abundance of 21-nt, 24-nt and 20-nt types. The miRNAs and their targets were mapped to all LGs except CcLG 05 and CcLG09.Target prediction using psRNATarget identified a total of 2,282 and 445 genes as targets of known and novel miRNAs, respectively. Majority of these targets were considered to be associated with"Cell", "Cell part" and "organelle" GO terms.

Among 'Molecular Function' category, "binding" and "catalytic activity" were the key functional groups, whereas large percentage of genes participated in "cellular" and "metabolic processes" under the category 'Biological processes'. Dedradome sequencing identified 1833 gene targets.

A subset of 28 miRNAs was found to show differential expression between the CMS line and the fertile line. This is the first report on identification of microRNAs in pigeonpea using high throughput sequencing.

Comparative transcriptome profiling to find candidate genes and metabolic pathways associated with A_4-CMS: Genome-wide gene expression profiles were obtained in CMS line ICPA 2043 and its isogenic maintainer line ICPB 2043 through whole transcriptome sequencing of two stages (<10 mm and >10 mm size) of unopened flower buds of two genotypes. Mapping of the sequence reads to the reference genome of pigeonpea using Hisat2 showed up to 96% alignment rate. Sets of genes expressing differentially (DEGs) across two stages and two genotypes were found. A total of 2,036 genes showed differential expression between stage 1 and stage 2 of ICPA 2043, whereas only 62 genes had differential expression between stage 1 and stage 2 of ICPB 2043 (Fig. 9). Differential expression was also monitored for 2,007 genes between the stage 2 of ICPA 2043 and ICPB 2043.

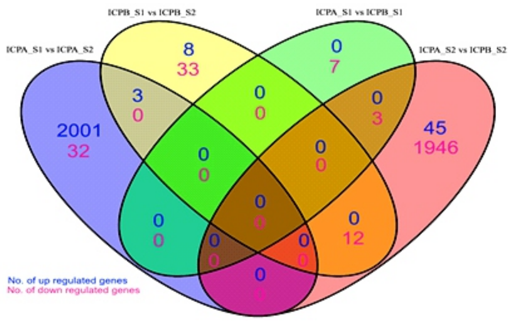


Figure 9: Venn diagram depicting DEGs between two stages and two genotypes

All DEGs were then assigned into three main GO categories: biological process (BP), cellular component (CC), and molecular function (MF). Among the BP category, "metabolic processes" "cellular processes" and "response to stimulus" were the dominant functional groups. Similarly, "cytoplasm", "nucleus" and "integral component of membrane" were the three most highly enriched GO terms in CC category. Among the MF category, enriched GO terms associated with the DGEs included "ATP binding", "metal ion binding", "RNA binding" and "GTP binding".

WEGO plots showing the GO terms of DEGs: Experimental validation of the DEGs inferred from RNASeq is underway. This study offers novel insights into the candidate genes and biological processes involved in flower development and male sterility in pigeonpea.

7. CRP on hybrid technology

CMS Hybrid identified and released for NWPZ: IPH 15-03 is the first pigeonpea hybrid notified for cultivation in the North Western Plain Zone (NWPZ).The hybrid is derived from the cross PA 163A × AK 250189R. In AICRP trials, average yield of IPH 15-03 was 1595.6 kg/ha, which was 28.30% over Pusa 992 (National check), 30.2% over ICPL 88039 (Local check) and 55.2% over PAU 881 (Zonal check). Potential yield of IPH 15-03 is 2,426 kg/ha. The hybrid matures in 153 days.The growth habit of the hybrid is indeterminate and semi-spreading. Colour of standard petal (flower) is yellow with sparse red streaks. Stem colour is green and pods are green with purple streaks. Seed size is medium with the 100 seed weight is recorded to be 8.54 g. Dark seed colour of the hybrid clearly distinguishes it from other varieties in early maturity group. Hybrid seed has approx.19% protein content and more than 70% *dal* recovery.

Development of new CMS lines: With the aim of developing new male sterile lines, second backcross was accomplished of the male sterile $BC1F_1$s with the recurrent parents of extra-short duration (ICPL 11244, ICPL 11276, ICPL 11301, ICPL 11326, ICPL 20325, ICPL 20326, ICPL 20327 and ICPL 20329). The stable line GT 288A is being used a cytoplasm donor for CMS conversion of these new pigeonpea genotypes. Other pigeonpea lines (AL 15, ICP 7148, AL 201, Pusa 2002-2, MN 5, ICP 88034, ICP 20338, ICP 11255, ICP 20340, PAU 881) are under different stages of CMS conversion.

Maintenance of CMS, maintainer and restorer lines: A total of 27 CMS lines carrying A_2/A_4 cytoplasm (ICP 84023A, ICP 67A, PA 163A, UPAS 120A, CORG 990047A, CORG 990052A, ICPA 2039, ICPA 2089, GT 33A, GT 288A, GT 290A, AL 101A, ICPL 88039A, ICPA 2043, ICPA 2048, ICPA 2047, ICPA 2078, ICPA 2092, ICPA 2156, AL 100A, AL 102A, AL 103A, AL 104A, AL109A, AL 112A, AL 116A, AL 117A) and cognate maintainer (B) lines are being maintained. In parallel, 82 (R) restorer lines were self-pollinated to obtain pure seeds of these lines.

8. Widening the genetic base in pigeonpea through pre-breeding efforts for developing *Phytophthora* stem blight resistant/tolerant and photo-thermal insensitive early genotypes (DST-SERB)

A set of 208 early cultivated and 50 wild accessions of pigeonpea with three checks (UPAS 120, Asha and Maruti/IPA 8F) for estimating the effect of different dates of planting and photo-thermal regimes on pigeonpea. The seed of each experimental genotype was divided into three equal parts for sowing at three different dates at an interval of 20 days using augmented block design. The results revealed that during *Kharif* 2018, 27 cultivated and 15 wild accessions belongs to five species (*Cajanus scarabaeoides, Cajanus platycarpus, Cajanus albicans, Rhynchosia minima and Rhynchosia aurea*) recorded non-significant difference for their days to first flowering, 50% flowering and maturity across three sowing dates.

However, the second year planting (*Kharif* 2019) for validation of cultivated genotypes revealed that among the 27 a priory set, 11 genotypes namely PDAT 16, DSLR 43, ICPL 85010, ICPL 11299, ICPL 20327, AL 201-2, AL 201-1, AL 2091, AL 1992, WDN 2-47-1-1A and ICPL 11335 were stable for days to first and 50% flowering and maturity. The genotype, AL 1992 (129 days to maturity) and AL 2091 (136 days to maturity) are the earliest to attain maturity among the cultivated. While, in the wild accessions all the 15 genotypes flowered and attain to maturity at the expected days after planting. The first matured pod in *C. scarabaeoides* Acc. No. ICP 15683 was at 92 days after planting while in ICP 15690 and ICP 15699 in 95 days and ICP 15710 gave its first mature pod in 102 days. In *C. platycarpus* seven accessions (ICP 15921, ICP 15661, ICP 15662, ICP 15663, ICP 15664, ICP 15666 and ICP 15668) gave the first mature pod at 70-82 days after planting. *C. albicans* Acc. No. ICP 15616 matured in 106 days. In the tertiary genera called *R. minima* Acc. No. ICP 15838 gave matured pod in 83 days, while in *R. aurea* Acc, No. ICP 15819 and ICP 15809 gave their first mature pods in 92 and 110 days after planting respectively. In conclusion, the identified stable cultivated and crossable wild accessions of *C. scarabaeoides* can be used in the future pigeonpea breeding programme for developing photo-thermal insensitive population

Generation and advancement of breeding materials

F_2 crosses raised: AL 2091/ICPL 113529, ICPL 11258/Upas 120, ICPL 11273-B/ICPL 11301-3, IPAV 16-1/ICPL 113529, ICPL 113529/ICPL 1134, ICPL 11273A/VKS 11/24-2, Maruti/ Bahar, IPAM 16/BRG-2, ICPL 113529/ICPL 1134.

F_3 generation crosses: One way F_3 crosses namely, UPAS 120 / ICPL 11263, UPAS 120/ICP 15685-2 (scaraboides), UPAS 120/ICP 15763 (C. sericius), PUSA 992 × ICP 15642 (C. lineatus), PUSA 992 × ICP 15663, PUSA 992 × ICP 15685-2 (*scaraboides*), PUSA 992 × ICPL 11263, IPAC 438 × PUSA 992, WDBCE-6-6-1A × IPA 203, PUSA-992 X 1CP 15763 and WDBCE-6-3-7 × IPA 203. Three way F_3 crosses *viz*., UPAS 120 × [ICPL 20340 × ICP 15739] and PUSA 992 × [ICPL 20340 × ICP 15739].

9. Development of lentil cultivar with high concentration of iron and zinc (Harvest Plus program-ICARDA)

Intermediate product Development: Total 353 single plant progenies from 1 F_2 (38 SPS), 6 F_3 (127 SPS), 9 F_4 (135 SPS) and 6F_5 (53 SPS) crosses involving IPL 220 as donor for Fe and Zn are being advanced during current *Rabi* season 2019-20 for developing the fixed breeding lines. These lines will be evaluated for Fe and Zn content and yield potential for developing biofortified varieties.

Molecular marker development / Gene mapping: A BC_2F_4:5 population of >500 individuals derived from a cross between IPL 220 x ILWL 118 have been advanced during current *Rabi*-season 2019-20 through single seed descent method for developing NILs and these Nils will be used to identify markers associated with QTL controlling Fe and Zn concentration in lentil

Facilitate dissemination, promotion, and Consumer acceptance of crops: Produced 1.4 q nucleus seed of biofortified lentil variety IPL 220 for disseminating this variety among farmers. This variety had 5.1 q breeder seeds indent in 2018-19, which increased to 24.92 q in 2019-20 from DAC.

10. Establishing International Mungbean Improvement Network (IMIN)

A replicated field trial of mungbean minicore collection (MCC) comprising 296 accessions was conducted to evaluate the MCC during Summer 2019. Likewise another trial to evaluate MCC was conducted at ICAR-RS, Dharwad (Karnataka). Evaluation trial of these minicore accessions was also conducted during *Kharif* 2019. Five accessions *viz*., VI004957AG, VI004934AG, VI004973B-BLM, VI004937AG and VI002190BG were found highly resistant to yellow mosaic disease based on multi-season and multi-location data.

An evaluation trial of 90 advanced lines supplied by World Vegetable Centre which included advanced breeding materials for bruchid tolerance and elite varieties from Australia, Myanmar and Bangladesh was conducted at ICAR-IIPR, Kanpur and RC, Dharwad during *Kharif* season. All the entries were evaluated for yield and related traits. Based on two seasons' data (*Kharif* 2018 and *Kharif* 2019) 16 promising lines w.r.t yield and quality parameters were identified. Hybridization was attempted using these lines as donors but seed could not be obtained in any of the cross due to incessant rains during reproductive phase.

11. CRP-Molecular breeding for improvement of tolerance to biotic and abiotic stresses, yield and quality traits in crops: Chickpea

JG 16, an elite cultivar of chickpea was used as a recipient parent and it was crossed with Vijay as well WR 315 to incorporate multiple race resistance against *Fusarium* wilt.

During *Rabi* 2018-19, 08 BC_2F_1 plants were subjected to foreground selection with TR19 and TA96 SSR markersin the cross (JG 16 x WR 315) x JG 16 and 5 plants were confirmed as heterozygotes. In another cross (JG 16 x Vijay) x JG 16, 09 BC_1F_1 plants were subjected to foreground selection with TR 19, TA 194 SSR markers and 06 plants were confirmed as true heterozygotes. The identified true heterozgotes were backcrossed with JG 16. As a result, 9 BC_3F_1 seeds were harvested in the cross JG 16 X Vijay and 8 BC_3F_1 seeds were harvested in the cross JG 16 X WR 315. Simultaneously, in the backup population of the cross (JG 16 x WR 315) x JG16, 7 BC_1F_1 plants were subjected to foreground selection and five plants were identified as true heterozygotes. The confirmed plants were subjected to background selection and four BC_2F_1 seeds were harvested.

Pyramiding of multiple race resistance

In order to combine resistance to races 1, 2, 4 and 5 of *Fusarium oxysporum* f. sp. *Ciceri,* the F_1 plants identified through molecular analysis in the two cross combinations (JG 16 X WR 315 and JG 16 X Vijay) were initially intercrossed during 2016-17 to obtain F_1 X F_1 seeds. These were backcrossed with recurrent parents, WR 315 and Vijay and advanced in subsequent years. In this connection, during *Rabi* 2018-19 the 25 BC_1F_1s of the cross {(JG 16 x Vijay) x (JG 16 x WR315)}and 95 BC_1F_1 of the cross {(JG 16xWR 315) x (JG 16 x Vijay)} were sown in field and subjected to foreground selection using *foc* race specific SSR markers. Consequently, 7 and 15 BC_1F_1 true heterozygotes were identified and the identified plants were subjected to second round of backcrossing. As a result, 28 and 52 BC_2F_1 seeds were harvested in April 2019 in both the crosses, respectively. These will again be subjected to foreground selection and third round of backcrossing during *Rabi* 2019-20 to obtain BC_3F_1 seeds (Fig. 10).

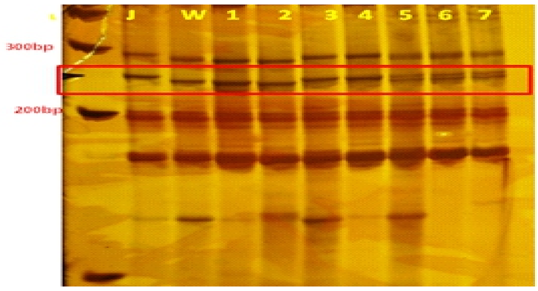


Figure 10: Foreground selection in BC_2F_1 plants with TA 96 BC_1F_1 plants with TR 19 SSR marker in the cross JG 16 XWR 315

12. Genetic enhancement of minor pulses: Characterization, evaluation, genetic enhancement and generation of genomic resources for accelerated utilization and improvement of minor pulses

This DBT funded project was started at ICAR-IIPR during November 2018 with a major focus on development of breeding materials and mapping populations, determination of diversity of viruses involved in YMD, generation of differentials for YMD resistance in mungbean and urdbean, functional genomics for YMD resistance and validation of molecular markers in developed mapping population and genotype profiling of five popular minor pulse cultivars *viz.*, mungbean, urdbean, cowpea, horsegram and mothbean. During 2019, single plant harvested seeds of one genotype each of mungbean (IPM 02-3), urdbean (IPU 2-43) and cowpea (DC-15) were supplied to ILS/NIPGR for sequencing besides, supplying a set of 96 genotypes for resequencing. A diverse panel of 96 genotypes in horsegram for sequencing and resequencing was sown at RC, Dharwad, single plant progeny seeds will be shared by the last week of March 2020 for sequencing and resequencing.

New crosses were attempted in mungbean and urdbean for generation of breeding materials, however, the F_1s seeds could not be harvested due to continuous rains in September, 2019. Twenty new crosses were developed for generating new breeding materials in cowpea using inter-intra specific crosses. At RC, Dharwad, 12 fresh crosses were made involving donor lines for yellow mosaic disease resistance (IC-458430 x IT-97K-499-35, IC-458430 x PL-3, CRM-1 x CO-4, NB-4 x CO-2, C-24-1 x EC-472250), heat tolerant (Goa Cowpea-3 x RC-101, GC-5 x GC-3, DC-47-1 x RC-101, Goa cowpea-3 x IT-97K-499-35), photo-thermo insensitive (PL-4 x GC-3, GC-5 x GC-3) and bruchid tolerance (RC-101 x IT-97K-499-35).

For bruchid tolerance, screening of 54 mungbean accessions was completed against *Calosobruchus chinensis.* The genotypes AVMU 1604, AVMU 1606 and 28 were moderately resistant carrying a susceptible index of 0.056, 0.051 and 0.058, respectively. Among the remaining, four genotypes were moderately susceptible (0.063-0.070), 31 susceptible (0.074-0.078) and 19 were highly susceptible (0.086-0.095). For another set of 45 genotypes, screening was completed against both, *C. chinensis* L. and *C. analis* F. The genotypes 29/2F9(m×u)101-102 and 29/3F9 (m×u)101-102 were found moderately resistant with a susceptible index of 0.052 and 0.059, respectively.

During Summer and kharif 2019, 148 samples of YMD affected minor pulses collected from nine States (Uttar Pradesh, Haryana, Punjab, Delhi, Rajasthan, Bihar, Karnataka, Tamil Nadu and Telangana) were processed for the characterization of YMD causing viruses. To enrich the viral DNA in the samples, rolling circle amplification (RCA) and the amplification of genomic components from 54, out of 148 samples by PCR was completed. Out of 54 samples, sequences of all the genomic components (#53 full-lengths DNA-A and DNA-B molecules) of viruses causing YMD have been obtained and submitted at NCBI database from 20 samples. Sequence data obtained so far indicate the association of MYMIV, MYMV and HgYMV. Mixed infection of three viruses (MYMIV, MYMV and HgYMV) was found with YMD affected mothbean sample collected from Belgaum, Karnataka, whereas in one sample of YMD affected urdbean from Raichur yielded the infection of two viruses (MYMIV and MYMV). Differential set of mungbean (36 genotypes) and urdbean (24 genotypes) were evaluated against yellow mosaic virus during kharif season at ICAR-IIPR, Main Campus and RS, Dharwad.

A $F_{2:3}$ mapping population was developed by crossing a donor line DPU 88-31 (tolerant to YMD) and a recipient line LBG-685 (susceptible to YMD) of blackgram. Parental screening using SSR Markers (from adzuki bean) was done which has revealed approximately 12% of the markers as polymorphic. Leaf samples from 335 $F_{2:3}$ population were collected and DNA extraction done. Screening for polymorphism is being done using SSR Markers (from adzuki bean). Towards genotype profiling of popular minor pulse cultivars, the variety panel for green gram, blackgram and cowpea comprising of 38, 22 and 21 varieties was developed. Adzuki bean SSR markers were screened or polymorphism in these, 75% markers in green gram and 70% in cowpea responded by generating reproducible and clear amplicons in range of 100 to 300 bp. 23% SSR markers revealed polymorphism amongst the panel of mungbean varieties, while in cowpea only 15% revealed polymorphism amongst very few varieties.

13. Creation of seed hubs for increasing indigenous production of pulses in India

The project is funded by DAC, MoA&FW, Govt. of India. Quality seed production of high yielding varieties of different pulse crops namely, chickpea, pigeonpea, fieldpea, lentil during *Rabi* 2018-19 and mungbean during spring/ summer 2019 & *Kharif* 2019 were taken following the mandate of the DAC funded project on “Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India, ICAR-IIPR, Kanpur Centre”. Under the project quality seed was produced through framers' participatory seed production approach on framers field of Kanpur Dehat, Fatehpur and Jalaun districts during rabi 2018-19, summer 2019 & kharif 2019 and produced was realized during June 2019. While, during *Rabi* 2019-20 in chickpea varieties JG-14, RVG-202 and RVG-203 were sown in an area of 8 ha for foundation seed production and about 35 ha were taken under certified seed production on farmers' field of Kanpur Dehat, Fatehpur and Jalaun districts, in field pea under varieties IPF 4-9 and IPFD12-2 were sown at farmers field of Kanpur Dehat district in in 5 ha area for foundation seed production and for lentil under IPL 316 for were sown in 5 ha area for foundation seed production in Hamirpur district. Under the project, a total of 1056.86 qtls quality seed (both foundation and certified category) of pulse crops namely, chickpea, pigeonpea, fieldpea, lentil and mungbean were produced (Table 6). Dissemination of newly released high yielding varieties of different pulse crops through farmers' participatory seed production of quality seed under DAC funded project on “Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India, ICAR-IIPR, Kanpur Centre” of high yielding varieties of different pulse crops.

Table 6 : Quality Seed Production of Pulse crops during the year 2019

Crop	Variety	Category of quality seed produced (qtls)	
		Foundation Seed (qtls)	Certified Seed (qtls)
Chickpea	RVG 202	82.00	100.8
	RVG 203	21.50	93.8
	JG 14	146.25	42.51
Fieldpea	Aman	90.00	-
Lentil	IPL 316	45.00	-
Mungbean (Spring/ Summer)	IPM 2-3	40.00	-
	Virat	160.00	-
	Shikha	50.00	-
	IPM 2-14	40.00	-
Pigeonpea	IPA 203	-	145.00
	Total	**674.75**	**382.11**

12. Genetic enhancement of minor pulses

Generation of breeding material: During *Kharif* 2018, total 15 crosses were made using different trait specific donors like determinate plant type, Yellow mosaic disease, powdery mildew, bruchid tolerance, pod length, number of pods, grain size and colour. Likewise, during *Kharif* 2019 total 20 fresh crosses were synthesized using different trait specific donors for generating new breeding material. For mapping population development, twelve fresh crosses were made at IIPR RS, Dharwad involving donor lines for Yellow mosaic disease resistance (IC-458430 x IT-97K-499-35, IC-458430 x PL-3, CRM-1 x CO-4, NB-4 x CO-2, C-24-1 x EC-472250), Heat tolerant (Goa Cowpea-3 x RC-101, GC-5 x GC-3, DC-47-1 x RC-101, Goa Cowpea-3 x IT-97K-499-35), Photo-thermo insensitive (PL-4 x GC-3, GC-5 x GC-3) and bruchid tolerance (RC-101 x IT-97K-499-35) during *Rabi*/spring-summer season 2018-19.

Sharing of materials: During reporting period, one genotype *i.e.* DC-15 single plant seeds were supplied to NIPGR, New Delhi for whole genome sequencing purpose. Similarly for re-sequencing 96 genotypes seeds were supplied to NIPGR, New Delhi. During spring, summer & *Kharif* 2019 single plant progeny seeds of genotypes which are being used for whole genome sequencing (DC-15) were produced and re-sequencing (96 genotypes). Released varieties (22 varieties) seed was supplied to Biotechnology Division for DNA profiling.

Generation advancement: Total 15 F_1s raised during *Kharif* 2019 for generation advancement and true hybrid test is being carried out.

Identification of trait specific donors through germplasm evaluation at IIPR, Kanpur: During *Kharif* 2018, total 282 germplasm accessions were evaluated for the following traits *i.e.* growth habit, days to 50% flowering, pod length (cm), days to pod maturity, testa texture, eye colour, 100-seed weight, seed coat color, flower colour, number of pods per peduncle, pod colour and grain yield/plant. Ample amount of variability was there for different traits such as days to maturity, seed size, pod length, seed coat color etc. The maturity ranged between 52-104 days and the entry EC-724439 (52 days) was the earliest mature genotypes followed by EC-366776, EC-723696, EC-723774, EC-724615, EC-724306 and ITIT97K-819-118(less than 61 days). The days to flowering varied from 32-75 days period and the best genotypes were GP-37, PL-4, IT96D-610, EC-472252, EC-724306 and EC-724365. In case of 100-seed weight, range was 4.3-19.7 gm and the best performing genotypes were EC 724303 and GP 48(more than 19.0 gm). Likewise ample amount of variability was observed for seed colour also.

Similarly, during spring season-2019, a set of 119 genotypes rejuvenated and evaluated for different qualitative and quantitative traits. Genotypes like EC-738206, VBN-1, GC-4, PL-4, GC-5, GC-6 and EC-738156 flowered in less than 49 days. On the basis of pods per plant, the best genotypes were EC-725978, EC-723774 and EC-723996 with > 15 pods/plant. Based on pod length, best performing genotypes were EC-738125, EC-723989 and Ec-458480 with more than 11.0 cm length. In case of days

Table 7: Trait specific genotypes identified

Characters	Accessions
1st Flowering open (<38 days)	EC 472252, EC 724306, EC-366776, EC-723784, EC-458480
Days to 50% Flowering (<40 days)	EC-472252, EC-724306, EC-724365, EC-724577, EC-366776
Pod length(cm) (>18 cm)	EC-723677, Goa-Cowpea-3, EC-723807, IC-97767, IC-402154
Days to pod maturity (<60 days)	EC-724439,PL-4, EC-458425, EC-458480, V-578-2
100-Seed Weight(gm) >18 gm	EC-724303,EC-723902,IC-402166, Dharwad local, EC-528687, EC-723895 IC-202781,EC-724642,EC-394779-2, IT-971-499-38,
No of Pods per peduncle(>3)	IC-402175, IC-1061, EC-528697
Plant Height(cm) >275 cm	EC-724366-B, EC-723996, EC-723771, EC-528421
Yield/plot(gm) >240 gm	IC-402172, EC-458425, C-198355-1, IC-402166, EC-458480

to maturity the best performing genotypes were PL-4, EC-738206, GC-4, GC-5 and GC-6. The same set of genotypes also evaluated in summer 2019 for different quantitative and qualitative traits. On the basis of days to flowering the promising genotypes were PL-4, Co-4, EC-366776, EC-738156 and EC-738181 flowered in 37 days. The best performing genotype for pod length were EC-738156, EC-738125 and EC-728206 (>12.0 cm). In case of maturity the best genotypes were EC-738206, EC-738156 and PL-4 (<53 days).

Cowpea germplasm evaluation for different traits at IIPR RS Dharwad: Total 190 accessions of cowpea germplasm were rejuvenated and evaluated for different morphological traits during *Rabi* season 2018-19. Wide range of variations were observed for different morphological traits such as days to maturity, seed size, pod length, seed coat color etc. The entries such as IC-402180 (73 days) and IC-198355 (73 days) were the earliest to mature followed by GP-37 (74 days) and EC-472252 (75 days). The accessions such as MP-2 (90 days), IT-97-1-499-38 (89 days) and IC-402172 (88 days) took more number of days to mature.

Collection of landraces/germplasm of cowpea (ICAR-IIPRRs Dharwad): Through joint exploration, collected landraces of cowpea (30 No.) from Belgaum and Bagalkot district of Karnataka.

13. Development of improved Indian Common Bean (*Phaseolus vulgaris* L.) lines resistant to Anthracnose disease by employing molecular breeding

Anthracnose disease screening: A set of 60 common bean genotypes comprising of varieties (susceptible & resistant checks), indigenous and exotic accessions (procured from NBPGR, Bhowali, Shimla and CIAT, Colombia) were evaluated during *Kharif* 2019 at NBPGR, Regional station, Shimla for resistance to Himachal Pradesh races of *C.*

lindemuthianum under natural epiphytotic conditions. *Anthracnose* disease reactions were rated visually using a scale from 1 to 9, as previously described by Pastor-Corrales et al. 1995. Plants with scores from 1 to 3 were considered resistant while those with scores from 4 to 9 were considered susceptible. Based on the disease reaction scale we found that IC 337275, EC 931228, IC 340947, EC 25517, EC 931216, EC 931275, IC 43572 were shown resistant reaction against *Anthracnose* disease. These genotypes might be further confirmed for resistance reaction against anthracnose disease through molecular marker study.

Plant Biotechnology

A. Institute Funded Projects

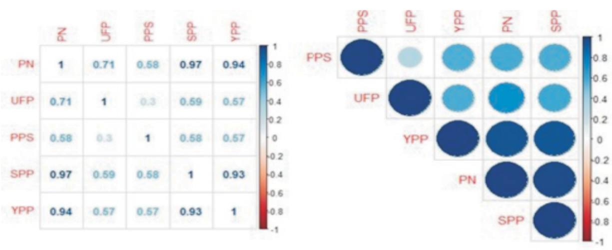
1. Genomics enabled crop improvement

Sub-project 1: Molecular dissection of response to terminal heat in chickpea

The aim of this project is to map the QTL/(s) responsible for heat stress tolerance in chickpea and to identify differentially expressed transcripts during heat stress. Different $F_{3:4}$ mapping populations (Table 1) were generated and are being advanced at main farm, IIPR during *Rabi* 2019-20 and will be utilized for mapping QTLs. QTL Mapping was carried out using F_2 mapping population derived from Vishal (highly heat tolerant) and ICC 1205 (moderately heat tolerant) varieties. Correlation analysis of various phenotypic traits of this F_2 population screened under late sown condition revealed positive correlation among all traits studied viz. number of pods per plant (PN), number of unfilled pods per plant (NUP), % pod set (PPS), seed per plant (SPP) and yield per plant (YPP) (Figure 1). Out of 250 SSR markers screened for parental polymorphism, 23 markers (9.2%) showed polymorphism. QTLs were mapped for 4 traits namely PN, PPS, SPP and YPP on chromosome number 4, 5, 6 and 8 (Figure 2). Heat7 and NCPGR202 markers are found to be located at the reported QTL intervals by Paul *et al*. (2018) those are present on chromosome 5 and 6, respectively and found to have association/linkage with PN, PPS, SSP and YPP expression based on single marker analysis and interval mapping approaches.

Table 1: Chickpea mapping populations segregating for heat stress

S. No.	Cross	Population stage	Population size
1	BG 256 x EC 556270	F_3toF_4	240
2	BG 256 x ICC 12155	F_3toF_4	160
3	ICCV 2 x ICC 9942	F_3toF_4	190
4	ICCV 2 x ICC 12155	F_3toF_4	195
5	ICC 5912 x ILWC 141	F_3toF_4	170
6	ICC 12155 x ICC 15614	F_3toF_4	200



	PN	UFP	PPS	SPP	YPP
PN	1	0.71	0.58	0.97	0.94
UFP	0.71	1	0.3	0.59	0.57
PPS	0.58	0.3	1	0.58	0.57
SPP	0.97	0.59	0.58	1	0.93
YPP	0.94	0.57	0.57	0.93	1

Figure 1: Correlation of phenotypic traits. A: Correlation table B: Diagrammatic representation of correlation analysis. PN: Pod Number per plant; UFP: Number of unfilled pods; PPS: Percent Pod Set; SPP: Seed Per Plant; YPP: Yield Per Plant.

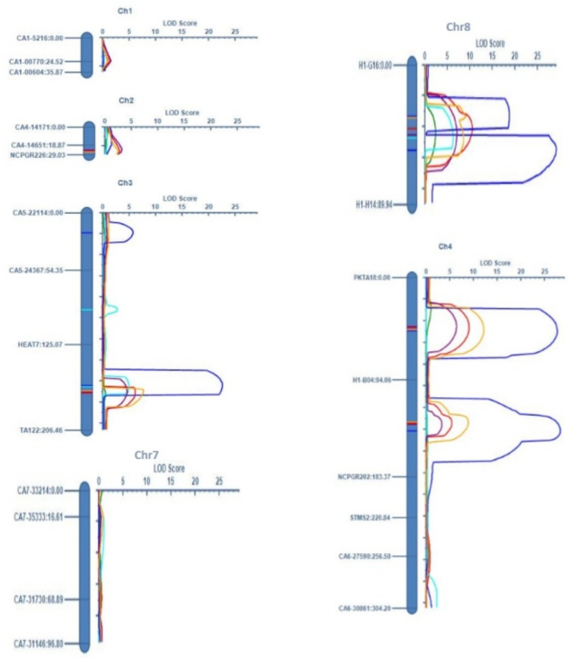


Figure 2: Interval mapping of heat stress tolerance associated traits

Sub-project 2: Trait mapping for developing plant ideotype in pigeonpea

The project was formulated for trait mapping in pigeonpea through marker trait association analysis in the germplasm for various ideotype component traits such as plant height, determinate and indeterminate growth habit, days to flowering and maturity, cleistogamy nature of flowering, seed size and number of seeds per pod. For this, a panel with 93 diverse pigeonpea genotypes was constituted and the mapping panel was evaluated in ICAR-IIPR field for various plant ideotype component traits including plant height, days to 50% flowering, days to maturity, number of primary branches, determinacy and cleistogamy. Association of traits with 63 SSR markers genotypic data were performed using following TASSEL V2.0 and could identify markers linked to days to initial flowering, plant height, days to 50% flowering, days to maturity, number of primary branches. For identifying genes linked with cleistogamy in pigeonpea, comparative genomics approach has been employed. The gene encoding AP2 was chosen to amplify from pigeonpea cleistogamous and non-cleistogamous genotypes. The amplicons obtained from the gene locus using gene specific primers was sequenced and are being analysed to find out any causal variation that change microRNA recognition or non-recognition thus results in appearance of cleistogamous trait in pigeonpea.

Sub-project 3: Marker assisted gene introgression for drought tolerance in elite chickpea

Markers assisted backcrossed breeding (MABC) lines (viz; IPC L4-14, IPC L4-16 and IPC L19-1) were evaluated under AICRP on Chickpea during 2018-19 and one of the lines vi. IPC L4-14 performed well under drought conditions and is being promoted to AVT2. Three more improved MABC lines (viz; IPC L4-25, IPC L4-7 and IPC L22-33-2) which have shown > 16% significant yield advantage over the recurrent parent in station trails is also submitted for AVT1 in AICRP chickpea during 2019-20. This QTL is also being mobilized into other chickpea elite lines. This year, we analyzed 62 BC_1F_1 progeny for foreground marker and found 23 and 13 heterozygotes lines in KWR 108 and GNG 1581, respectively. Backcrossing was performed in a positive heterozygote and considerable number of BC_2F_1 seeds were obtained.

Sub-project 4: Molecular mapping of loci for MYMV, MYMIV, Powdery mildew resistance and photo- thermo insensitivity in urdbean

Blackgram (*Vigna mungo*) has unique importance due its shorter life cycle, high productivity and use in numerous food preparations. The yield potential in the crop has not been harnessed to their maximum because of many biotic and abiotic constraints that includes YMD, powdery mildew and photo thermo sensitivity. This project aims to understand the genetics of resistance towards these biotic and abiotic stresses as well as molecular mapping of loci responsible for resistance. Different mapping populations of blackgram are being developed for powdery mildew resistance and photo-thermo insensitivity and are in different stages of development. Genomic DNA isolation and genotyping of parental lines using SSR markers is in progress. Status of mapping populations for different traits:

Trait	Cross	Status
Powdery Mildew (PM) resistance	LBG 17 (R) x IPU02-43 (S)	F_1s were grown during *Kharif*, 2019, however due to excessive rain F_2 seed could not be harvested. It will be grown during Spring, 2020.
Photo thermo insensitivity (PTI)	PGRU 95016 (R) x Uttara (S)	F_1s were grown during *Kharif*, 2019, however due to excessive rain F_2 seed could not be harvested. It will be grown during Spring, 2020.

2. Transgenic technology for genetic improvement in Pulses improvement

Sub-project 1: Genetic engineering for development of pod borer resistant chickpea using multigene approach

The aim of the project is to develop transgenic chickpea expressing anti-insecticidal genes using novel approaches. Under the project, development of marker free, multigene constructs bearing cryIAc and cry2Aa genes regulated by pod specific promoter has been taken up. In this direction, a highly pod specific *msg* promoter has been improved by modification of the transcriptional and translational context (Konda *et al*. 2019, Legume Research). Further the modified pod specific promoter developed has been utilized for generating *cry*IAc and *cry*2Aa gene cassettes which have been used for transformation of *Agrobacterium*. Freeze thaw method of transformation has been used for genetic transformation of the *Agrobacterium tumefaciens* LBA4404 and the transformants generated are being assessed for the intactness and stability of the gene constructs.

In addition to the tissue specfic gene expression, stress- inducibe genes are being investigated with an aim to identify the inducible promoters. In this direction, we have earlier reported the identification and up regulation of a WRKY TF under multiple stress conditions in chickpea, designated as *Cicer arietinum* multi-stress responsive WRKY TF (*Ca*MSR-WRKY TF) and deciphered the possible interacting partners. The gene LOC101494311 present on the chromosome: Ca7; locus 887189-889672 consists of 4 exons encodes a protein of 471 amino acid residues with a molecular weight of 51.318 kDa and theoretical pI of 5.01. SMART analysis indicated that *Ca*MSR-WRKY TF shares a WRKY DNA binding domain (241-297 aa) at the C-terminal. The full length cDNA of 1413 bp was cloned in pET28a vector with NdeI-BamHI sites and confirmed by sequencing.

Over-expression of the *Ca*MSR-WRKY TF in *E. coli* BL21 (DE3) resulted in the formation of inclusion bodies (IBs). The transcription factor was recovered from IBs and successfully refolded into a biologically active form. The protein was further purified by ammonium sulfate fractionation and Ni-NTA affinity chromatography, and the his-tagged-*Ca*MSR-WRKY TF protein showed a molecular mass of approximately 58 kDa as determined by SDS-PAGE and was further confirmed by Western blotting.

Subproject 2: Development of whitefly tolerant genetically transformed green gram (*Vigna radiata*)

Genetic transformation of green gram using gene imparting tolerance to whitefly infestation has been proposed in effort to develop a genotype tolerant to whiteflies. The genotypes initially chosen for the study were selected based on their partial ability to tolerate YMD that is transmitted through whitefly and it was found from the study that though the genotype SML 668 is responsive to *in vitro* regeneration, its efficiency is very low and elongation of regenerated shoots is a problem. Modified embryonic axis was also not very responsive to regeneration *in vitro*.

Based on literature survey, the genotype ML267 was further selected and *in vitro* regeneration was initially attempted in it using DCN as choice explant. Use of BAP at a higher dose followed by its removal induced multiple shoots in the genotype that also elongated and were successfully hardened. However, the number of shoots regenerated was in the range of 4-6. Modified Embryonic axis (EA) also responds to in *vitro* regeneration. Experiments in this direction are underway.

As *Agrobacterium* mediated genetic transformation is dependent on availability of an efficient *in vitro* regeneration system, transformation was attempted using cotyledon with embryo of green gram cultivars viz. ML 267 and SML668 as explants for infection with *Agrobacterium* strain LBA4404 harboring binary vector pRI201AN containing *nptII* gene as a selectable marker. A modified method has regenerated plantlets that survived selection pressure of kanamycin @ 100 mg/l that are being analyzed for presence of desired gene, here *nptII* (Fig. 3).

Modified EA   Regenerating plantlets under selection pressure

Figure 3: *Agrobacterium* mediated genetic transformation using mEA as explant in green gram

Sub-project 3: Development of regeneration and transformation protocol in grasspea (*Lathyrus sativus* L.)

The presence of neurotoxin β-ODAP in grasspea seeds and other plant parts renders it unfit for consumption. One of the approaches is to reduce β-ODAP content is by down-regulating/knocking out β-ODAP biosynthesis pathway related genes by genetic engineering/genome editing technology. For harnessing the potential of the technology, an *in vitro* regeneration system amenable to genetic transformation as well target gene for modification is prerequisite.

Complete *in vitro* multiple shoot induction in grasspea cv. Pusa 24 and Mahateora was achieved with embryonic axes as an explant under the influence of 6-Benzyl Aminopurine (BAP). Minimum two elongation cycles in basal medium was required to elongate all shoot buds of the explant. Fifteen to thirty shoots regenerated *in vitro* in Mahateora and 6 to 16 shoots in Pusa-24 at varying BAP concentration. *Agrobacterium*-mediated transformation was also performed with the optimised regeneration protocol in both cultivars. Approximately, 30% explants in Pusa 24 and 59% explants in Mahateora gave rise to at least one green shoot in a kanamycin containing selection medium. Regenerated shoots could not be established in soil *via* micro-grafting/rootex treatment.

Establishment of *Agrobacterium*-mediated transformed shoots in soil needs further optimization. To bypass the establishment of transformed shoots in soil by grafting or rooting, genetic transformation through biolistic was also attempted. Embryonic axes of Pusa 24 were bombarded and their establishment in soil and selection using GUS assay are in progress. PCR analysis of some of the Agrobacterium-mediated transformed T0 shoots are also in progress.

Project: Rapid generation advancement for speed breeding in chickpea (*Cicer arietinum* L.)

The project intends test bed optimization to accelerate generation turnover in chickpea by speed breeding approaches involving extending/ manipulating the photoperiod using supplementary lighting, humidity and temperature control in contained conditions. A total of 17 chickpea genotypes (JG 14, JG 11, JAK I9218, KWR 108, KPG 59, GNG 1581, JG 16, RVG 202, JGK 5, GCP 105, RSG 888, HC 5, ICC 96029, BGD 9971, ICC 96030, SA-1 and BG 3043) are being assessed in puff insulated chamber under 1200 fluorescent lux, 22h:2 h light-dark regime and humid conditions. Detailed analyses of the experiments are in progress

Subproject 4: Identification and evaluation of potential Bt strains for managing lepidopteran pest of pulse crops

The presence of multiple *cry* 2 genes in the native Bt isolates viz., F8.IIPR, Ak2.IIPR, F1.IIPR, F4.IIPR, F5.IIPR were confirmed through amplification of specific primers for *cry* 2Aa, *cry* 2Ac (Fig 4). These isolates were known to harbour *cry* 1A also and it was confirmed by the presence bipyramidal and cuboidal crystal proteins through SEM analysis (Fig 4). Further following *Bt* isolates F8.IIPR, Ak2.IIPR, F6.IIPR and F5.IIPR were found to harbour *Chi36* gene also. The LC_{50} of the spore crystal mixture of *Bt* isolates viz., Ak2.IIPR, F8.IIPR, F6.IIPR, F5.IIPR and HD1 against *Helicoverpa armigera* larva was 2.93 $x10^3$, 2.22$x10^3$, 5.06$x10^3$, 6.82$x10^3$ and 3.33$x10^3$ CFUs/ml respectively. Similarly, the LC_{50} against *Spodoptera litura* was 4.65$x10^3$, 2.52$x10^3$ and 5.31$x10^3$ CFUs/ml for Ak2.IIPR, F8.IIPR and HD1 respectively.

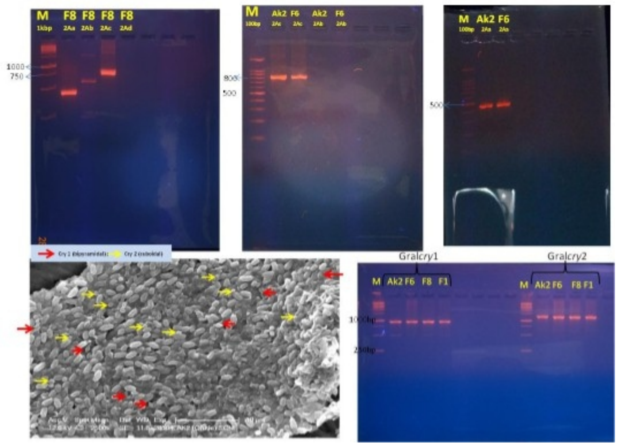


Figure 4: *cry* gene characterization through PCR and SEM analysis

Externally Funded Projects

Project 1: Molecular approaches for mapping of novel gene(s)/ QTL(s) for resistance/ tolerance to salinity stress in chickpea

Two hundred thirty three RIL population population derived from DCP 92-3 x ICCV 10 crosses was used for genotypic and phenotypic study, wherein DCP 92-3 is susceptible and ICCV 10 is tolerant @6 EC. For genotyping 50K SNPs array were used and high-density linkage map developed covering approximately 3065 SNPs markers anchored in 8 linkage group covering 1637.37cM distance. The field phenotypic evaluation of RIL population was carried out at CSSRI, Karnal, PAU and IARI, New Delhi and IIPR, Kanpur for two-years.

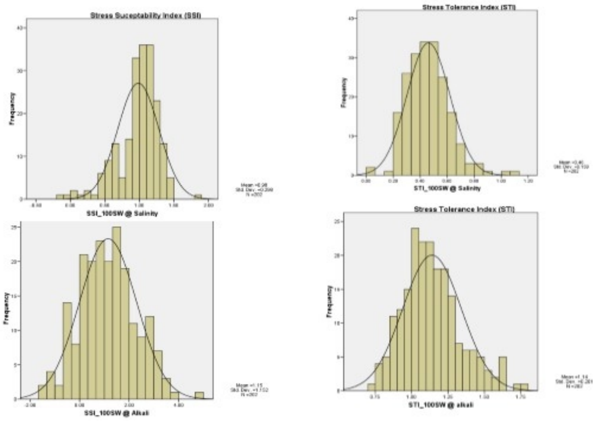


Figure 5: Phenotypic attributes of salinity tolerance index

The phenotypic data was recorded for number of days to 50% flowering (DF), days to maturity (DM), number of pods per plant (PPP) and seeds per pod (SPP), plant height (PHT, cm), grain yield (GYLD g five plants), 100 seed weight (100 SDW,Na and K uptake in roots and shoots, stress susceptibility index (SSI) and stress tolerant index (STI) (Fig. 5).

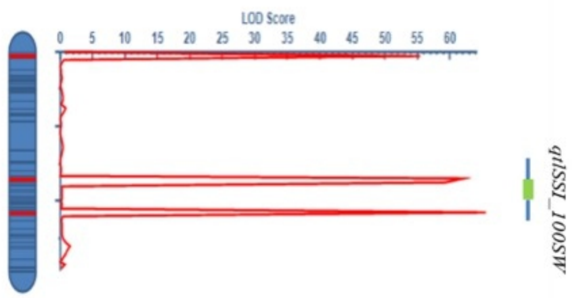


Figure 6: QTLs region governing for salt tolerance & susceptible Index for 100 seed weight (*qtlSSI*_100SW).

Identification of genomic region governing for salt tolerance & susceptible Index for 100 seed weight (qtlSSI_100SW), yield per plant (qtlSSI_PY), salt tolerant Index for 100 seed weight (STI_100SW) and yield per plant (qtlSTI_PY) in interspecific cross, DCP 92-3 (cultivated, susceptible) x ICCV 10 (Tolerance) RIL population was also done (Fig. 6). Total 2135 chickpea germplasm lines from global composite set were screened for salinity stress at vegetative (150 & 200 mM) and selected 126 lines and advance breeding materials were screened for reproductive stages (EC > 6ds/ms) along with cultivars CSG 8962, ICCV 10 were used as positive checks. Few of the germplasm lines (ICC 5442, ICC 6679, and ICC 6662 etc.), cultivars (ICCV 10, KWR 108) and breeding lines (L-169 and L-181) have shown high tolerance to the vegetative and reproductive stage.

Project 2: NPFGGM Project Network project on functional genomics in chickpea

High quality genomic DNA was isolated from 170 RIL population (K850 x IPC 2004-52) segregates for the traits and genotyping was done using SNPs based approaches. We discovered 6177 high-quality SNPs differentiating two parental genotypes of a RIL mapping population using reference genome-based GBS assay. An integrated molecular marker map of the chickpea genome was established using 170 recombinant inbred lines from cross between a cultivar resistant to *Fusarium* wilt IPC 2004-52 and susceptible genotypes K 850. A total of 6177 SNPs markers were mapped on the eight different linkage group (CaLG01- CaLG08). In all the linkage group, sufficient number of SNPs markers have been placed covering entire chromosome. The high-resolution genetic maps information generated will be integrated for rapid QTL/gene identification developed to expedite genomics-assisted breeding applications in crop plants, including chickpea for their genetic enhancement.

Project 3: ICAR-NPFGGM: Genetic mapping of *Fusarium* wilt (FW) and sterility mosaic disease (SMD) in pigeonpea

In this project, genetic mapping for *Fusarium* wilt (FW) and sterility mosaic disease (SMD) in pigeonpea has to be done. Genetic analysis and mapping for SMD resistance was carried out using F_{2s} derived from Maruti (S) and Bahar (R). F_2 population derived from Maruti and Bahar is being screened for SMD at ICAR-IIPR Regional Station, Dharwad during *Kharif* 2019 and leaf samples are collected to identify/map the loci responsible for SMD resistance in pigeonpea following bulked segregant analysis. Based on phenotyping of F_2 mapping population revealed that the trait is governed by two genes in non-allelic fashion (inhibitory gene interaction). The genotyping of extreme bulks along with parents with polymorphic markers is in progress. F_2 mapping population of the above cross is also being screened for fusarium wilt incidence in pot condition during *Kharif* 2019 and this experiment is still ongoing and this population will be utilized to validate the already identified linked markers for *Fusarium* wilt resistance in pigeonpea

Project 4: DBT network project on genetic enhancement of minor pulses

Under this DBT network project on Genetic Enhancement of Minor Pulses, the objectives include genotyping of popular minor pulses, functional genomics wrt YMD resistance and MAS for breeding for YMD tolerant minor pulses.

Genotyping of popular minor pulses

Independent variety panels for proposed minor pulses *viz.* mungbean, urdbean and cowpea have been developed and include 38, 22 and 21 varieties, respectively. Predominant varieties in current seed chain that have not completed ten years, across India, have been included along with recently developed promising varieties. The heterologous system adzuki bean SSR markers were used for screening generated amplicons for polymorphism amongst the varieties in mungbean and cowpea. Only 75% markers in mungbean and 70% in cowpea responded by generating reproducible and clear amplicons in range of 100 to 300 bp. Twenty three per cent SSR markers revealed polymorphism amongst the panel of mungbean varieties, while in cowpea only 15% revealed polymorphism amongst very few varieties as revealed in single test (Fig. 7). Reproducibility of polymorphism however, needs to be confirmed.

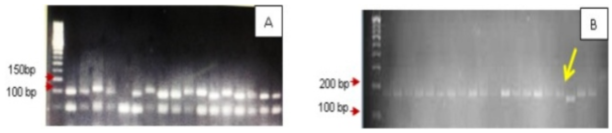


Figure 7: Polymorphism in (A) mungbean and (B) cowpea varietal panel using adzuki bean SSR markers

Molecular mapping of gene/loci providing resistance against YMD in urdbean (*Vigna mungo)*

In effort to create improved lines tolerant to YMD, a $F_{2:3}$ mapping population has been developed by crossing a donor line DPU 88-31 (tolerant to YMD) and a recipient line LBG 685 (susceptible to YMD) of blackgram. Parental screening using 78 available SSR Markers (from adzuki bean) has revealed 9 of the markers as polymorphic. Leaf samples from 335 $F_{2:3}$ population was collected and DNA extraction of this $F_{2:3}$ generation population has been done using the Qiagen DNA extraction kit. Screening for polymorphism is being done using SSR Markers (from adzuki bean). The markers found to be polymorphic between parents in preliminary screening are CEDG081, CEDG281, CEDG075, CEDG128, CEDG077, CEDG002, CEDG048, CEDG130 and CEDG086. Moreover, the population will be further advanced up to F_6 generation and screening for polymorphism will be done using the SSR Markers, to know about the gene(s)/loci responsible for providing resistance against the YMD in blackgram.

Project 5: NPFGGM Project: Development of pod borer resistant transgenic chickpea and pigeonpea

The project envisages development of transgenic chickpea and pigeonpea lines with codon optimized *Bt* gene (*cry1Aabc*) for the trait insect resistant (IR). Event selection trial was done for one season and the best identified event was selected detailed characterization. Transgenic chickpea and pigeonpea lines appear to be segregating and possibly in hemizygous state. Crosses and sib mating have been attempted employing transgenic chickpea line (IPCa2) and with the pigeonpea line (IPCc1). A total of 850 transgenic chickpea lines (crossed and sib-mated) and 477 transgenic pigeonpea lines (crossed and sib-mated) were sown in Transgenic Containment Facility. Genomic DNA was isolated from all the lines and screening using PCR and ELISA are in progress. Once the zygosity status and site of integration of the transgene is ascertained, biosafety evaluation trials can be planned.

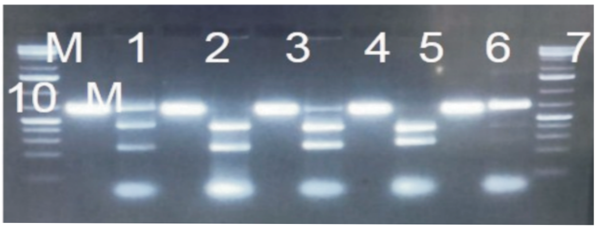
Project 6: Agrobacterium tumefaciens-mediated gene-editing in chickpea (*Cicer arietinum* L.) using CRISPR-Cas9 system (DST_INSPIRE)

PCR based allele mining of BS1 gene in chickpea genotypes using primer walking concept

To amplify the BS1 gene in different chickpea genotypes, 9 sets of primers were designed using primer walking concept (Primer 3 software). A total of 110 chickpea genotypes including wild types were collected varying in seed size and weight and genomic DNA was isolated from the leaves of all the genotypes. Initially, BS1 gene was amplified from 11 chickpea (*Desi* and *Kabuli*) and 9 wild genotypes. All amplified fragments of BS1 gene in different genotypes were extracted and sequenced. Some of the fragments having low sequence reads, were reamplified and sent for Sanger sequencing. BS1 allelic sequence of four genotypes has been completed and fews gaps were left in remaining genotypes.

Designing sgRNA spcific to BS1 gene

The designed sgRNAs specific to BSI gene were designed using CHOP CHOP software (http://chopchop.cbu.uib.no/), and CCTOP (https://crispr.cos.uni-heidelberg.de/index.html) using default parameters. Initially, 13 sgRNAs has been selected based on genomic location and their off targets effects. *In vitro* screening of theses sgRNAs has been performed using Guide-itTM sgRNA *In Vitro* Transcription and Screening Kit (DSS Takara Pvt. Ltd.) to check their efficiency and specificity. For screening, 56-58 nucleotide sequences (Forward primer) containing sgRNA sequence (20 nucleotide) has been designed for every sgRNA and synthesized. Primers flanking to sgRNAs were also designed and synthesized in such a way that it contains the target sequence in an asymmetric position that will produce two cleavage fragments of unequal size and synthesized. Out of 13 tested sgRNAs only 8 were cleaved by the cas9. Three sgRNAs were synthesized initially.



Lanes are as follow: M: I Kb plus ladder 1,3,5,7.9-Uncleaved DNA, 2,4,6,8,10-Cleaved DNA by cas9

Design and construct of Cas9/gRNA specific to BS1 in chickpea

pUC gRNA shuttle and p201N cas9 vectors were procured from Addgene, USA. For cloning, p201N was first digested with SwaI followed by cleanup and then digested with SpeI. MtU6 (377 bp) and scaffold (106 bp) fragments were amplified using their respective primers with a high-fidelity DNA polymerase using pUC gRNA shuttle vector as template. Four DNAs were mixed together; U6 promoter fragment, gRNA ssDNA, scaffold fragment and linearised p201 vector using NEB Bulder assembly Kit. 2 µL of ligated product has been transformed into 50 µL chemical competent cells and plated on LB Kan50 plates. Positive colonies were screened using PCR, restriction digestion and sequencing. Three constructs having three different sgRNAs has been prepared and confirmed by restriction digestion and sequencing.

Project 7: Evaluation of bio-efficacy of coragen 20SC against lepidopteran pests of green gram (FMC India Pvt. Ltd)

In the field efficacy trial, the *H. armigera* larval population varied from 9.33 to 10.40 larvae per plant during first spray. Coragen 20 SC @ 150 g/ha (2.87, 0.00 & 0.00 larva/plant)and Coragen 20SC @ 125 g/ha (3.13/plant, 0.00 & 0.00 larva/plant) has recorded lowest larval population on 1^{st}, 3^{rd} and 7^{th} day after spraying. The per cent reduction over untreated control was also lowest for Coragen 20SC @150 g/ha followed by Coragen 20SC @ 125 g/ha during 1st (71.28 & 70.27), 3rd (100 & 99.22) and 7th (100 & 100) day after spraying. The pretreatment larval population of *H. armigera* during 2nd spray varied from 6.67 to 6.87 larvae per plant. The lowest larval population on 1st day after spraying was recorded from Coragen 20SC @ 150 g/ha (2.33 larva/plant) followed by Coragen 20SC @ 125 g/ha (2.73 larva/plant). The percent reduction over control was lowest for Coragen 20SC @ 150 g/ha and Coragen 20SC @ 125 g/ha for 3rd (100 & 100) and 7th (100 & 100) day after spraying. Thus, the coragen 20SC @ 125 g/ha and 150 g/ha were superior in managing *H. armigera* than Chlorpyriphos and Emamectin benzoate.

The tobacco caterpillar, *Spodoptera litura* Fabricius larval population recorded before spraying were on par with all the treatments and it varied between 5.20 and 5.87 larva per plant. The per cent reduction over control was the highest from for Coragen 20SC @ 150 g/ha (87.51) and Coragen 20SC @ 125 g/ha (78.96) followed by Coragen 20SC @ 100 g/ha (73.22) (Fig 8). The Coragen 20SC @ 150 g/ha and 125 g/ha has resulted in 100 percent reduction over control on 3rd and 7th day after spraying. The pretreatment larval population varied from 4.40 to 4.73 during 2nd spray. The per cent reduction over control on 1st day after spraying was the highest for Coragen 20SC @ 150 g/ha (85.38) followed by Coragen 20SC @ 125 g/ha (83.27). The 3rd and 7th day after spraying has recorded the highest per cent reduction over control i.e. 100.

The highest marketable yield was obtained from the treatment having Coragen 20SC @ 150 g/ha (5.81q/ha) followed by Coragen 20SC @ 125 g/ha (5.14 q/ha) and Coragen 20SC @ 100 g/ha (3.96 q/ha). Many odonata (dragon fly), hymenopterans (sphecid wasps, ants, mudwasp, Xylocopa sp, honey bees), dipterous (Syrphids, Tachinids), Coleopterans (Coccinellids, Ellateridae) and Lepidopteran (leaf roller, looper, skipper) insect activity along with Spider (Clubsiona sp, Lynx sp) were recorded during flowering and podding. Interestingly, none of them were found dead after spraying coragen 20SC during *Kharif* 2019.

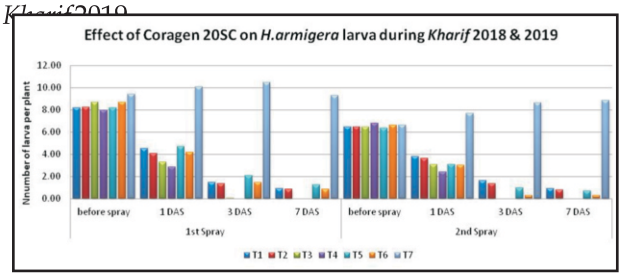


Figure 8: Effect of coragen 20SC on pod borer in green gram during *Kharif* 2018 & 2019 (pooled data)

Crop Production

Long-term effect of nutrient management and cropping system

- Four rice-based cropping systems in lowland such as rice-wheat (R-W), rice-chickpea (R-C), rice-wheat-mungbean (R-W-Mb), and rice-chickpea-rice-wheat (R-C-R-W) were evaluated with three fertilizer management systems *such as* control (CT), integrated nutrient management (INM, crop residues + biofertilizers *viz*., *Rhizobium* for pulses and phosphate solubilising bacteria for cereals + farmyard manure at 5 t/ha + 50% NPK), and inorganic fertilizers (RDF, recommended dose of N, P, K, S, Zn and B). The experiment was initiated in 2003. Results revealed that rice yield was higher in R-W-Mb system followed by R-W-R-C and the lowest yield was in conventional R-W system.
- On soil physical properties, legume inclusive systems (R-W-Mb, R-C, and R-C-R-W) and INM had higher content of sand (%) and lower percentage of clay (%) in soil. Also, R-W-Mb, R-C systems and INM led to considerable reduction in bulk density at surface and subsurface soil over R-W. Soil chemical study revealed that legume R-W-R-C and INM had higher potassium pools at 0-20 cm and 20-40 cm soil depth. Also, R-W-Mb and INM resulted in higher aggregated nitrogen and phosphorus content at surface and sub-surface soil depths.
- Similarly, four upland cropping sequences each maize-based such as maize-wheat (M-W), maize-wheat-mungbean (M-W-Mb), maize-wheat-maize-chickpea (M-W-M-C) and pigeonpea-wheat (P-W) and bajra-based such as bajra-wheat (B-W), bajra-wheat-mungbean (B-W-Mb), bajra-wheat-bajra-chickpea (B-W-B-C) and pigeonpea-wheat (P-W) were evaluated at three nutrient management practices: CT, INM, and RDF. Maize yield was significantly higher in M-W-Mb system followed by M-W-M-C and the lowest yield was in conventional M-W system.
- M-W-Mb, M-W-M-C systems led to the higher sand (%) and lower silt and clay (%) over M-W system. M-W-Mb and INM significantly enhanced the water holding capacity (WHC), % porosity, and volume expansion in surface soil subsurface soil, whereas, continuous M-W rotation caused reduction in WHC and porosity (%) in subsurface soil. P-W and INM had higher macro- and micro-aggregated N and P concentration.

Nutrient management

- In an experiment with rice-lentil relay system, transplanted puddled rice (PTR) have an advantage over non-puddled transplanted rice (NPTR) as PTR resulted in higher germination of the lentil crop (surface seeding) in sandy-loam soil of Kanpur. Lentil seed soaking for 4 h (hydro-priming) increased the rate of seed germination and successful establishment of crops over non-soaked dry seeds. Among the different crop management practices in lentil, *utera* (hydro-priming) with standing rice stubble (20 cm) + urea spray (2%)+ micronutrient spray had higher plant population of lentil.
- Micronutrient management in soybean-chickpea system highlighted that application of ammonium molybdate 1 g/kg seed treatment + 0.5% foliar spray of $ZnSO_4$ resulted higher yield attributes of soybean and chickpea than other micronutrient management options and remained at par with ammonium molybdate 1 g kg seed treatment + $ZnSO_4$ @ 25 kg/ha and ammonium molybdate 1 kg/ha soil application + $ZnSO_4$ @ 25 kg/ha.

Precision irrigation scheduling

- A field experiment was conducted in lentil (cv. 'IPL 316') to study the effect of irrigation (sprinkler irrigation *vis-à-vis* normal flood irrigation at critical stages of branch and pod development) coupled with diverse tillage options (conventional: CT, reduced: RT and zero tillage: ZT) on crop performance, water use and efficiency of applied inputs.
- Sprinkler irrigation especially at branching led to higher grain productivity, biomass yield, straw yield, pods/plant, and grain weight/plant in comparison to *rainfed* cultivation. Thus, sprinkler irrigation based irrigation scheduling at peak branching (50-55 days) could be optimum in lentil with accelerated crop productivity and

water use efficiency (Fig. 1).

- Another experiment with hydrogel and foliar supply of agrochemicals in chickpea cultivar 'JG 16' for enhancing its nutrient and water use efficiency under rainfed/limited irrigated situation confirmed higher grain yield with foliar spray of salicylic acid (100 ppm) followed by urea (2%) or NPK (19:19:19) at 0.5% at both flower initiation and pod development stages. Improvement in chickpea yield and its attributes were not pertinent following application of hydrogel up to 5 kg/ha over that in control. Beneficial residual effect of hydrogel applied to *rabi* pulse (chickpea) was observed on *kharif* cereal crop (Jowar).
- Higher sorghum grain yield was obtained with zero tillage under conservation agriculture in a sorghum-fieldpea rotation (Fig. 2).

Figure 1: Effect of sprinkler irrigation *vis-à-vis* flood irrigation in lentil 'IPL 316' at 110 DAS

Figure 2: Effect of conservation tillage (Field view, zero tillage in left vs. conventioal tillage on right) on Jowar (MH 8508)

Organic cultivation of pigeonpea and sorghum

Experiment on organic form was repeated during 2019 to develop the refined package of cultivation in long duration pigeonpea 'IPA 203'. It was evident that additional 20% in plant population (with 75 x 20 cm) could result in 0.26 t/ha bonus yield in the experimental light textured sandy loam soils. Therefore, if seeds are not a constraint, or narrow-row spacing could be useful in these low fertility alluvial soils of Uttar Pradesh. The crop performance was good as it yields a maximum of 1.93 t/ha under organic cultivation, which was comparable to that of non-organic farming (Fig. 3). In rainy season of 2019, sorghum yield was also comparable in organic and chemical farming

Figure 3: Performance of pigeonpea 'IPA 203' at maturity following organic cultivation

Conservation agriculture

- A field experiment was initiated during 2009 involving two tillage practices [zero tillage (ZT) and conventional tillage (CT)], three cropping systems [rice-wheat (RW), rice-chickpea (RC), rice-wheat-mungbean (RCM)] and two residue management practices [residue retention (R^+) and residue removal (R^-)]. From 2015 onward, ½ dose of P (without K) was applied to *Rabi* and summer crops under conservation agriculture (CA) practices (ZT+R^++ RWM). The yield of rice was the highest in ZT (5.2 t/ha) which was 35.3% higher over CT. Similarly, the yield of rice was higher under R^+ (4.6 t/ha) over R^- (4.2 kg/ha). Introduction of mungbean enhanced rice yield by around 13.2% over RW. Similar to rice, wheat yield was 9.8% and 9.6% higher in ZT and R^+ over CT and R^-, respectively. Following growing of mungbean, wheat yield under RWM system was also 6.3% higher over RW. Whereas, yield of chickpea was 34% higher under conservation tillage (ZT+R^+) over CT without residue retension (R^-). Performance of mungbean was also better under CA practices with yield advantage of 43.2% over conventional practices (CP). As a result, system productivity in terms of chickpea equivalent yield (CEY) was significantly higher (81.7%) in CA over CP (Fig. 4).

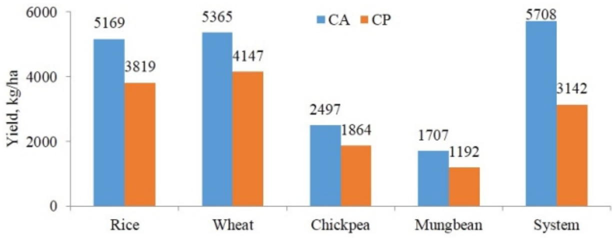


Figure 4: Performance of component crops and system under conservation agriculture (CA) and conventional practice (CP)

Weed management

- ***Weed seed bank:*** Significant variation in weed seed bank was observed at both the soil depths *viz.*, 0-7.5 and 7.5-15 cm. Number of weed seeds was significantly higher in Puddled transplanted rice followed by conventional tilled pulses with residue retention (PTR-CT+R) at both soil depths. Among cropping systems, maximum weed seed density was observed in rice-chickpea and the least in RWM. In treatment PTR-ZT (zero tillage) and PTR-ZT+R, maximum weed seed was accumulated in 0-7.5 cm soil depth, whereas it was only 40% in case of PTR-CT+R. A total number of 28 weed species belonging to different families were observed in weed seed bank study. Among these, *E. indica, L. chinensis, C. rotundus* and *D. aegyptium* were the major narrow leaved; and *C. dedymus, A. arvensis* and *C. album* were the dominant weed species. Diversity indices of weeds seed bank, like Shanon-Wiener, Simpson and Evenness indices were significantly higher in PTR-ZT+R systems over PTR-CT. Similarly, amongst cropping systems, RWM had significantly higher Shanon and Evenness indices over those in RW.
- ***Seed quality of rice:*** Analysis of rice samples for amylose and amylopectin in different rice establishment systems revealed that PTR-ZT and PTR-ZT+R had higher amylopectin over that in PTR-CT, whereas among cropping systems, lowest values of amylopectin was recorded in RWM. Milling quality was analysed using '*Universal Grain Testing Mill*' with different milling parameters, like recovery percentage and rice grain width and length. These were not influenced due to the treatments (tillage, residue and cropping systems).
- New post-emergence herbicides such as clodinafop-propargyl + Na-acifluorfen 122.5 g/ha at 10-15 DAS in mungbean, and topramezone 20.6 ml a.i./ha up to 21 DAS controlled broad-spectrum weeds with realization of higher grain yield. These herbicides provided selectivity to pulse crops.

Performance of summer mungbean under CA involving rice-wheat system in IGP

A field experiment was initiated from *Kharif* 2015 to study the performance of summer mungbean under conservation practices which involved three rice residue management practices (*viz.*, 30 cm stubble, rice residue burning and no residue), two tillage practices for summer mungbean (*viz.*, zero tillage and conventional tillage), and 5 mungbean varieties (*viz.*, IPM 2-3 with 60 days maturity, IPM 2-14 with 65 days, HUM 16 with 58-60 days, Samrat with 55-58 days and IPM 205-7 with 50-52 days. Although the effect of tillage on mungbean yield was at par, yet, significantly higher grain yield of mungbean was recorded with residue retention (1216 kg/ha) over residue burning (1077 kg/ha). Among different mungbean cultivars, the sequence for decreasing grain yield was in order of :IPM 205-7 (1304 kg/ha) > HUM 16 (1185 kg/ha) > Samrat (1164 kg/ha) > IPM 2-3 (1088 kg/ha) > IPM 2-14 (971 kg/ha) (Fig 5). Tillage operations has no effect of mungbean on yield of rice and wheat although numerically higher grain yield of rice was recorded in ZT (4302 kg/ha). Among residue management practices, maximum paddy yield was recorded in residue retention (4691 kg/ha) and the least in residue burning (3849 kg/ha). Similar trend was also observed in wheat yield. System productivity in terms of mungbean equivalent yield (MEY) was higher in ZT (4232 kg/ha), residue retention (4392 kg/ha) and IPM 205-7 (4338 kg/ha) in comparison to conventional tillage, residue burning and IPM 2-14, respectively. Among mungbean varieties, the sequence of system productivity was IPN 205-7 > HUM 16 > Samrat > IPM 2-3 > IPM 2-14 (Fig 6).

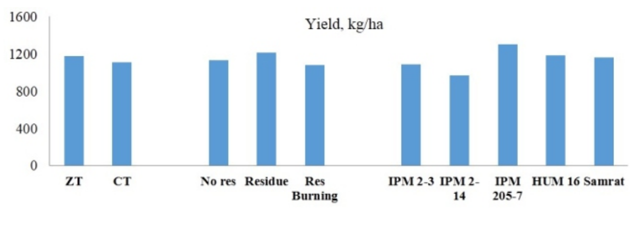


Figure 5: Performance of summer mungbean under different practices

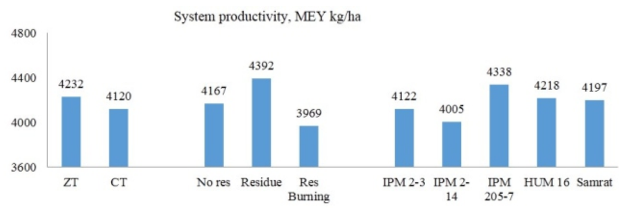


Figure 6: System productivity under different practices

Pulses in upland cropping systems under CA for climate resilience

A field experiment was initiated during *Rabi* 2017-18 to optimize a cropping system with higher system productivity, resource-use efficiency and soil health for climate resiliency. Ten potential and diversified cropping systems suitable for upland condition under irrigated agro-ecosystem include rice (DSR)-wheat, rice (DSR)-wheat-mungbean, rice (DSR) + *dhaincha*–wheat–mungbean, rice (DSR) – chickpea + mustard (6:2), rice (DSR)–mustard–mungbean, maize-wheat, Maize–wheat–mungbean, maize–chickpea + mustard (6:2), pearl millet – lentil + linseed (4:2) and maize+ *dhaincha* (*in-situ GM*)– chickpea–mungbean. System productivity in terms of chickpea equivalent yield was maximum in rice-wheat-mungbean (4880 kg/ha) followed by rice+*dhaincha* (GM)-wheat-mungbean (4866 kg/ha), maize-wheat-mungbean (4670 kg/ha) and the least in pearl millet-lentil+linseed (2189 kg/ha) (Fig. 7). The results further revealed that system productivity can be significantly up-scaled following inclusion of summer mungbean in rice-wheat and maize-wheat system under conservation agriculture (Fig. 8).

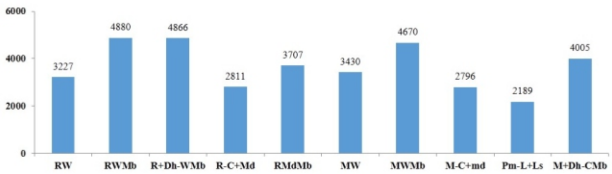


Figure 7: System productivity (CEY, kg/ha) of different cropping systems

Figure 8: Performance of maize under green manure (right side) and normal practice (left) under CA parctices

Details of technology developed

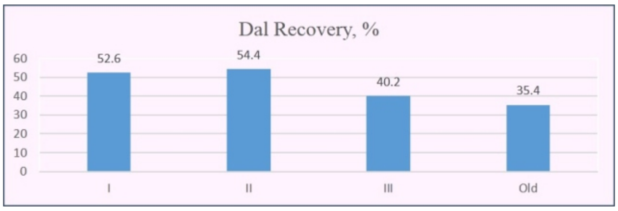
- Rice-wheat-mungbean is remunerative cropping system under conservation agriculture practices.
- Suitable mungbean cultivars screened under CA revealed the following sequence in order of productivity level: IPM 205-7 > Samrat > IPM 2-3 > HUM 16 > IPM 2-14.
- Supplementary irrigation once to lentil at (peak) branching is remunerative following absence of precipitation during *Rabi*. Sprinkler irrigation given only at branching of lentil 'IPL 316' had higher grain yield (75%), biomass yield (77%), straw yield (78%), pods/plant (64%) and grain weight/plant (65%) in comparison to rainfed cultivation.
- Improvement in chickpea 'JG 16' grain yield was apparent following application of either nutrient solution (2% urea versus 0.5% NPK spray) or growth chemicals (salicylic acid at 100 ppm).
- Ammonium molybdate at 1 g/kg seed treatment + 25 kg $ZnSO_4$ ha^{-1} should be fertilized to soybean in soybean-chickpea system in central India.
- Clodinafoppropargyl + Na-acifluorfen 122.5 g a.i./ha in *Kharif* mungbean and topramezone 20.6 g a.i./ha in chickpea are promising as post-emergence herbicides.

Mega Project 2: Post harvest management of pulses, value addition and by-product utilization

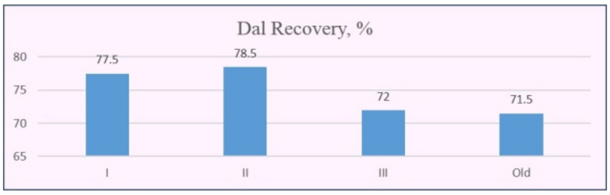
Sub-project 2: Enhancing efficiency of abrasive dehusking unit of IIPR Mini Dal Mill for different pulses

Pitting of whole pulse grain surface is an essential operation for better soaking of water or oil applied for pre-milling treatment of pulses. In improved model of IIPR Mini Dal, emery roller was added to accomplish this operation. Efforts are being made to improve emery roller to achieve maximum dehusking in first pass. Second pass is made through rubber-steel disk vertical *chakki* after pre-milling treatment for deshuking and splitting of treated grains. Initially the roller was made of commercially available grinder medium emery grit size. First pass through emery and second pass through rubber-steel disk mechanisms minimizes the scouring losses, though it leaves 5-10% husk cover over *dal*. This reduction in dehusking results into higher *dal* recovery, but husk over *dal* reduces market acceptance, though it is rich in fibre and phenols. In order to achieve better dehusking, treated samples can be passed through emery roller in second pass as well. This project was developed to ascertain appropriate emery grit combination achieve maximum dehusking in first pass. Initially emery disks of 16, 20, 24, 30 and 36 mesh got fabricated from M/s Sterling Abrasives, Ahmedabad. The disks of size 15.24 x 3.81 cm can fit into lab scale grain testing mill. Performance of these disks were evaluated for milling of different pigeonpea, chickpea, lentil, mungbean, urdbean and fieldpea. Maximum dehusking for pigeonpea obtained was 77.47% with 24 grit emery. For chickpea 84.21%, lentil 81.53%, mungbean 79.13%, urdbean 91.53% and fieldpea 86.33% maximum dehusking was obtained with 16, 20, 20, 30, 30 mesh grits, respectively. Based on the results combination emery rollers of two, three and five grit combinations were prepared. Combination rollers 24:30 (Roller I), 18:24:30 (Roller II) and 14:16:20:24:30 (Roller III) were prepared to fit into experimental *dal* mill designed and fabricated for the purpose of evaluation of these rollers. The results were compared with the previously used emery roller made with commercially available grinders of medium grit size. These rollers can be fitted in experimental *dal* mill prepared for evaluation of different emery rollers. The results obtained are presented in graphical form as below:

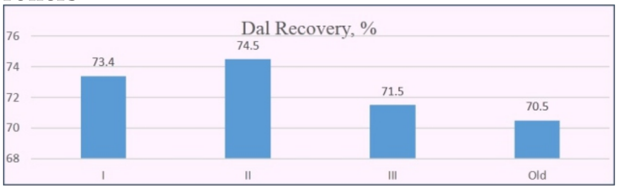
Whole pulse grains are passed through emery roller for ease of pre-milling treatment. For pigeonpea, the performance of the designed rollers ispresented in graphical form as below :



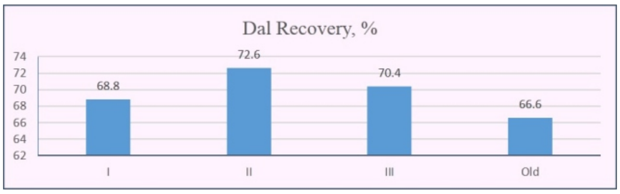
The performance of emery rollers after water soaking pre-milling treatment indicates maximum *dal* recovery of 78.5% in three grit combination roller after second pass. Old roller and five grit combination roller the recovery was lesser than two and three grit combination emery rollers.



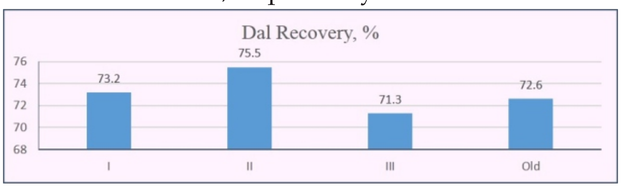
In case of oil treated pigeonpea grains, milling recoveries in second pass was obtained to be 74.50% and 73.40% with three and two grit combination rollers



Dehusked mungbean (*Mung Dhuli*) was prepared after oil treatment to in two passes through combination emery rolls. Second emery roller which is combination of three grits performed better than other rollers in terms of *dal* recovery.



Dehusked whole of lentil (*Malka Masoor*) is prepared without any kind of pre-milling treatment. Milling recoveries obtained with two, three, five and old emery rollers were obtained to be 73.20%, 75.50%, 71.30% and 72.60%, respectively.



Crop Protection

A. Institute Funded Project

Pigeonpea

Host plant resistance against wilt

1500 pigeonpea lines were screened in the wilt sick field at IIPR Research Farm during *Kharif*, 2019-20 for identification of new sources of resistance against *Fusarium udum* (Race-2) causing the wilt disease. Bahar was used as susceptible check.

Observations on wilt disease incidence were recorded fortnightly the line of 1200 advance breeding materials, (IPAC-66, IPCA-67, IPAC-68, IPA10W-2-9, IPA10W-14, IPA10W-3-8, IPA10W-12, IPA10W-18, IPA10W1-8, IPA10W 20-2, IPA10W 20-4, IPA10W 2-0-1, IPA10W 4-10, IPAC-68-6, IPA 16-6, IPA 16-2, IPA 17-1, IPA 17-2, IPA 17-4 and IPA 17-5) were prometing against *Fusarium* wilt.

Thirty pigeonpea lines developed by IRB (DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-11, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16 and IPA-38, IPA 16F, and IPA 15F) showed resistant reaction against wilt.

Out of 42 genotypes received from ICRISAT, five genotypes (ICPWS 1615, ICPWS 1634, ICPWS 1636, ICPWS 1606, and ICPWS 1610) were planted in wilt sick field and performed good. 115 genotypes of AICRP centres along with check variety Bahar were planted for evaluation.

Host plant resistance against *Phytophthora* stem blight

500 early and medium duration pigeonpea lines were planted for evaluation against Phytophthora stem blight (PSB) resistance in sick field during *Kharif* 2019-20. UPAS 120 and ICP 7119 were sown as check after every two rows of test entry. PSB incidence was recorded fortnightly in different genotypes. Based on the mean disease incidence of the three replications, 11 pigeonpea lines *viz.*, IPAC-79, IPAPB 7-2-1-7, IPAPB 7-2-1, KPBR 80-2-1, IPAC-3, IPA 15-01, IPA 15-07, IPAP-19-08, IPH 18-02, IPH 18-01 and IPA 16E-7) were identified as promising entries.

Mungbean and Urdbean

Host plant resistance against YMD

During *Kharif* 2019, 131 genotypes of mungbean and 72 genotypes of urdbean were screened against yellow mosaic disease using infector row technique. Mungbean genotype DGGV 2 and urdbean genotype CO 5 were planted after every two rows of test genotypes as susceptible check. Disease build up was good as indicated by >80% YMD incidence in both the checks. Observation recorded on the disease reaction of test genotypes revealed 10 mungbean genotypes (IPM 1205-2, IPM 14-49-5, KPM 16-17, IPM 139xSPS 187-1, RMG 1034, IPM 2K 08-1-1, PDM 139, RMG 1045, IPM 2K 14-7 and IPM 305-1-2) and 18 of urdbean (IPU 99-220, IPU 131, IPU 85-86, IPU 96-3, IPU 13-1, PUL 570, IPU 99-4, EH 84-4, NP21, IPU 99-336, PDU 3, NKDU2, IPU 13-3, IPU 13-7, IPU 99-22, IPU 16-6, V3108 and IPU 10-1) to be completely free from disease.

Rajmash

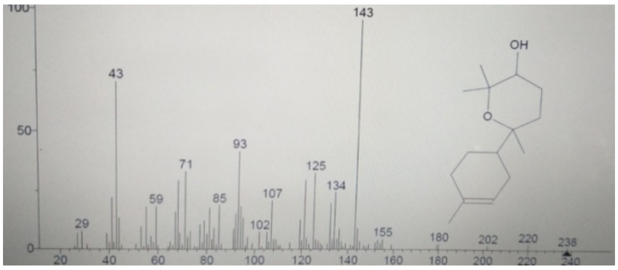
Host plant resistance against BCMV

Out of 50 rajmash germplasms screened against BCMV through sap inoculation under artificial condition, 11 lines viz., EC 5644797, EC-150250, IC 340947, GPR 203, EC 400445, IC 341435, ET 8409, EC 540173, EC 541703, BLF 141, ET 4515B, showed resistant reaction (Fig. 1) and rest of them were susceptible under both natural and artificial inoculation condition.

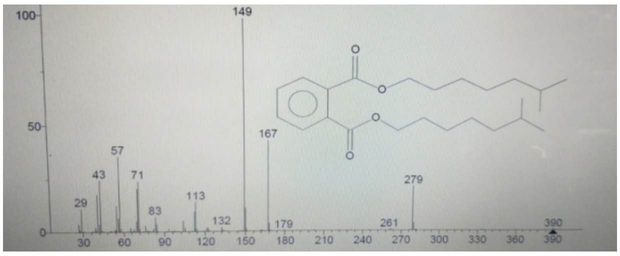
Figure 1: Screening of rajmash genotypes against BCMV disease through sap transmission

Isolation and identification of volatile metabolites from the biocontrol agent *Trichoderma harzianum* through GC-MS analysis

Secondary metabolites play an important role in mycoparasitic action. These metabolites kill/degrade the hyphae of target pathogen and help in penetration of *Trichoderma* species. Isolation and characterization of volatile metabolites from the culture filtrate of *IIPRTh-4* and *IIPR Tlongi-31* was done (Fig. 2). This sample was then used for GC-MS analysis. 1, 2- benzenedicarboxylic acid delected in this sample is well known for its antimicrobial activity and 2H-Pyran-3-ol,which acts as a plant growth regulator and is helpful in mycotoxin



(A)



(B)

Figure 2: ***Chromatogram showing major secondary metabolites produced by Trichoderma spp A-.2H-Pyran-3-ol, B-1, 2- benzenedicarboxylic acid***

Characterization of viruses

Lentil plants showing symptoms of viral etiology such as mottling, yellowing and overall growth reduction (Fig. 3) were noticed in the fields of the Indian Institute of Pulses Research, Kanpur. Studies were conducted to characterize the virus involved. In PCR assays several primer pairs for both RNA and DNA viruses were used. Result of PCR assays with primer pairs (ToLCNDV-F GTGAAGCGACCAGCAGAT/ ToLCNDV-R TTAATTTGTTACCGAATCATA) indicated involvement of ToLCNDV in seven of ten samples processed (Figure 3).

In case of chickpea, 11 samples of plants showing typical symptoms of stunt disease were processed for the detection of the viruses involved. Based on the sequences obtained from the RCA product of two samples, involvement of *Chickpea chlorotic dwarf virus* in the stunt disease at Kanpur has been confirmed.

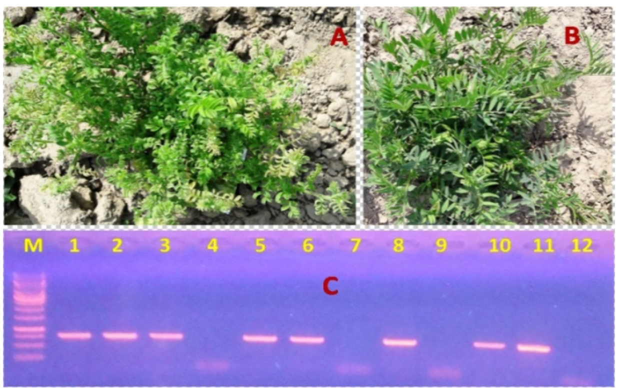


Figure 3: Symptom of ToLCNDV in lentil plants (A), healthy lentil plant (B) and detection of ToLCNDV in 7 plants (Lane 1-3, 5-6, 8 and 10) out of 10 plants (C). M=1Kb DNA ladder (Fermentas), Lane 11= positive control and Lane 12= healthy plant

Characterized the *Bean common mosaic virus* using virus specific primers by PCR amplification (820bp) and sequencing confirmed the Kanpur strain and Palampur strain belonging to the same strain of the BCMV (NL1) (Fig. 4).

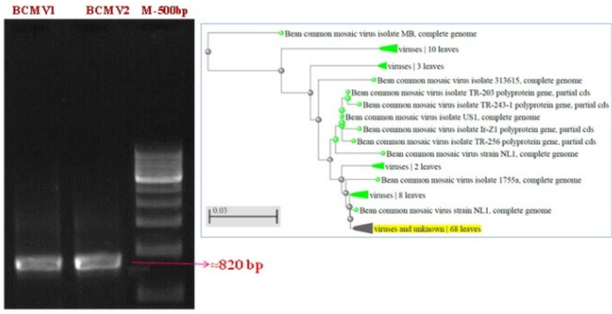


Figure 4: Amplification of Polyprotein gene of BCMV infecting rajmash through RT-PCR technique

Entomology

A process for microencapsulation of microbial inoculants/ bio-compounds

To ensure the stability and persistence, the technical concentrate or active ingredients are often formulated as microcapsules in liquid suspension. The process of formation of sodium alginate-based microcapsules was standardized and microcapsules were formulated as emulsion concentrate. Corn oil (63 ml) was used as base material to form dispersion medium. An emulsifier, Tween-20 was added to reduce specific gravity and surface tension; and stirred for 10 minute at 1500 RPM to achieve homogenised suspension. A mixture (76 ml) of calcium chloride (0.1 M), ethanol and acetic acid was added to dispersion medium and stirred for 15 minute at 1500 RPM. Aqueous suspension of polymer, sodium alginate (3% w/v) (containing technical concentrate or active ingredients to be formulated) was dripped for five minute using a syringe into the dispersion medium and stirred for 15 minute at 2000 RPM. Finally, 65 ml of calcium chloride (0.2 M) was added to suspension mixture and stirring was continued until the microencapsulation was achieved. The spherical microcapsules were confirmed under light microscopy which ranged between 12 and 150 µm in size (Fig. 5).

Figure 5: Sodium alginate based microcapsules viewed under light microscope

Management of whitefly in mungbean and urdbean

Four different dates of sowing *i.e.* 15th and 25th March, 5th and 15th April for mungbean in the summer and 22nd July, 1st, 11th and 21st August were selected for both mungbean and urdbean in the *Kharif* to study the effect of sowing time on whitefly population dynamics. Two varieties of mungbean, *i.e.* IPM 205-7 (Virat) and DGGV 2 and one variety of urdbean (IPU 94-1) were selected for the study. Whitefly population was recorded at 35 days after sowing (DAS) for each treatment by the sudden trap method and were identified by molecular and taxonomic characterization as *Bemisia tabaci* species complex. Further, the genetic group was confirmed as Asia II 1 by phylogenetic tree construction. The population of whitefly was observed always higher on IPU 94-1 (urdbean) as compared to Virat and DGGV 2 (mungbean). Also, the overall population was higher in *Kharif* as compared to summer season. The mean whitefly population on IPM 205-7 (Virat) was observed markedly less on all dates of sowing as compared to DGGV 2, and also differed significantly with different dates of sowing. In case of summer mung (DGGV 2), the mean whitefly population per plant increased significantly from 1.08 to 1.64 due to 10-day delay in sowing, *i.e.* from 15th to 25th March. Similarly, in *Kharif* season, whitefly population per plant increased significantly from 3.68 to 4.52 in IPM 205-7 (mungbean), 7.38 to 14.52 in DGGV 2 (mungbean) and 28.46 to 31.7 in IPU 94-1 (urdbean) due to delay in sowing just by 10 days *i.e.* from 22nd July to 1st August (Fig 6). Hence, it was observed that early sowing in both summer and *Kharif* helped escape from whitefly infestation. Population of whitefly was recorded using yellow sticky traps at weekly interval which has been shown in Fig 7.

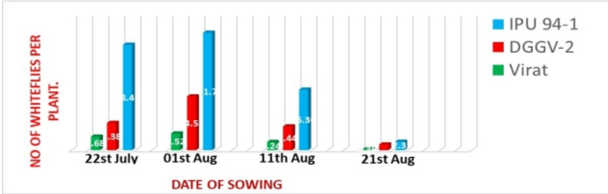


Figure 6: showing No. of whiteflies per plant in Virat (Mung bean), DGGV 2 (Mungbean) and IPU 94-1 (Urdbean) sown on different dates in *Kharif* 2019

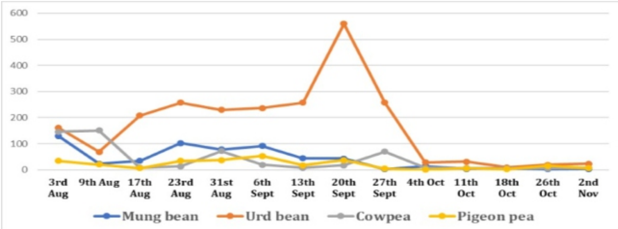


Figure 7: showing population of whiteflies recorded at weekly interval in different crops

Toxicity of actinobacteria crude extract against *Spodoptera litura* (Lepidoptera: Noctuidae) in pulses

Spodoptera litura is a polyphagous insect pest that feeds on at least 87 plant species in over 40 plant families, including many vegetables, fruits, cotton, groundnut, chilli, tobacco, castor, lady finger, cauliflower and pulses. Actinobacteria strains (48) isolated from soil samples, collected at different geographical location were cultured in Starch Casein (SC) broth at 28°C by shaking (150 rev./m) for initial 7d, subsequently on still position for 21d. After 28d, the fermented broth was centrifuged to extract the biocompounds from the supernatant using ethyl acetate (EtoAc) solvent. The crude extract of 48 actinobacteria was tested against 2nd instar larvae of *S. litura* to observe the oral toxicity by following surface diet contamination method. It was observed that *S. litura* larval mortality ranged from 20 to 100% (Table 1). Cultural morphology of 18 actinobacteria strains no growth to good growth in starch casein agar and seven different International Streptomyces Project (ISP1-7) media. Spore structure of actinobacteria belonging to different genera was observed under scanning electron microscope (Fig. 1). Further, actinobacteria strains were identified by amplifying 16S rRNA gene (Table 2).

Table 1: Toxicity of actinobacteria crude extract against *Spodoptera litura* larvae

Isolate	Larval mortality (%)	Isolate	Larval mortality (%)
AIN 6	56.67	AIN 39	50.00
AIN 9	45.00	AIN 40	35.00
AIN 11	45.00	AIN 41	30.00
AIN 12	40.00	AIN 42	62.50
AIN 13	35.00	AIN 43	70.00
AIN 16	30.00	AIN 44	30.00
AIN 18	40.00	AIN 45	30.00
AIN 19	45.00	AIN 47	35.00
AIN 21	63.33	AIN 49	45.00
AIN 22	50.00	AIN 52	60.00
AIN 23	46.67	AIN 53	55.00
AIN 24	55.00	AIN 55	20.00
AIN 25	63.33	AIN 56	60.00
AIN 26	43.33	AIN 57	30.00
AIN 27	62.50	AIN 58	35.00
AIN 28	52.50	AIN 59	65.00
AIN 29	83.33	AIN 61	40.00
AIN 30	83.33	AIN 62	50.00
AIN 31	45.00	AIN 63	60.00
AIN 32	73.33	AIN 64	50.00
AIN 34	53.33	AIN 65	50.00
AIN 35	60.00	AIN 66	40.00
AIN 36	60.00	AIN 67	100.00
AIN 37	53.33	Control	0.00
AIN 38	73.33	Methanol	0.00

Table 2: Particulars of actinobacteria strains

S.No.	Isolate	Strain	NCBI Accession no.
1	AIN 6	*Streptomyces ginkgonis* IIPR:KP01:02	MK818488
2	AIN 9	Nocardiopsis sp. IIPR:BP03:01	MK825534
3	AIN 11	*Streptomyces ginkgonis* IIPR:BP04:01	MK595692
4	AIN 12	Streptomyces badius IIPR:AK02:01	MK142738
5	AIN 13	Streptomyces sp. IIPR:BP05:01	MK825535
6	AIN 16	*Streptomyces lonarensis* IIPR:BP05:02	MK158076
7	AIN 18	Amycolatopsis sp. IIPR:AK03:03	MK825532
8	AIN 19	Saccharopolyspora sp. IIPR:AK03:04	MK825536
9	AIN 21	Streptomyces sp. IIPR:CI01:02	MK621807
10	AIN 22	Streptomyces sp. IIPR:KA02:01	MK825533
11	AIN 23	*Streptomyces albidoflavus* IIPR:KA02:02	MK248519
12	AIN 24	Streptomyces sp. IIPR:KA03:01	MN108029
13	AIN 25	*Streptomyces werraensis* IIPR:KR05:01	MK825539
14	AIN 26	*Streptomyces puniceus* IIPR:KR01:01	MK825538
15	AIN 27	*Streptomyces badius* IIPR:KR01:02	MK629291
16	AIN 29	*Streptomyces badius* IIPR:KR04:01	MK629316

17	AIN 31	*Streptomyces ginkgonis* IIPR:KR03:01	MK595689
18	AIN 32	Streptomyces sp. IIPR:KR03:02	MK158075
19	AIN 34	Streptomyces sp. IIPR:KA:01:01	MK595693
20	AIN 35	*Streptomyces puniceus* IIPR:TB01:01	MK825540
21	AIN 36	Amycolatopsis sp. IIPR:BP01:01	MK825542
22	AIN 37	Streptomyces sp. IIPR:CB01:01	MK825537
23	AIN 38	Streptomyces sp. IIPR:CB01:02	MK825541
24	AIN 40	Streptomyces sp. IIPR:SH01:02	MK595690
25	AIN 41	Streptomyces sp. IIPR:CH01:01	MK595691
26	AIN 42	Streptomyces sp. IIPR:NN01:01	MK595704
27	AIN 45	Streptomyces sp. IIPR: BH02:01	MK595702
28	AIN 49	Streptomyces sp. IIPR:CH03:01	MK611656
29	AIN 53	Streptomyces sp. IIPR:HD01:02	MN108026
30	AIN 55	Streptomyces sp. IIPR:HD01:04	MN108032
31	AIN 57	Streptomyces sp. IIPR:HD01:07	MN108027
32	AIN 58	Streptomyces sp. IIPR:HD01:07	MK595703
33	AIN 59	Streptomyces sp. IIPR:HD01:08	MK629324
34	AIN 62	Amycolatopsis sp. IIPR:BR01:03	MK621322
35	AIN 63	Amycolatopsis sp. IIPR:BR01:04	MN108028
36	AIN 64	Amycolatopsis sp. IIPR:SB01:01	MK629366
37	AIN 65	Streptomyces sp. IIPR:SB01:02	MK629368
38	AIN 67	Streptomyces sp. IIPR:SB01:04	MK629656

Confirmation of bruchid field infestation in cowpea

An experiment to re-confirm the bruchid field infestation was done by taking cowpea and mungbean twice in 2018-19 and 2019-20. The bruchid field and storage infestation study completed for cowpea and is underway for mungbean. The study found and confirmed the field infestation of two bruchid species, *Callosobruchus maculatus* F., and *C. analis* L., on cowpea from 4th week after flowering (WAF). The infestation started and increased towards crop end when all the pods dried with more egg laying observed on exposed seeds of shattered pods than unshattered ones (Fig. 8). The per cent oviposition (0.54 & 1.58), mean eggs per pod (0.38±0.25 & 1.13±0.52), per cent pods damage (0 & 0.30) and no. of adults observed per plant (0.79±0.41 & 0.86±0.4) was observed only during 4th and 5th WAF, respectively in caged plants. In case of open plants, as they are exposed for bruchid attack all the weeks, the per cent oviposition (1.26, 1.15, 1.03, 0.89 & 0.85), per cent pods damage (0.60, 0.59, 0.58, 0.59 & 0.76) and no. of adults observed per plant (0.26, 0.23, 0.23, 0.33 & 0.42) was observed more or less same. Whereas, the caged plants during 1st, 2nd and 3rd WAF not exposed to bruchid infestation as compare to the plants netted during 4th and 5th WAF (Fig. 9).

Figure 8: Infestation of bruchids on standing crop of cowpea and mungbean at field level

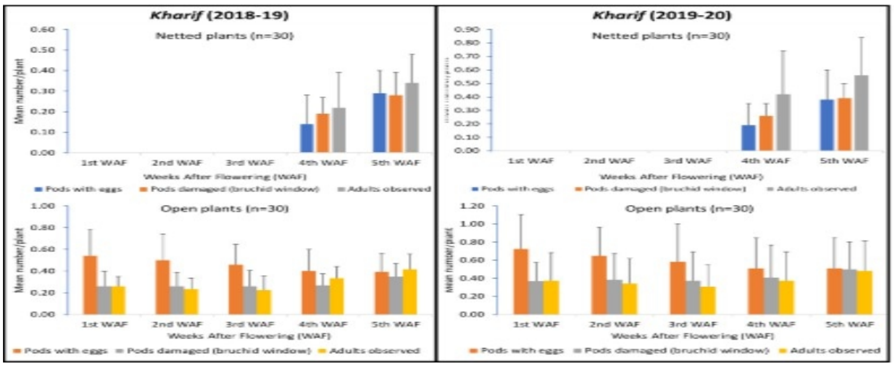


Figure 9. Field infestation of bruchids in cowpea

Further, the grains of both crops representing different WAF were harvested from open and caged plants and stored separately in cloth bags and bimonthly observations are completed for cowpea on per cent oviposition, grain damage, weight loss and adult density. The results confirmed carryover of field infestation into storage. Interestingly there was no oviposition, damage and adult activity observed in grains harvested from the plants caged during 1, 2 and 3 WAF, whereas, more oviposition, damage and adult activity was observed in case of grains from plants caged during 4th and 5th WAF (Fig. 10). In contrast to this, cent per cent oviposition and grain damage along with more adult density and nearly 50 per cent weight loss was observed in grains harvested from the open plants tagged during 1st to 5th WAF. This is because grains from open plants from all the weeks were exposed equally to bruchid infestation which started from 4th WAF.

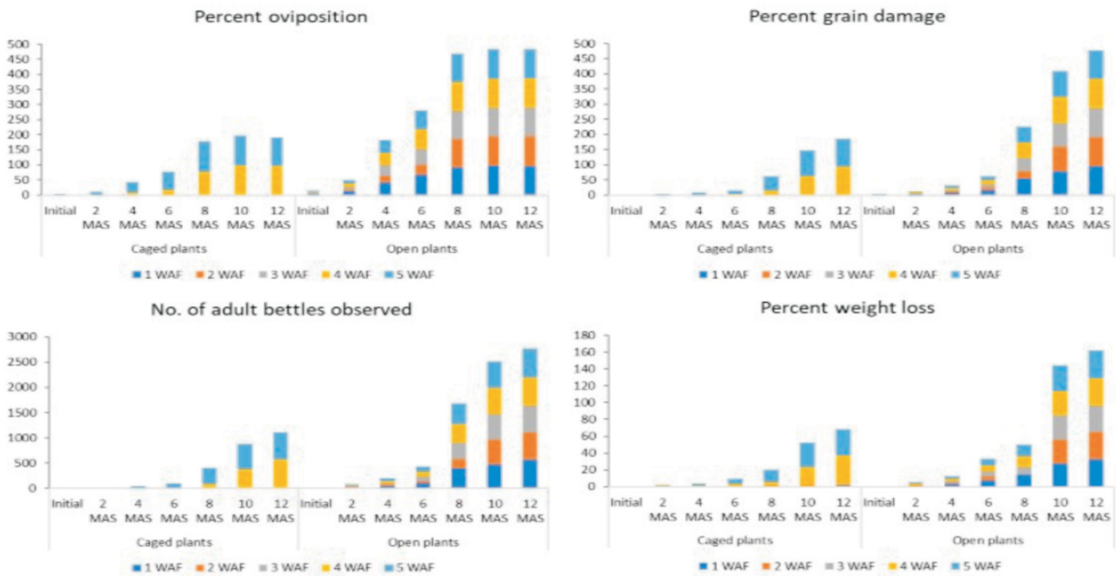


Figure 10: Parameters of bruchid field infestation and its carryover to storage in cowpea grains representing different WAF when stored in cloth bags for one year

Nematology

Host plant resistance

Screening of germplasm of pulses to find out resistant sources against root-knot nematode, *Meloidogyne javanica* was done in pigeonpea, mungbean and urdbean:

Sixteen genotypes/lines of pigeonpea were evaluated of much Six RVSA 16-1, IPA 206, Pusa-151, Pusa-163, WRGE 93 and PA 291 were moderately resistant and remaining 10 were susceptible to *M. javanica*.

Twenty nine lines of mungbean were evaluated and none of the lines was found resistant. Seven lines namely, COGG 912, IPM 512-1, KM 2241, KM 2355, MH 2-15, PKV AKM 4 and SKNM 1504 were moderately resistant. All lines screened were either susceptible or high susceptible to *M. javanica*.

Fifteen lines of urdbean were evaluated and none of the lines was found resistant. Two lines PU 14-19 and KUG 791 were moderately resistant. Eleven lines were susceptible and two were highly susceptible to *M. javanica*.

Management technologies

Effect of different cropping sequences on the population dynamics of *Heterodera cajani*

In a two year experiment on the effect of different cropping sequences on the population of *Heterodera cajani*, after growing of *Rabi* crops second year under cropping sequences(CS) 1. Urdbean – chickpea – maize – sorghum – chickpea – maize – urdbean 2. Urdbean–linseed-pearlmillet-urdbean-linseed-pearlmillet-urdbean. 3. Urdbean–wheat – mungbean-urdbean- wheat–mungbean–urdbean. 4. Long duration pigeonpea followed by long duration pigeonpea., the population recorded was 11, 14, 60 and 91 cysts/100 cc soil after chickpea, linseed, wheat and pigeonpea. After that the crops were followed as per the sequence during summer and in pigeonpea plots only stubbles remained without any crop (Fig. 11). Cyst population recorded after summer crops and before sowing of urdbean in all the plots was 13, 18, 65 and 70 in CS1, CS 2, CS 3 and CS 4, respectively. At maturity of urdbean crop, observations were recorded on cyst population, grain yield and per cent gain of yield after different cropping sequences over cropping sequence with susceptible crops only. Cyst population increased with growing of urdbean in all the treatments. The increase was more in CS 3 and CS4 because of more initial population. Grain yield recorded was more in CS1 followed by CS2, followed by CS3. Minimum yield was recorded in CS4. The per cent gain in yield over control (CS4) was 65.3, 23.5 and 12.4 in CS1, CS2 and CS3, respectively (Fig. 2). This suggests that at least two year non host cropping sequence is require for lowering the cyst nematode population and increasing the grain yield of urdbean.

Figure 11. (A) Crops grown during Summer, (B) Urdbean during *Kharif* season

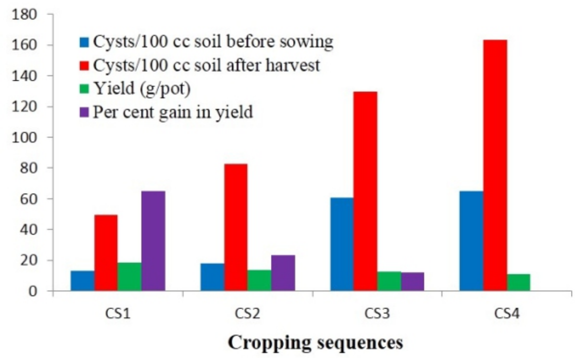
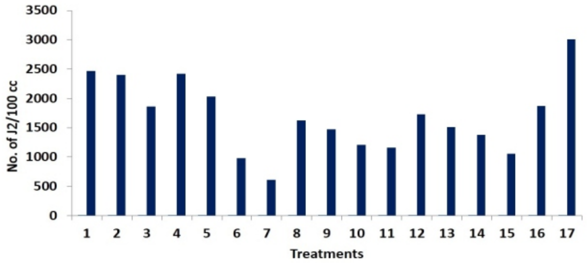


Figure 12: Cyst population before sowing and after harvest of urdbean, grain yield and per cent gain in yield over control

Evaluation of rapeseed and mustard varieties as bio-fumigant crop against root knot nematode, *Meloidogyne javanica*

Five varieties of *Brassica juncea*, five varieties of *B. napus*, four varieties of *B. carinata* and two varieties of *Eruca sativa* were evaluated. Trial was laid out in 8 inch diameter plastic pots having about 2 kg infested soil with second stage juveniles of root knot nematode at a level of 3900/100 cc soil. Three replications were taken for each variety along with one control. Chopped leaves of different varieties were mixed in soil and after slight moistening the soil were covered with plastic sheets and kept for 15 days before estimating the juvenile population. After estimating the juvenile population, five seeds of fieldpea variety Pant, 399 were sown in each pot and maintained for two and half month to record galling and plant fresh and dry shoot and root weights.

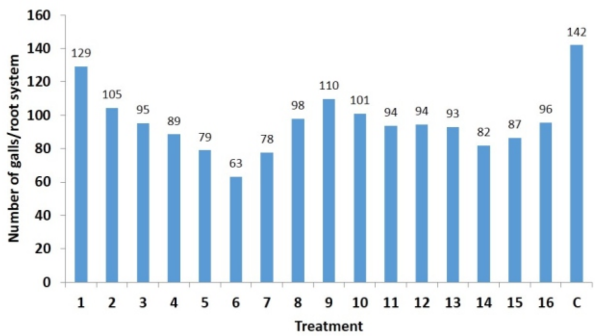
Nematode population was reduced in all treatments where chopped leaves were incorporated in soil over control (Fig. 13). However, maximum reduction was 80% in GSL 2 followed by 68% in Neelam variety of *Brassica napus* followed by 65% in Karan Tara of *Eruca sativa*



Brassica juncea	*B. napus*	*B. carinata*	*Eruca sativa*
1. Rohini	6. Neelam	11. Kiran	15. Karan tara
2. RGN-73	7. GSL-2		16. T-27
3. Urvashi	8. GSC-5		17. Control
4. Vasundhara	9. GSL-1	12. Pusa Aditya	
5. RB-50	10. Sheetal	13. PC-	

Figure 13: Effect of different varieties of rapeseed and mustard on the juvenile population of root knot nematode

Galls were comparatively less in all the treatments compared to control. The lowest galls (65 galls/root system) were recorded in pots which were bio-fumigated with Neelam variety followed by 78 galls/root system (Fig. 14). The fresh and dry shoot weight was the highest in plant grown after bio-fumigation with Neelam variety followed by GSL 2. Fresh and dry root weight was maximum in plants grown after bio-fumigation with Neelam variety.



1. Rohini , 2. RGN 73, 3. Urvashi, 4. Vasundhara , 5. RB 50, 6. Neelam, 7. GSL 2, 8. GSC 5, 9. GSL 1, 10. Sheetal, 11. Kiran, 12. Pusa Aditya , 13. PC 5, 14. Pusa Swarnim, 15. Karan tara, 16. T 27, 17. Control (C)

Figure 14: Effect of bio-fumigation on the number of galls on root of fieldpea variety Pant 399.

Characterization of IIPR strains of nematode egg parasitic fungus, *Purpureocillium lilacinum*

1. **Chitinase production (Plate assay)**

Ten IIPR strains of *Purpureocillium lilacinum* were tested for their chitinase production ability. Colloidal chitin enriched PDA medium was used. The medium colour changed from yellow to purple indicating the amount of chitinase produced by the fungus. Based on the diameter of coloration and the intensity of colouration, chitinase activity was determined

2. **Chitinase activity (Spectrophotometric assay)**

The chitinase activity of IIPR strains was evaluated in fungal cultural filtrates of 5, 10 and 20 days growth period derived from chitin enriched PDA medium by adding colloidal chitin through incubating at 37°C for 1-12 hrs. Spectrophotometric OD value recorded at 510 nm. The chitinase activity increased as the duration of growth period increased. Maximum chitinase activity was observed in strain IIPR *Pl*-11 (16 units) followed by IIPR *Pl*-10 (24.2 units) and IIPR *Pl*-1 (36 units) @ 5, 10 and 20 days respectively.

Fungus strains took 10 days to reach full diameter 9.0cm (Fig. 15).

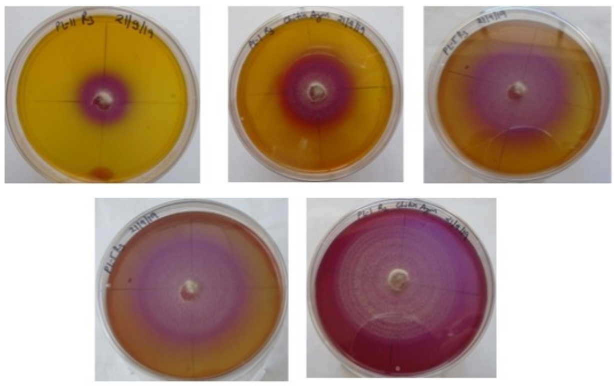


Figure 15: Chitinase production by *P. lilacinum* grown in chitin agar media indicated by purple colouration

Chitinase production	Strains
High chitinase	IIPR *Pl*-1, 4, 7, 9, 10 and 11
Medium chitinase	IIPR *Pl*-3, 5,6 and 8

1. **Total protein content (Lowry's method)**

The protein concentration was measured by Lowry's method with BSA as the standard. The protein concentration increased as duration of growth period increased. Maximum protein concentration was observed in strain IIPR *Pl*-1(69.5µg/ml), IIPR *Pl*-11(306.5 µg/ml) and IIPR *Pl*-10 (340.65 µg/ml) @ 5, 10 and 20 days, respectively.

2. *In-vitro* bioassay

One millilitre of cultural filtrated of all the strains with three replications was taken in 12 well tissue culture plates. One hundred freshly hatched juveniles were inoculated in each treatment. After 48 hrs, the dead nematodes were counted and kept separately in water to confirm whether juveniles were dead or nematostatic. The result reveals that juvenile mortality increased as the growth period increased. The maximum mortality was observed in strain IIPR *Pl*-9 (43.0%) followed by IIPR *Pl*-10 (63.3%) and IIPR *Pl*-1 (92.0) at 5, 10 and 20 days growth period.

B. Externally funded Projects

Innovative and contextual agromet advisory services for climate smart agriculture

Developing a disease forecasting model co-relate with weather parameters and monitoring of pest / disease on pigeonpea and chickpea

Observation on different weather parameters and per cent pest/disease incidence were recorded from farmer fields of four blocks in Hamirpur district of Bundelkhand region indicate that the minimum/maximum temperature, relative humidity and rainfall play an important role in the development of pest/disease in pigeonpea. Weather conditions play a predominant role in determining the course and severity of pest and pathogen incidence in different crops worldwide. Due to irregular rains distribution and variation in temperature, the productivity of pigeonpea continuous to be lower. The present findings were aimed to analyse the relationship between weather parameters and *Fusarium* wilt disease incidence in pigeonpea. Observation on different weather parameters and per cent wilt incidence were recorded from farmer fields of four blocks (Sumerpur, Kurara, Muskara, Maudhaha) in Hamirpur district of Bundelkhand region. These weather parameters were converted to monthly averages to find out association with the monthly wilt incidence (%) in pigeonpea in this region. Data were subjected to correlation analysis and results revealed that the correlation coefficient between wilt incidence and maximum temperature (0.13), minimum temperature (0.45) and rainfall were positive (0.50) (Fig. 16). The correlation coefficient between wilt incidence and relative humidity (-0.29), wind speed (-0.08) were negative. Results indicated that with increase in temperature, wilt incidence was increasing however rise in relative humidity led to decline in wilt incidence.

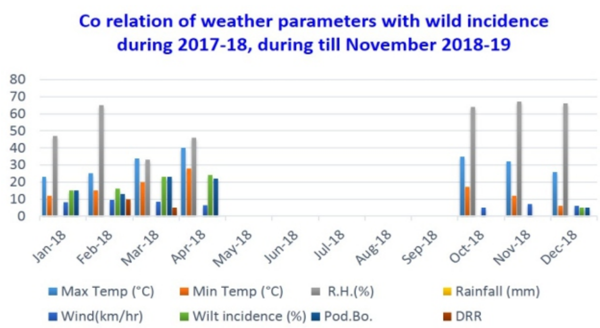


Figure 16: Transcriptome dynamics in host-viruses interaction to identify multi-virus resistant genotypes in mungbean

Transcriptome dynamics in host-viruses interaction to identify multi-virus resistant genotypes in mungbean

Testing of infectious clone of MYMIV

Infectious clone of MYMIV developed using In-Fusion Technology was tested on mungbean, frenchbean and soybean. For inoculation transforemed *Agrobaterium* culture was grown in AB minimal medium in a shaker at 28 ^{0}C till the OD of the culture reached 1.0 absorbance at 600 nm. The bacterial cells were collected by centrifugation at 1000 g for 10 min at 28°C. The pellet was re-suspended in an AB minimal medium (pH 5.6) containing 100 mM acetosyringone in equal volume. 10-11 days old seedlings of test plants were inoculated by pricking with the growing tip with sterile 30 G needle and placing 20 micro liter inoculum. Inoculated plants were maintained in plant growth chamber (28 ^{0}C, 60% RH and 16/8 hours light/dark). Plant were regularly watched for 25 days and watered as and when needed. Test plants inoculated with this clone did not show any apparent symptoms upto 25 days. However, presence of virus in the inoculated plants was detected through PCR assays.

Virulence profiling of *Ascochyta rabiei* and deciphering molecular interactions with chickpea

1. Using different culture media, 42 *Ascochyta rabiei* isolates was studied for morphological variability. We found that chickpea seed meal dextrose agar was the best media for cultivation and multiplication of *Ascochyta rabiei* followed by potato dextrose agar, oat meal agar and Czapeks Dox agar, where chickpea seed meal agar supports maximum mycelia surface growth.

2. The colour of the mycelia was initially white, later turned to dark brown on PDA and CDA media. At 5 days after incubation, light brownish on oat meal agar and light greyish color on Czapecks dox agar were observed

3. Four pathotypes (I, II, III, IV) were identified across the India based on evaluation of standard international chickpea differentials against *Ascochyta rabiei* isolates. Maximum location Pathotype III was observed followed by pathotype I, Pathotype IV and Pathotype II (Figure 17 and Table 3).

Figure 17:. Ascochyta blight differential for pathotypes and races identification

Table 3: Grouping of A. rabiei isolates into Pathotypes and Physiological races

Pathotypes	Isolates name	No. of isolates	Race	Isolates name	Total no. of isolates
I	AR 1, AR 3, AR 9, AR 11, AR 14, AR 24, AR 40, AR 41	8	1	AR 1, AR 3, AR 11, AR 14, AR 24, AR 40, AR 41	7
II	AR 4, AR 7	2	4	AR 4, AR 7, AR 18, AR 33, AR 34	5
III	AR 2, AR 12, AR 13, AR 16, AR 17, AR 18, AR 19, AR 22, AR 23, AR 27, AR 31, AR 33, AR 34, AR 39, D 13	15	5	AR 2, AR 12, AR 13, AR 16, AR 17, AR 19, AR 22, AR 23, AR 27, AR 31, AR 39	11
IV	AR 6, AR 21, AR 28, AR 32	4	6	AR 10	1
			7	AR 6, AR 21, AR 32	3

1. Screened 60 RAPD markers for 45 isolates of *Ascochyta rabiei* for diversity analysis and 20 SSR markers specific to *A. rabiei* isolates.
2. Mating types were determined on 45 North Indian isolates of *Ascochyta rabiei* using multiplex MAT-specific PCR with three primers. MAT1-1 specific primer Sp21 (ACAGTGAGCCTGCACAGTTC), MAT1-2 specific primer Tail 5 (CGCTATTTTATCCAAGACACACC) flanking region-specific primer Com1 (GCATGCCATATCGCCAGT) were combined in equal concentrations in a single PCR (Barve *et al.*, 2003). Mating types analysis was done to identify the presence of different mating types od *Ascochyta rabiei* prevalent in India. All 45 isolates of 4. *Ascochyta rabiei* belonged to MAT-2 and found completely absence of MAT1-1 among Indian isolates of *A. rabiei* (Figure 18).

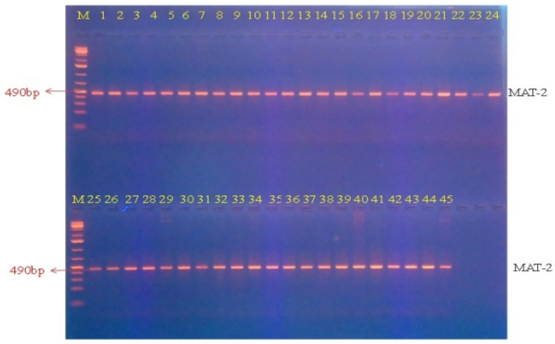


Figure 18: Mating type profiles of North Indian isolates of *Ascochyta rabiei* as detected trhough MAT specific primers

Insecticidal activity of plant essential oils on pulse beetle

To assess the insecticidal activity of plant origin essential oils, the locally available plant materials were subjected to hydro-distillation to obtain the plant volatile oils (plant essential oils) (Fig. 19-20). The preliminary evaluation of insecticidal activity of essential oils was carried out by impregnated filter paper assay as described by Tapondjou *et al*. (2005) (Fig. 21).

Figure 19: Hydro-distillation for extraction of plant essential oils

Figure 20: Plant essential oils

Figure 21: Impregnated filter paper assay

Appropriate amount of test essential oils was dissolved in acetone and applied uniformly to filter paper disc (Whatman No.1) to obtain the dose of 3.00 µl/cm^2. A group of 25 adults of pulse beelte, *Callosobruchus analis* (F.) were introduced to the petri dishes containing the filter papers treated with test essential oils, and controls treated with acetone alone. The exposure of test insects to the treatments was continued for 24 h and mortality of adult beetles was recorded at 24 h interval. The essential oils of *Ocimum* sp., *Curcuma* sp., *Mentha* sp., *Citrus* sp., *Eucalyptus* sp. and *Cymbopogon* sp. exhibited considerable mortality (≥ 70 %) in pulse beetle, *C. analis* at 3.00 µl/cm^2. The potential essential oils which demonstrated significant bioactivity are being tested for fumigant toxicity against pulse beetle, *C. analis.*

Genetic enhancement of minor pulses: Characterization, evaluation, genetic enhancement and generation of genomic resources for accelerated utilization and improvement of minor pulses

Screening of mungbean genotypes for bruchid resistance

Screening of 54 WorldVeg mungbean genotypes was completed against *Calosobruchus chinensis*, whereas, for other 45 genotypes, screening was completed against both *C. chinensis* L. and *C. analis* F (Plate 1). Among 54 WorldVeg Genotypes, the genotypes AVNU 1604 and AVNU 1606 were found moderately resistant carrying a susceptible index of 0.056, 0.051 and 0.058, respectively (as per Howe, 1971). The remaining 4 genotypes were moderately susceptible (0.063-0.070), 31 were susceptible (0.074-0.078) and 19 were highly susceptible (0.086-0.095). Among 45 genotypes, the genotypes 29/2F9 (m×u) 101-102 and 29/3F9(m×u)101-102 found moderately resistant with a susceptible index of 0.052 and 0.059, respectively. The remaining 6 genotypes were moderately susceptible (0.067-0.070), 26 were susceptible (0.071-0.076) and 13 were highly susceptible (0.08200.098).

Development of protocols for procurement, safe storage and milling outturn of major Pulses" funded by DoCA, Ministry of Consumers Affairs, Govt. of India

Survey of major pulse storage godowns

Developed a brief outline of data collection methods and schedules required to execute the project through series of surveys at NAFED hired godowns maintained by State Warehousing Corporations of Uttar Pradesh and Madhya Pradesh, namely, Atarra, Mahoba, Chhatarpur, Sagar, Vidisha, Tikamgarh and Niwadi for the year 2019-20. First visit to all the selected locations has been completed. At each location, stacks were identified and samples were collected for laboratory analysis of the grains stored regarding level of insect infestation and other existing storage conditions. At laboratory level, lentil (with different moisture) storage has been completed in different packaging materials after completing initial observations.

Basic Science

Project 1: Management and analysis of production constraints in pulses as influenced by different abiotic stresses and photothermoperiods

Sub-project 1: Physiological assessment of effects of various abiotic stresses on chickpea based on crop sensors and imaging and mitigation through foliar nutrition and growth stimulants

One hundred chickpea genotypes were grown under rainfed and irrigated conditions. At periodic intervals chlorophyll index, anthocyanin and NDVI (Normalized deviation vegetation index) observation were taken in irrigated and rainfed crop (limited moisture condition). In general, chlorophyll index was lower in rainfed crop subjected to limited moisture than irrigated crop (Fig 1). However , few genotypes such as Vijay, ICC 5912, C 214, Pusa 1053, ICCV 10, Tyson, BDG 75 and GNG 663 had higher chlorophyll index than irrigated crop, while chlorophyll index did not change in genotypes ICCV 92944, Vijay, RSG 991, and RSG 888 (Fig. 1).

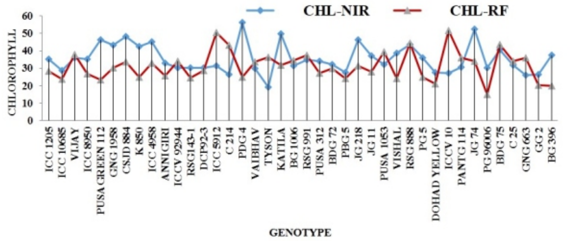


Figure 1: Chlorophyll index of chickpea crop grown under adequate moisture (irrigated) and limited moisture (rainfed without irrigation)

Anthocyanin, an important pigment in leaf protects leaves from oxidative stress. Some of the genotypes had increased anthocynanin when grown under limited moisture (rainfed) as compared to irrigated counterpart. This inferred that these genotypes are better adapted to water-limiting environment. The genotypes shown to have increased anthocyanin content under rainfed were ICC 1205, ICC 8950, ICC 4958, Annegiri,PDG 4,Vaibhav, Katila, Pusa 312, PG 96006, BDG 75 *etc* (Fig. 2).

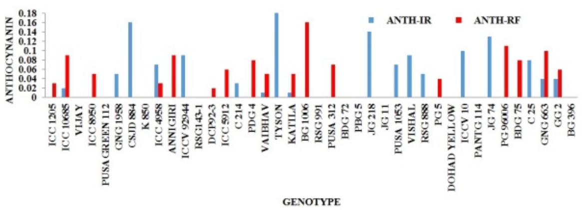


Figure 2: Comparative values of leaf anthocyanin in chickpea genotypes grown under irrigated and rainfed condition

NDVI values in almost all genotypes decreased under water-limited soil (rainfed) and this NDVI was found to be related with biomass (net photosynthetic area) and chlorophyll index . Some of the genotypes grown under rainfed had NDVI values at par with their irrigated counterpart, and they were GNG 1958, Pusa green 112, ICCV 92944, PDG 4BG 1006, RSG 991, Pusa 312, Pusa 1053 (Fig. 3). These genotypes have higher photosynthetic assimilatory surface or higher functional leaves under stress .

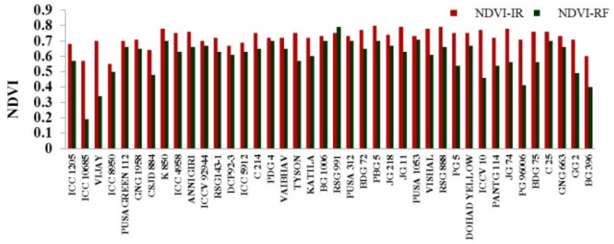


Figure 3: Comparative NDVI values of chickpea genotypes grown under irrigated and rainfed condition

Sub-project 2: Biochemical basis of heat tolerance in chickpea (*Cicer arietinum* L.)

Chickpea is an important cool season pulse crop grown all over the world including India. Heat stress particularly at reproductive stage is the major cause of yield losses in chickpea. When temperature exceeds 30°C, chickpea plants show reduced vegetative and reproductive growth.It has been reported that the thermo-tolerance capacity in plants is often correlated with the activities of antioxidant enzymes such as catalase, superoxide dismutase and glutathione reductase (GR). Under this project, the isozymes of superoxide dismutase (SOD) and glutathione reductase (GR) were studied in four heat tolerant (ICC 1205, ICCV 92944, ICC 15614 and Annegiri) and three heat susceptible genotypes of chickpea (ICC 10685, Pant G 114 and ICC 1923). The expression of these isozymes in the mentioned genotypes under control and heat stress conditions was studied by using native-PAGE. Heat stress conditions were induced by growing plants at higher temperature in growth chamber. It was observed that in chickpea, four isozymes of SOD were present in the heat tolerant genotypes whereas only three isozymes were present in the heat susceptible genotypes.The isozyme SOD III was induced in all the heat tolerant genotypes under heat treatment condition whereas the expression of SOD I was reduced under heat treatment condition (Fig. 4a). The enzyme glutathione reductase catalyzes the reduction of oxidized glutathione to reduced glutathione by using NADPH as reductant. It was observed that altogether five isozymes were present for this enzyme in the both heat tolerant as well as heat susceptible genotypes of chickpea (Fig. 4 b). Overall, not much difference was observed in the expression of this enzyme under heat treatment as compared to the normal condition.

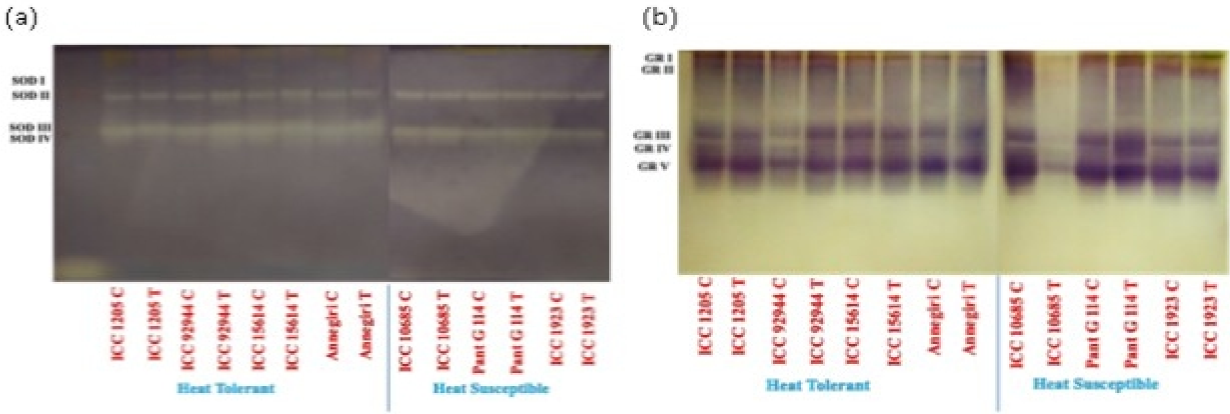


Figure 4: (a). Isozyme expression of superoxide dismutase (SOD) and 4(b). Glutathione reductase (GR) in heat tolerant and heat susceptible genotypes of chickpea

Sub-project 3: Identification and Physiological characterization of pigeonpea [*Cajanus cajan* (L Millsp.)] genotypes for cold tolerance

A total 102 genotypes of pigeonpea were screened against cold stress using four checks (IPA 203, Bahar, NDA 1, ICPL 7035) on the basis of three parameters such as retention of flowers/pods, apical damage and per cent regeneration/recovery after cold stress.The genotypes IPA 15F, Dhule-D, JBT46/27, IPACT-6, IPACT-14, IPAC-1-17, IPACT-68, IPACT-22 were found highly sensitive to cold stress and retained only 0-10% flowers/pods. Genotypes such as NDA 2, MAL 13, ICP 2275, IPACT 2 retained 60-80% flowers/pods which were considered as tolerant to cold stress. During 2019-20, eight genotypes from/sensitive group and 08 genotypes from tolerant/ moderately tolerant group and 14 crosses with 4 checks (IPA 203, Bahar, NDA 1, ICPL 7035) were used for further studies based on morphological, physiological and biochemical parameters during cold stress (December, 2019 to February, 2020).The observations on morphological, physiological and enzymological parameters are in progress and simultaneously meteorological data are also being recorded. The details of pigeonpea genotypes included in the study are as follows :NDA 1, Bahar, IPA 203, NDA 2, MAL 13, ICP 2275, IPACT-2, MA 6, IPACT 3, IPACT 24, Rajendra Arhar, IPA 15F, Dhule-D, JBT 46/27, IPACT 6, IPACT 14, IPAD1 17, IPAC 68, IPACT 22, ICPL 7035 and Crosses received from CI Division:

Sub-project 4 : Identification and physiological characteristic of high-temperature and drought tolerant genotypes of lentil (*Lens culinaris* Medik) for improving productivity and resilience screening for heat tolerance

A field experiment was conducted during *Rabi* season 2019 using 52 genotypes of lentil for the second consecutive year for screening for heat tolerance. Sowing of the crop was done under timely (normal) and late sown (one month) conditions on 25th November 2019 and 24th December 2019, respectively on ridge beds in two replications following the standard package of practices so that crop may be exposed to normal as well as higher temperature (>30^{0} C) at flowering. Very good germination was recorded in all genotypes within 7 days of sowing in normal sown crop, whereas late sown crop may take more time for germination due to low temperature. Further, morphological, physiological and biochemical observations apart from yield and yield attributes will be recorded during progress of the crop growth..

Screening for drought tolerance in lentil

A field experiment has been conducted in four Dugout micro plots (Wet, Moderately wet, Moderately drought and Drought) with 45 genotypes of lentil in two replications at Main Research Farm of the Institute for screening to drought tolerance. Sowing of the crop was done on 28th November 2019. Soil samples were collected from all the microplots from 0-15 cm and 15-30 cm depth for monitoring of soil moisture at different intervals. Initial crop vigour was recorded at periodical intervals using green seeker hand held crop sensor (Green Seeker portable NDVI). Further, morphological, physiological and biochemical observations apart from yield and yield attribute will be recorded for screening of genotypes..

Sub-project 5: Strategies for improving yield stability in urdbean through photothermo – insensitivity

A field experiment was conducted to identify photothermo-insensitive blackgram genotypes. One hundred selected high yielding genotypes of different geographical origin were grown at Kanpur 26.418 N longitude, 80.232 E and altitude 126.0 meter at 46/22^{0}C maximum/minimum temperature. Planting was done staggered over two dates on 20.6.2019 and 26.8.2019 in augmented design under irrigated field. Phenological observations were recorded on date of germination, 1st flowering, 50% flowering, 1st podding, 50% podding, and maturity. Five photothermo insensitive urdbean genotypes *e.g.* PU-19, IPU 99-79, IPU 99-213, PLU 65, PGRU 95016 were identified at Kanpur based on similar flowering time of crop at.different dates of sowing (Table 1).

Table 1: Putative selection of photothermoinsensitive blackgram genotpes

Genotype	20.6.2019 Photoperiod (13.47 h)	26.8.2019 Photoperiod (12.10 h)	Identified as
	1st flowering days after sowing		
PU 19	38	36	Photothermo -insensitive
IPU 99-79	35	32	Photothermo -insensitive
IPU 99-213	36	34	Photothermo -insensitive
PLU 65	39	36	Photothermo -insensitive
PGRU 95016	38	35	Photothermo -insensitive
Uttara	46	34	Photothermo-sensitive
IPU 2-43	43	33	Photothermo-sensitive
Shekhar	41	31	Photothermo-sensitive

Project 2: Nutritional and phytochemical profile of cowpea and fieldpea with emphasis on their bioavailability and health promoting properties

Starch constitutes a major fraction of legumes, accounting for 22-45% of the seed. It is composed of the linear amylose and branched amylopectin. Ratio of amylose and amylopectin depends on the starch source and has important nutritional implications. Legume starches are known for their high amylose content, typically greater than 30%. Because this high amylose concentration, legume starches exhibit lower glycemic index (GI) than cereal starches. Under this project, the amylose content of fifteen fieldpea varieties (including two vegetable type varieties) and fourteen cowpea varieties (including two vegetable type varieties) was estimated. Results are expressed in terms of amylose % of total starch (Table 2). It was observed that the vegetable type fieldpea varieties, Arkel and Azad P3 have starch composed mostly of amylose. These varieties have 94.88 and 93.15% amylose of total starch respectively. In cowpea also vegetable type varieties have higher amylose % as compared to grain type varieties. The unusually high amylose% in vegetable type wrinkled peas is associated with lack of starch branching enzyme 1 in them.

In recent years, there has been a rise in the reports on the ability of legume extracts in inhibiting the activity of carbohydrate metabolizing enzymes such as alpha amylase and alpha glucosidase. This suggests that legume extracts can be useful in controlling hyperglycaemia. The enzymes alpha amylase and alpha glucosidase are involved in starch breakdown. Another study taken up under this project was to estimate the *in-vitro* potential of field pea and cowpea extracts in inhibiting the activity of these enzymes. It was revealed that these extracts have higher potential for inhibiting alpha amylase activity than alpha glucosidase activity.

Table 2. Amylose % of total starch in fieldpea and cowpea

Fieldpea varieties	Amylose % of total starch	Cowpea varieties	Amylose % of total starch
IPF 99-25	44.42	TPTC 29	22.47
IPF 5-19	23.05	TCS 160	38.08
IPFD 10-12	30.10	GC 901	29.70
IPFD 1-10	21.33	TC 901	30.10
IPFD 12-2	30.74	KBC 7	32.21
IPFD 2014-2	26.79	KBC 9	28.52
Arkel	94.88	PL2	33.03
Azad P-3	93.15	PL3	26.52
IPF 16-13	52.03	DC 15	29.42
P 1586	27.56	DC 16	28.26
P 489	38 82	GC 3	26.33
IPF 12-20	54.87	RC 101	30.22
EC 328758	62.08	Kashi Kanchan	63.94
EC 341792	34.68	Kashi Gauri	53.30
B 22	35.25		

Project 3: Harnessing symbiotic efficiency of germplasm of major pulses for improving biological nitrogen fixation

Sub-project-1: Harnessing symbiotic efficiency of germplasm of major pulses for improving biological nitrogen fixation

Mungbean genotypes *viz* CL 267, CL 223, CL 218, CL 207, CL 3, and CL 5 were identified for high nodulation trait under P-deficient soils. CL 269 was reported with an average of 22 root nodules/plant and showed consistent results under field environment. Urdbean genotypes U70 and U96 were found to be good nodulators whereas U65, U70, U91, U94 were found to be high biomass accumulator (Fig. 5). Nodule number varied from 4-26 per plant. Fieldpea genotypes *viz* P19, P32, P48, P49 and P89 showed higher nodulation potential. Beside good nodulation, higher biomass accumulation was recorded for P32 and P89. Three fieldpea specific rhizobia were evaluated and based on nodulation and biomass data isolate PR-3 was found most promising. *Rhizobium* repository was developed for different pulse crops. Mungbean *Rhizobium* IIPR-MR-127 has reported with 18.16% yield enhancement over uninoculated control (Table 3).

Table 3. Evaluation of mungbean rhizobial isolated for BNF traits

Mungbean *Rhizobium*	Nodule no./plant	Nodule biomass (mg)/plant	Plant biomass (g)/3 plants	%increase yield over control
Uninoculated	9.33 ± 0.9	211.67 ± 11.0	29.41 ± 2.1	-
IIPR-MR-64	9.00 ± 0.8	225.33 ± 15.5	32.09 ± 2.9	4.75 %
IIPR-MR-78	13.33 ± 0.5	305.33 ± 10.8	32.20 ± 1.4	5.04 %
IIPR-MR-127	12.00 ± 0.8	295.67 ± 09.5	31.72 ± 2.1	18.16 %
IIPR-MR-128	14.67 ± 0.5	336.67 ± 21.1	38.84 ± 1.6	13.81 %
IIPR-MR-154	9.00 ± 1.4	236.67 ± 06.9	29.23 ± 1.8	5.78 %

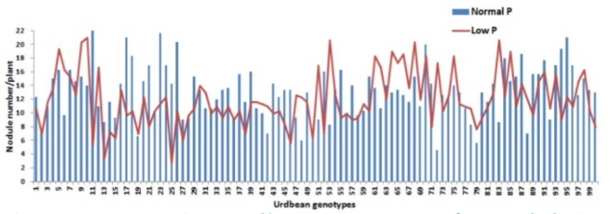


Figure 5: Screening urdbean genotypes for nodulation traits

Sub-project 2: Improving nodulation potential of rajmash

A total of 50 rhizobial strains isolated from different rajmash genotypes were evaluated for their nodulation potential under pot experiment. Nodule number varied from 1 to 7 per plant. Nodule specific weight varied from 0.002-0.005 g/nodule. Best three rhizobial isolates were selected for further studies. However, no nodulation was observed in rajmash varieties Arun and Uday. Antibiotic profiling of the rhizobial isolates were carried out based on susceptibility and tolerance of the isolates towards ten different antibiotics with different concentrations. Kirby-Bauer disc diffusion method was used to ascertain antibiotic tolerance of rhizobial isolates.

Project 4: Development of nano-material based microencapsulated formulation of imazethapyr for weed control in pulse crops and minimizes residue dynamics to the environment

Developed microencapsulated and nano-structured formulations: Two different types of the granular formulations of small nano loadings (~1-5 wt %) were developed successfully in laboratory first by taking a mixture of nano range clay materials (clay particle size of 90% particle <500 nm, alabaster 90% of particle of particle <700 nm size) and second by sodium alginate as granular matrix. For developments of the granular formulations initially the known quantity of commercially available formulations of imazethapyr was loaded on a known quantity of nano-hydrogel/nano-cellulose (particle size <200 nm). The pan coating process was utilized in that the nano-hydrogel/nano-cellulose particles are tumbled in a pan while the coating material (herbicide) sprayed and dried. A known quantity (to give~1-5 wt % concentration of toxicant in final product) of this toxicant coated hydrogel/nanocellulose was mixed well with nano-structured core materials *i.e.* a mixture of different clay materials in specific rations. The suitable ratio of various clay minerals was identified by judging the physical barriers received for toxicant release that includes the kinetic parameters governed by size, shape, and polarity of penetrant and by morphology of diffusion medium.

For *Kharif* season pulse crops (mungbean) nano-cellulose was utilized as absorbent for imazethapyr, whereas, for *Rabi* season (chickpea) nano-hydrogel was used for this purpose. Initially, a known quantity of imazethapyr was mixed to a known quantity of nanocellulose/nanohydrogel and dried well under shade at room temperature. Detailed information on developed products are given in Table 4: Microencapsulated formulations of imazethapyr and pendimethalin herbicides of 1-5 wt% were developed by utilizing the Coacervation-phase separation methodology. To achieve this, toxicant coated nano-cellulose (core material) was initially dispersed in the coating polymer solution (sodium alginate). In this process the core material got coated well by a polymer material. The rigidization of coating was achieved by following dissolution techniques. The entire process comprises of a mixture of *neem* oil (63 ml as base material of dispersion medium) and Tween 20 (as emulsifier). Initially the oil and emulsifier mixture was constantly stirred for 10 minutes at 1500 rpm to achieve homogenised suspension. Thereafter, a mixture comprises of 76 ml of calcium chloride (0.1 M), ethanol (36 ml) and acetic acid (1 ml) was added to dispersion medium and stirred for 15 minute at 1500 rpm. While stirring, a 10 ml aqueous suspension of herbicide coated sodium alginate (3 % w/v) was dripped drop by drop with the help of a medicated syringe within a period of five minute into this dispersion medium and kept continue stirring for 15 minutes at 2000 rpm. Finally, for hardening the microcapsules 65 ml of calcium chloride (0.2 M) solution was added to suspension mixture and stirring was continued till the proper microencapsulation was achieved. The prepared microcapsules were viewed under light microscopy and found to range between 12 to 150 µm in size and spherical in shape.

Table 4: Composition of improved version of nano structure formulation

Type of nano structured formulation	Physical barriers for to xicants and main materials and their ratio in Nano-structured formulations composition					Total amount of granules formed (gram)	Conc. of granular formulation (%)	The amount of granule applied in 30M^2 area to give conc. of ai /h		
	Nano-C 300-400 nm (binder)	Al 500-700 nm (filler)	Nc <200 nm (toxicant absorbent)	Ai (toxicant) 10% liquid formulation Amount of commercial EC taken in gram	Actual ai			100	200	300
Clay based nano structured granular formulation	2.5	6.5	13	10	1	490	1.8	16.66	33.33	50
	SA	W	Nc	EC	Actual ai					
Sodium alginate based granular formulation	0.89	11	13	10	1	210	4.2	7.5	15.0	22.5
	Veg oil	emulsifire	Other chemicals	Amount EC						
Imazethapyr Microcapsule formulation	60	2	350	5	1	2100	0.24%	125	250	375
Pendimethalin microcapsule formulation	20	0.66	117	3	1	2800	0.64			

Field experiment: The nanostructured granular formulations prepared so were evaluated for their herbicidal action and release kinetics in field experiments of chickpea during *Rabi* 2017. Replicated field trials were conducted in area of 30m^2 with different concentrations ranging from 150-250 g/h at new research farm of IIPR during 2018-2019. Results revealed that the chemical manipulations in the commercial formulations of imazethapyr were not only found to increase its efficacy against weeds but also observed safe for chickpea plants since the imazethapyr was found toxic to the crop plants even at extremely low concentration *viz*., <50 g/h in direct spray of commercial formulation. The granular formulations of nano structured matrix were applied on soil surface at two different times *i.e.,* before one week of sowing and at the time of sowing. The developed formulations under field conditions were observed to release toxicant in 3 to 4 fractions of certain quantity as and when field received water either by irrigation or by natural rain *via* a mechanism of diffusion. In this fashion of release, the formulations remained efficacious nearly to 50-60 days, hence, provide protection to the crop from weeds for the entire crop season without rendering any injurious effect to the chickpea crop. In addition to decreased damage to the chickpea crop, the products also proved beneficial in reducing pesticide spike concentrations in the environment, prolonging residual activity and reducing the number of applications. The formulations on their different concentrations *viz*., 150, and 250 g/h were found to reduce weed population and their biomass and density by 30-80% besides lowering in dry matter of the weeds by 30-80% in different treatments as compared to untreated control (weedy check). No significant difference in treatments of two application times and types of formulation were observed however activities significantly vary with concentrations of the formulation. As compared to control, nearly 50% increase in yield of chickpea was observed in most of the treatments of both kinds of nano-structured formulations. Detail results are given in different Tables (5-7).

Table 5: Effect on weed density and biomass in chickpea applied at the time of sowing

Formula-tion	Concentration	Data collected on 4-1- 2019				Data collected on 15-3- 2019			
		Weed density	% reduction over control	Weed dry biomass	Per cent reduction over control	Weed density	% reduction over control	Weed dry biomass	Per cent reduction over control
S.A. based	150	14	-73	1.253	-72	14	-22	9.12	-39
	250	12	-77	0.563	-87	06	-67	6.51	-56
Clay based	150	33	-38	3.06	-31	12	-33	8.79	-41
	250	6	-88	0.47	-89	08	-56	5.34	-64
Weed check	untreated	53	00	4.41	00	18	00	14.96	00
Weed free	Hand weeding	32	-40	3.63	-17	04	-78	4.60	-69

Table 6: Effect on weed density and biomass in chickpea applied before first week of sowing

Formulation	Concent-ration	Data collected on 4-1- 2019				Data collected on 15-3- 2019			
		Weed density	% reduction over control	Weed dry biomass	% reducti-on over control	Weed density	% reduction over control	Weed dry biomass	% reduction over control
S.A. based	150	11	-27	2.57	-0.4	12	-25	9.01	-28
	250	06	-60	1.98	-23	08	-50	4.40	-65
Clay based	150	08	-47	0.97	-62	08	-50	7.59	-39
	250	05	-67	0.68	-74	06	-63	3.35	-73
Weed check	untreated	15	00	2.58	00	16	00	12.54	00
Weed free	Hand weeding	19	+27	2.38	-08	12	-25	0.826	-93

Table 7: effect of developed formulations on chickpea yield

Formulation	Concentration	Applied at the time of sowing		Applied one week prior to sowing	
		Yield /plot (g)	% I/D over control	Yield /plot (g)	% I/D over control
S.A. based	150	1063	+21	1483	+48
	250	1423	+62	1270	+27
Clay based	150	1267	+44	1200	+20
	250	1350	+55	1440	+43
Weed check	Untreated	877	00	1003	00
Weed free	Hand weeding	1190	+36	1557	+55

Field experiment: The efficacy and kinetics of prepared nanostructured products were evaluated in replicated field trials conducted in area of 30 m^2. Entire field experiment comprise of five different treatments *viz*., 1. Nano-structured sodium alginate based formulation, 2. Nano-structured clay based formulation, 3.Imazethapyr liquid EC direct sprays @ 100 g/h, 4. Weed check (Untreated control) and 5. Weed free. The granular formulations of nanostructured matrix were applied on soil surface at the time of sowing whereas foliar spray of imazethapyr commercial EC was done after 20 days of sowing as recommended. The formulations on their different concentrations *viz*., 100, 200 and 300 g/h were found to reduce weed biomass and density by 60-80% besides lowering in dry matter of the weeds by 70-80% in different treatments as compared to untreated control. Whereas, in case of post emergence foliar spray, compared to untreated control, only 30-35% reduction in weed density and their biomass was observed. The formulations under field were observed to release the toxicant constantly in sustained manner for longer period of nearly 40-50 days and in this fashion of release, the formulations not only gave good control of weeds but also observed safe for mungbean plants as no phyto-toxicity symptoms were observed on crop plants. Moreover, observations recorded on certain plant growth promoting parameters *viz*, plant height, per plant fresh weight. Per plant dry weight, root biomass *etc*., of mungbean plant also revealed a positive impact by 10-60% and 1-21%, respectively in some the treatments of nano-structured formulations. As compared to control, nearly 60-100% increase in yield of mungbean was observed in most of the treatments of both kinds of nanostructured formulations however a maximum increase of 209% in yield in comparison to the untreated control was found in clay material based nano matrix granular formulation when applied at 300 g/h concentration. Higher doses *viz*., 200 and 300 g/h treatments of the formulations were also found nearly 10-15% superior in yield in comparison to the weed free plots. The results are given below in different Tables 8-10.

Table 8: Effect on weed density and biomass in mungbean field experiment

Formulation type	concentration	Weed density	% reduction over control	Dry weight of weeds	% reduction over control
S.A. based formulation	100	53	-61	14.456	-58
	200	52	-61	14.58	-57
	300	23	-83	10.183	-70
Clay based formulation	100	51	-62	8.33	-75
	200	33	-76	8.07	-76
	300	31	-77	6.30	-81
Weed check	000	136	00	34.06	00
Weed free	000	45	-67	11.96	-65
Imazethapyr foliar spray	100	90	-34	21.08	-38

Table 9: Effect on plant growth parameters of mungbean

Formulation type	Concentration	Plant height (cm)	% R/P over control	Fresh weight/p (g)	%R/P over control	Dry weight/p (g)	%R/P over control
S.A. based formulation	100	22	-8.33	4.71	-18	0.603	+10
	200	24	0.00	9.33	+63	0.773	+41
	300	23	-4.16	8.48	+48	0.815	+49
Clay based formulation	100	29	+21.00	7.90	+38	0.671	+22
	200	23	-4.16	7.30	+27	0.905	+65
	300	27	+12.00	5.40	-06	0.530	-03
Weed check	000	24	0.00	5.73	0.00	0.548	0.00
Weed free	000	25	+4.16	4.88	-15	0.489	-11
Imazethapyr foliar spray	100	20	-16.66	5.57	-03	0.767	+40

Table 10: Effect on yield

Formulation type	Concentration	Yield/plot (g)	% R/P over control	% R/P over Weed free
S.A. based formulation	100	883	+56	-15
	200	967	+71	-06
	300	1137	+100	+10
Clay based formulation	100	1133	+100	+10
	200	1100	+94	+06
	300	1183	+209	+15
Weed check	000	567	0.00	-45
Weed free	000	1033	+82	00
Imazethapyr foliar spray	100	833	+47	-19

EXTERNALLY FUNDED PROJECTS

Identification and characterization of Nodule-specific Cysteine Rich (NCR) peptides in chickpea (DBT Funded Project 2018-2021)

Symbiotic nitrogen fixation (SNF), a signature feature of legumes makes them self-reliant for N-requirement. Enhancing SNF at farmers' field can lead one step ahead in bridging yield gap between genetic potential of released varieties and their actual productivity. One of the hindrances to achieve the above goal is knowledge gap on a critical process of SNF *i.e.* bacteroid differentiation during nodule development, where the free living rhizobial cells are converted into different morphotypes (E-Elongated/S-Spherical/U-Unmodified) of nitrogen fixing bacteroids in indeterminate root-nodules. Bacteroid differentiation is mediated by plant derived nodule specific cysteine rich (NCR) peptides first identified in model legume *Medicago truncatula*. Experimental results indicated that E or S morphotype bacteroids possess higher symbiotic efficiency compared to U-morphotype. Large structural and functional diversity of mature NCR peptides within *M. truncatula* as well as *Aeschynomene* was demonstrated and the level of NCR peptides diversity is positively linked with bacteroids morphotypes and nitrogen fixating potential.

Chickpea transforms the rhizobial cells into E-morphotype bacteroids with poor enlargement. The E-morphotype bacteroids in *M. truncatula* nodules enlarged up to 10 µm in length, compared to less than 2 µm of that in chickpea. Hence, it is essential to reveal the natural variations for bacteroid morphotypes and NCR peptides in chickpea to achieve higher symbiotic efficiency. In the present investigation, 67 putative NCR peptides including 30 unique sequences of *Cicer arietinum* were identified using three different strategies and characterized (Fig. 6). Similarly, 44 putative NCR peptides were identified in *Cicer reticulatum* genome. Phylogenetic tree constructed with putative NCR peptides of *Cicer arietinum* and *Cicer reticulatum* indicated the existence of two clusters and revealed closely related NCR peptides. NCR peptides of IRLC legume *Glycyrrhiza uralensis via* GuNCR01, GuNCR06, GuNCR05, and GuNCR07 clustered with chickpea NCR peptides CaNCR41, CaNCR30, CaNCR19 and CaNCR34 respectively (Fig. 7). OlNCR33, a NCR peptide of *Onobrychis lamberti* was clustering with CaNCR64. All the putative NCR peptides of *Cicer arietinum* showed the presence of N-terminal secretory signal and conserved cysteine residues. Understanding the diversity of NCR peptides of chickpea using transcriptome as well as proteome approaches is under progress. In general, information generated through this investigation will help to develop tools for optimizing the symbiotic efficiency under natural farming environment.

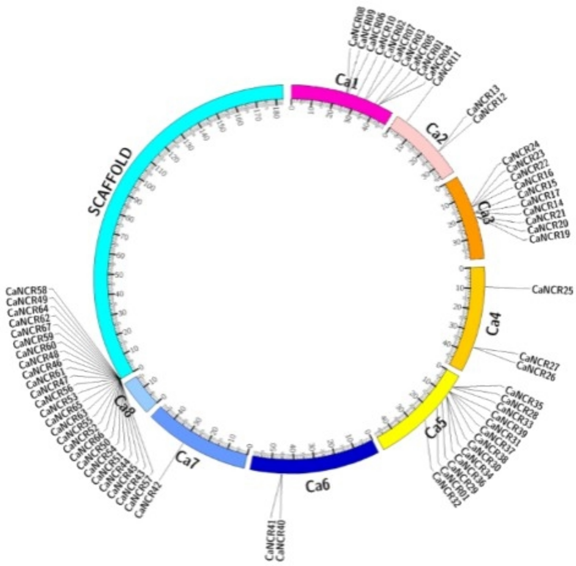


Figure 6: Genomic location of putative NCR-peptide genes in *Cicer arietinum*

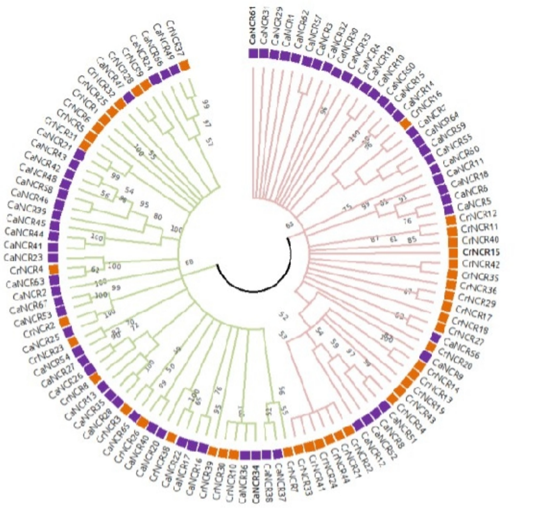


Figure 7: Phylogenetic analysis of putative NCR-peptides of *Cicer*

NICRA PROJECT

New sources of heat tolerant lentils identified having threshold temp tolerance limit upto 43^{0}C . These genotypes are ILL 10712, IG 2507, IG 3327, IG 3546, IG 4258

A mapping population of lentil was developed from the cross IPL98/193xEC208362 targetting the root trait. About 211 RILs were phenotyped using the phenomics facility available at NIASM, Baramati. The results involving biomass, compactness, average hull area and NIR intensity under limited moisture condition. Based on these parameters, promising RILs identified for drought tolerance. The findings are shown in the following presentation :

More than 200 markers are being tested for polymorphism detection between heat tolerant TPU-4, GU-1, DU-1, TU-40 and sensitive urdbean genotypes *e.g.* Azad-3, Kullu-4, Naveen, LBG 648.

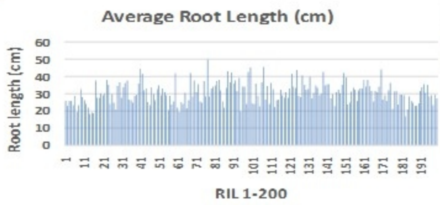
Light x Temp interaction studies were done using blackgram genotypes having different sensitivity to heat stress at 45^{0}C revealed superior photosynthetic performance of heat tolerant blackgram genotype TPU-4.

To introgress heat tolerance in elite mungbean lines, fresh crosses were attempted. These donors were identified based upon physiological & molecular characterizationon & comprehensive evaluation of >400 germplasm & elite materials in last three years. Accordingly, 08 fresh intra-specific and inter-specific crosses were attempted such as IPM 2-14 / LGG-460 , IPM 410-3 / LGG 460 , IPM 2-3 X HUM 16 , IPM 2-14 / *V. umbellata* , IPM 2-14 / *V. glabrescens* , IPM 2-3 / VBG 04-003 , IPM 2-3 / *V. umbellata*, IPM 205-7 / *V. umbellata.*

High NDVI values as possessed by chickpea genotypes ICCV 92944 and ICC 4958 were identified as the best indicator of plant to maintain high photosynthesis and biomass under drought, hence, they were selected as drought tolerant genotypes. The low NDVI has been found to be associated with reduction of photosynthesis, chlorophyll and poor rooting system.

Lentil : Phenotyping for Root Traits

Parents/ Mapping population	Root length (cm)		Shoot length (cm)	
	2018	2019	2018	2019
P1 (IPL98/193)	46.3	37.7	17.0	18.3
P2 (EC208362)	15.0	19.7	13.0	10.0
RILs	11.8-67.6	7.8-55.3	4.7-21.5	8.6-19.8

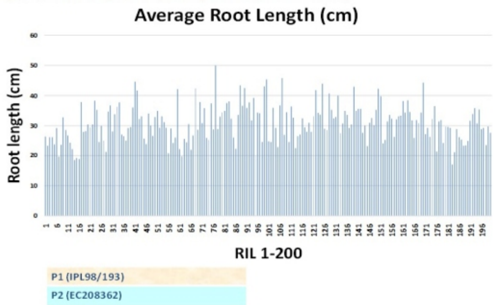


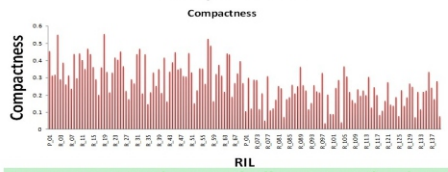
2018 2019 2018 2019 2018 2019 2018 2019 2018 2019

P1 IPL 98/193 P2: EC208362 RILRT-139 RILRT-178 RILRT-107

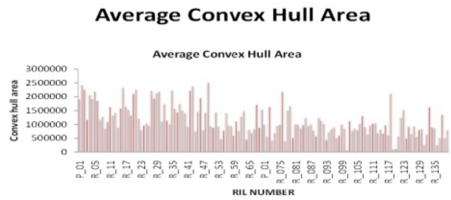
- **Evaluation of RIL mapping population:** 200 RILs along with parent evaluated under rainfed conditions at RS-IIPR, Bhopal and under terminal drought conditions in the rainout shelter at IIPR, Kanpur
- **Identification of QTLs for root traits: Polymorphic 49 SSR markers and 94 SNP marker**s were identified between the parental lines. Based on bulk segregant analysis, **15 SNPs showed their association with root length**

Variation in root length in RILs of lentil developed from parents P1 (IPL98/193) x P2 (EC208362)

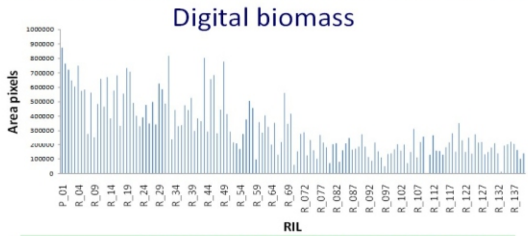




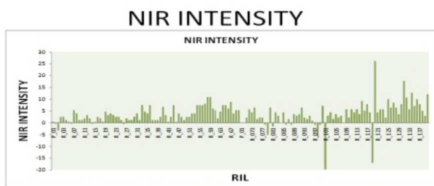
Compactness and convex hull measure the degree of leaf area coverage, analogous to the agronomic measure of LAI



Phenomics for physiological assessment of RILs



Area Pixel: The green pixels and crop projected area used to estimate biomass which can be called as 'digital biomass'



NIR intensity is the indicator of water content in plant tissues. Low NIR intensity explains higher water content as water molecules absorb NIR radiation, while higher NIR intensity indicates lower water content. Decrease in per cent of NIR intensity showed the higher water content in genotypes as compared to both parents.

Promising RILs identified

	NIR	Area pixels	LAI compactness	LAI Convex hull area	Root length (cm)
P_01	0.348	873559	0.455413	1918170	26
P_02	-0.348	764140	0.313997	2433593	22
R_01	-3.136	720562	0.318569	2261870	22
R_06	-0.348	583871	0.314645	1855651	29
R_43	0.348	802771	0.336362	2386629	43
R_46	0.348	684378	0.348971	1961129	45
R_78	-0.704	218135	0.112683	1510395	50

RIL number R 06, R 43, R 46 and R 78 have more root length over their respective parent P 01 and P 02. These RILs have high green area, leaf area index and more leaf water content

Social Science

Institute Funded Projects

Estimation of Acreage and Production of Pulses in Bundelkhand region of Uttar Pradesh using remotely sensed data and geo-spatial technologies

Advance estimation of acreage and production of a group forwards is of great utility in pulses implementing appropriate production and protection management. Remote sensing technologies have demonstrated their potential in providing information of characteristics and spatial distribution of natural resources. The main objective of the present study is to estimate the acreage and production of pulse crops in districts of Bundelkhand region of Uttar Pradesh during *Rabi* and *Kharif* seasons. The methodology consisted of selection of datasets, processing of satellite data, incorporation of ground information, analysis of the satellite data and generation of the output products (Fig. 1). District wise acreage estimation of pulses was done by using the following formulae:

Area in meter^2= Number of pixels of clusters * Resolution of the image

Area in hectare = Area in meter^2/10,000

For MODIS- Area in meter^2 = Number of pixels of clusters * 250 * 250

Externally-funded Collaborative project Development of farmer mobile-based Applications for pulses on mKRISHI platform

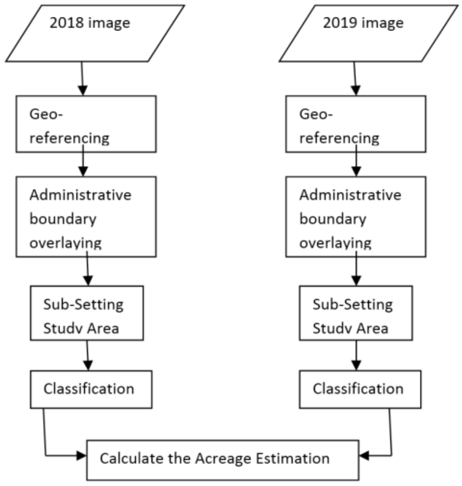


Figure 1: Flow chart of acreage estimation

Under the collaborative project with Tata Consultancy Services(TCS), mobile app services for Farmers (Table 1) and web console services for Experts (Table 2) have been designed and developed on mKRISHI platform. Contents related to the diseases and insect-pests and their control measures for major pulse crops *viz*., chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea have been developed in four languages (English, Hindi, Marathi and Kannada) and shared in the customized platform for the development of PulsExpert Mobile Service (Fig. 2).

Table 1 : Mobile App Services- For Farmers

Farmer Self registration (Name*, Mobile No.*, Age, Village*, Block*, District*, State*, Area, Crops (multiple selection) **Advisory Services** ❖ Ask Query-(Voice recording*, Image Capture (2-3)*, Context selection, Crop) ❖ Best Practices-(context, title, description, image) ❖ Advisory Inbox - (text advices) ❖ Alert Inbox - (Broadcast Text Alert) ❖ Weather Forecast - (Clouds, Temperature, etc.) ❖ News Ticker - (Title Description, duration, dates, expiry date, context & importance level) ❖ PulsExpert - (disease, pest, irrigation, fertilizer, crop economics)	**Sub -Menu** ➢ Change Mobile No. - (Enter new No. OTP) ➢ Update Profile - (Name, Location) ➢ Crop Registration - (Select Crop, Area, Date of Sowing) ➢ Change language - (English, Hindi) ➢ Share App - (Share app through Whats App and other medium) ➢ Rate App - (Star Rate, Write Text Comment) ➢ About App - (Information about the app) ➢ About Initiative - (Information about the Initiative –English/local Languages ➢ Log out

Table 2 : Web-Console Services- For Expert

A. **Dashboard -** (No. of farmers registered, Villages Registered, Queries and Alert Sent)

B. **Advisory**

- **Query Inbox -** (Context-wise query tabs, Query Resolution (text local language) with the option of sending images)
- **Send Alert -** (Local text alert – Filters like location, crop, context, user type etc. to be given, save alert option, Info. on total SMSs being sent)

C. Knowledge

- **Best Practices -** (Add, edit, delete – BP, Photo Gallery)
- **View Alerts –** View details of all alert sent
- **Saved Advice –** View all the advise, Context, Crop and Language wise

D. Farmer

- **Farmer Search -** (Through Name, Mobile No., Village, Block, District, State, Crops,) on selection should display
- **Farmer Registration** -(Name*, Mobile No.*, Age, Village*, Block*, District*, State*, Area, Crops (multiple selection)

E. Support

F. News - (Add, Update the Text and Image)

G. Master Data - Pulse crops (Add the new pulse crop)

H. Reports – View Farmer Report, Village Report, Query Report, Alert

Figure 2: PulsExpert Mobile Service

Assessing suitability of chickpea genotypes in multi-environment testing

Multi-environmental trials generally significant genotype as main effect and genotype x environment interaction (GEI) effect and, therefore, different univariate and multivariate stability methods have been used to study the GEI. Among the multivariate methods, the additive main effects and multiplicative interaction (AMMI), analysis is widely used for GEI investigation. This method has been effective because it captures a large portion of the GEI sum of squares; it clearly separates main and interaction effects and often provides meaningful interpretation of data to support a breeding programme such as genotypic stability. Based on the AMMI model, a stability index has been used to rank the genotypes. This index is the weightage of stability and yield component and higher the index value, better is the genotypes. The index of 45 promising chickpea genotypes was computed with two different weight of yield (50% and 75%) and stability component (50% and 25%). These genotypes were evaluated at seven locations *viz.*, Gulbarga, Dharwad, Nandyal, Lam, Vijaypur, Coimbtore and Hiriyur representing the South Zone of All India Coordinated Research Project on Chickpea during 2017-18.

Ranking of genotypes was done based on two different weight of stability and yield component. Genotype CSJ867 with 4.9700 index value was found the best genotype followed by genotype AKG1401 with index value 3.9730 and genotype GJG1505 with index value 3.6720 when alpha=1 *i.e.* stabaility component w2=0.5 and yield component w1=0.5. When alpha=0.33 *i.e.* stability component w2=0.25 and yield component w1=0.75, genotype CSJ 867 with 2.3036 index value was found best genotype followed by genotype AKG 1401 with index value 1.9851 and genotype GJG 1505 with index value 1.9257. Hence, these genotypes may be used by the chickpea breeder for developing high yield and stable chickpea lines on AMMI based simultaneous selection for yield and stability.

Impact analysis of the project "Creation of seed hubs for increasing indigenous production of pulses in India"

This project is estimates the trends in quality seed production of pulses in India and to estimate the potential benefits of project "Creation of seed hubs for increasing indigenous production of pulses in India". Year wise quality seed produced and seed multiplication ratio for major pulse crops have been compiled to arrive at the potential area which can be covered using these quality seed and to estimate annual potential benefits.

Farm-retail price behaviour and transmission in Indian pulses market

Time series analysis of prices helps to capture the movement, trend and seasonality in price series which is useful to different stakeholders such as farmers, consumers and policy makers. Monthly Wholesale Price Indices (WPI) from January 2005 to March 2019 consisting of 171 time series observations were collected from Office of the Economic Adviser, Ministry of Commerce & Industry, Govt. of India (Fig. 3). The WPI captures the changes in the price level at the initial stages of transaction and government periodically changes the base year to improve the representativeness. To make the WPI series comparable, linking factor were calculated using the average ratio of overlapping monthly

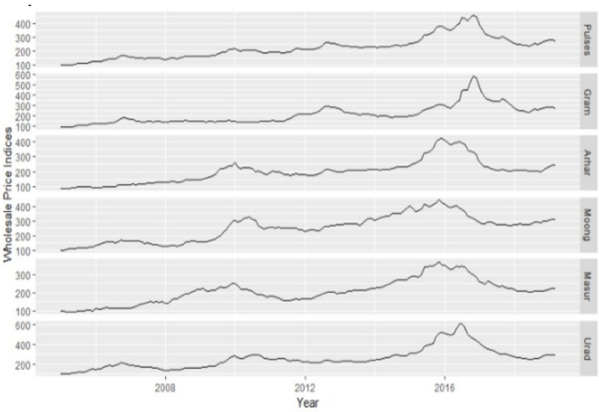


Fig. 3 : Monthly Wholesale Price Indices of major pulses in India (Jan-05 to Mar-19) (Base 2004-05)

Using R software, time series decomposition was carried out to estimate trend and seasonal components in the price series. To capture the movement in prices of pulses, three types of models were fitted. Using the forecast package in R software, Holt's linear method with multiplicative errors and damped trend [ETS(M,Ad,N)], ARIMA model and ARIMA model with log transformation were fitted on price indices. Model parameters were automatically selected to fit the best performing models in each category. On log transformed price series, 192 ARIMA models were fitted and ARIMA (1,1,0) was found to be the best performing model as measured by corrected Akaike information criterion (AICc). This model performed better in terms of minimum Root Mean Square Error (RMSE) when compared to other two models. Ljung-Box test which tests the presence of autocorrelation in residuals also indicated that model 3 was the better model as test statistic (33.94) was not significant at 5 per cent level of significance.

Externally Funded Projects

Farmer FIRST Programme

Integrated approaches for food, nutrition and livelihood security of rural households in Fatehpur district of Uttar Pradesh

Demonstration of SRI method of paddy cultivation

SRI Method of paddy cultivation was studies in project area to the crop for enhanced productivity and income of the farmers through introduction of new varieties of rice. High yielding variety of paddy as critical input was provided to the farmers for enhancing production and income in project area. The recorded yield under farmer field was 84.50 q/ha from Pusa Basmati 1 variety and net return of ₹ 102057 /ha recorded.

Establishment of Agri-horti Model in project area

During 2019-20 08 mango orchards and one Guava orchard were developed under Farmer FIRST Project for long term income, employment and nutritional security.

Transplantation of mango plants under Farmer FIRST Project

Poultry farming for income and employment generation for rural youth: Poultry units are considered as remunerative enterprise by the farmers in project area for obtaining income, employment and nutritional security in rural households in project area farmers are not obtain of income ₹ 250-300/ day from selling of eggs and in winter season they obtain ₹ 450-500 per day.

Goat Units: Woman farmers are happy to get income as well as milk from goats.

Fish farming

Fish Farming was also introduced to utilize the community ponds for income and employment generation as well as nutritional security. Altogether 50 kg (fingerlings 10810/fish fry) purchased from ICAR-NBFGR, Lucknow have been introduced in community ponds of villages in project area of Fatehpur district of Uttar Pradesh. Fingerling/fish fry in 5 pond measuring one hectare area were introduced.

Demonstration on mustard

Farmers were provided critical input to conduct the demonstration on mustard variety Kanti to enhance yield and ensuring oil security through high yielding varieties 18 farmers covered 3.33 ha crudely item variety.

Demonstration on chickpea

Thirty eight Farmers were provided critical inputs to conduct the demonstration on 5.55 ha area chickpea in project area to solve the problem of wilt disease.

Participatory demonstration on bio-fortified variety of wheat:

Farmers were provided critical inputs to conduct the demonstration on wheat to enhance yield and ensuring food and Nutritional Security through high yielding and zinc rich variety K 1006. This variety is suitable for children and old people. Ten farmers were covered with 5.00 ha area.

Mera Gaon Mera Gaurav

Under MGMG programme of demonstrations on chickpea, fieldpea, lentil, pigeonpea and mungbean were conducted for dissemination of technologies, enhancing the income and creating employment for the rural youth and women various villages in Fatehpur, Kanpur Dehat and Kanpur Nagar districts. Activities were conducted for, communication of pulse production technologies advisories in the form of text messages and receiving feedback on various aspects, distributing extension literature, monitoring of demonstrations in fields etc. Majority of farmers were provided Farmer FIRST Diary. Farmers were also encouraged for adoption of summer mungbean for addition income in summer season. Farmers were linked different development agencies to get benefit of state and central government schemes. Farmers were also facilitated for marketing of produce through FPOs. Rural youth were trained for seed production in pulses. Farmers were given training on crop and livestock to upgrade their knowledge and skill. Farmer Scientist interaction and Field Day programme have been organised to disseminate popular pulse production technologies among farming community. Entrepreneurial activities such as motivating and facilitating the rural youth for establishment of retail input outlets of agriculture pesticides, seed and fertilizer inputs through home delivery marketing approach.

Frontline demonstrations

1300 demonstrations were coordination on pigeonpea, chickpea, mungbean, urdbean, lentil, fieldpea, cowpea, horsegram, mothbean, lethyrus, rajma and clusterbean in different States of India. Participatory demonstrations were conducted pigeonpea (10), mungbean (7), cowpea (03), chickpea (10), fieldpea (05) and lentil (5) in different districts of Uttar Pradesh for enhancing income and nutritional security.

Implementation of SC Plan

The SC plan was implemented in different districts of Uttar Pradesh for increasing their income and nutritional security. Farmers are provided seed of chickpea, lentil and fieldpea for cultivation in *Rabi* season to increase income and nutritional security.

Development and validation of digital platforms for dissemination of information on pulse production technologies

Content development and customization for use

in digital platforms on pulse production technologies was under table. Maintenance of www.dalhan gyanmanch.res.in.and up gradation of ***chanamitra*** application in five languages *viz*. Marathi, telegu and kanada version was done The said app has 4.9 star rating with ***3210*** plus downloads till date.

A total of 47965 voice advisories related to field pea, chickpea, mungbean and urdbean were fowarded through ***Dalhan Sandesh*** service to 3500 partner farmers during the reporting period.

1.1. Digitized information use behaviour of stakeholders

1.1.1. Information use behaviour of farmers

Information source use pattern of sampled farmers was studied on basis of frequency of use on three point continuum and weighted scores were calculated (Fig. 4). Fellow farmers & relatives and input dealers were utilized to a greater extent among the sampled farmers as compared to formal sources of information like extension personnel and experts(Table 3). With regards to use of ICT based information sources, television followed by kisan call centres was used to a greater extent.

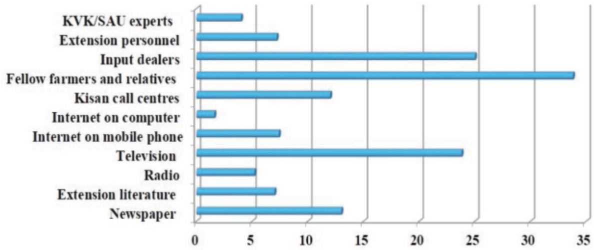


Figure 5: Information source use pattern of farmers related to agricultural technology (N=150)

Study on information source use pattern of farmers of Jharkhand state revealed that among the ICT based information sources, television followed by internet on phone and mobile phone for text messages were most utilised, while newspaper was most utilized source among the print information source(table2). Among the interpersonal sources, progressive farmers and input dealers were used to a greater extent.

Table 3. Farmers' information use pattern with regards to agricultural production technology (n=18) (Jharkhand)

Information sources	Frequently used	Used sometime	Not used	Weighted score	Info. Source Use Index
ICT based sources					
Computer	0	3 (16.66)	15 (83.33)	21	5.0
Internet on mobile phone	4 (22.22)	5 (27.78)	9 (50.00)	31	7.5
Mobile phones for text messages	2 (11.11)	9(50.00)	7 (38.89)	31	7.5
Phones for voice SMS	4(22.22)	3 (16.66)	11 (61.11)	29	7.0
Information kiosks	0	2 (11.11)	16 ((88.89)	20	4.8
Radio	2 (11.11)	8 (44.44)	8 (44.44)	30	7.2
Television	9(50.00)	8 (44.44)	1 (05.55)	44	10.6
Print media					0.0
Newspaper	3 (16.66)	11 (61.11)	4 (22.22)	35	8.4
Extension literature	4 (22.22)	7 (38.89)	7 (38.89)	33	7.9
Interpersonal sources					0.0
Progressive farmers &relatives	12(66.67)	6 (33.33)	0	48	11.5
Input dealer	6 (33.33)	12(66.67)	0	42	10.1
Extension personnel	2 (11.11)	7 (38.89)	9(50.00)	29	7.0
KVK /SAU staff	1 (05.55)	3 (16.66)	14 (77.78)	23	5.5

Regional Station, Phanda, Bhopal

Research achievements:

1. **Varieties released:** State Varietal Trials were conducted during *Kharif* 2018 for Madhya Pradesh and three varieties namely, IPU 13-1, IPU 11-2 and IPU 10-26 of urdbean and one variety IPL 534 of lentil wer released and notified (S.O. 99(E.) dtd. 06/01/2020) for Madhya Pradesh State.

(a) Lentil var. IPL 534 (b) Urdbean var. IPU 13-1 (c) IPU 11-02 and (d) IPU 10-26

Newly released varieties for Madhya Pradesh

2. **State Varietical Trial on Chickpea:** The State Trial for Madhya Pradesh is being conducted at seven centres namely, Indore, Ujjain, Jhabua, Shajapur, and IIPR, RS, Bhopal and crop expression is good. Data is being recorded by above mentioned centres.

3. **Plant Genetic Resource:**

I. **Pigeonpea (*Cajanus cajan* (L.))**

(i) Medium duration pigeonpea: Newly collected 165 genotypes were characterized and six dwarf and early maturing genotypes (EC 0109902, EC 0109904, EC 0552873, EC 0552874, EC 0552875, EC 0552882) were identified from exotic sources. Similarly, 579 genotypes were grown for evaluatation for agro-economic traits. Due to heavy and consistent rainfall (more than 1800 mm) in *Kharif* season, 75 % genotypes were completely damaged due to water logging condition of field. Twenty five percent genotypes survived which have low plant population but have inherent ability to grow under waterlogged condition.

(iii) CRP on Agro biodiversity in pigeonpea : In *Kharif* 2018-19, six dwarf genotypes (IC 0490169, IC 369575, IC 384030, IC 261339, IC 446083 and IC 343913) were identified earliness and vegetable types out of 400 genotypes evaluated in pigeonpea. Similarly, another 400 genotypes were grown for characterization. Due to heavy and consistent rainfall (more than 1800 mm), 75% genotypes have been completely damaged and remaining 25% genotypes with low plant population showed tolerance to water logged condition.

CRP pigeonpea tolerant to waterlogging condition Medium duration pigeonpea Experiments

(ii) ICRISAT Pigeonpea Nurcery: Total four station trials were conducted for super early (determinate and non determinate), short duration and medium duration crop. Two determinate type entries namely ICPL 20340 (104 d) and ICPL 11252 (107 d) were identified under super early maturity group. Similarly, ICPL 20326 (140 d) was identified under non-determinate early category.

Identified early genotypes in ICRISAT trials

Farmer's visited to see early lines of pigeonpea

4. National Shuttle Breeding Programme in Pigeonpea

Breeding lines from S.K. Nagar, Gujarat (03); Gulbarga, Karnataka (03) and Badnapur, (04) were evaluated (10 entries with three checks namely UPAS 120, Rajeshwari and TJT 501) during *Kharif* 2019.

5. Seed production in hybrid pigeonpea: Hybrid demonstration trial was sown with different row and plant spacing (75 x 25 and 75 x 45 cm). Hybrid seed trial was raised with different ratio of A lines with R line (1:12, 1: 10, 1:8, 1:6) with border line of R line in three replications. It was observed that 1:10 ratio was found best on the basis of profuse flowering and podding. Trial is still under field.

6. Genral in New breeding material

New crosses (08) for short and medium duration pigeonpea were attempted between early varieties in both the directions using male as well as female parents. Due to heavy and consistent rainfall, seeds of only one cross (MN5X PUSA 16) was obtained.

2. Chickpea (*Cicer arietinum* L.)

Plant genetic resources in chickpea

Total 2457 germplasm including 931 core genotypes were grown during *Rabi* 2018-19 for evaluation. A high magnitude of variability was observed among the genotypes. Promising genotypes were identified and selected for further validation.

Unique genotype for open flower (IC 349468), large seeded *Kabuli* (ICCV 181307), early maturity (IC 271435, IC 209236, IC 468644, PA03716) 3- seeds per pod (IC 16423, IC 16397, IC 83891, IC 83406, IC 342699, IC 116328, IC 275319, ICC 8992, IC 275447-1 and EC 555720), high anthocynin content (IC 349468) and tlat stem (IC 424391, IC 83745 and IC 83743) were chickpea identified during *Rabi* 2018-19 and validated and multiplied in *Rabi* 2019-20. Total 908 germplasm are grown for evaluation of agro-economic traits. Crop is in the field and all genotypes have shown good germination and vigour. 303 breeding lines are being evaluated for yield and earliness.

Era trial under BMGF project : Thirty entries of chickpea with two replication in RBD is grown to study the genetic gain during *Rabi* 2019-20 at the station. The expression of crop is excellent and data is being recorded .

Chickpea Era Trial

International chickpea trials

Long pods (IC 486999)

Open flower (IC 349468)

ICARDA International Nursery: Seventeen breeding lines were evaluated during 2018-19 at Station and FLIP 11-164c (43.4 g) was found best under extra large seeded category in *Kabuli* as compared to Kripa (42.0 g). In *Rabi* 2019-20, 76 entries of *Kabuli* chickpea with four checks are being evaluated.

ICRISAT International Nursery: Out of 20 entrires of *Kabuli* chickpea, ICC 14203 (49.9 g) followed by ICCV 181307 (47.2 g) and ICC14220 (44.8 g) were found the best as compared with check Kak-2 (34.8 g) and Kripa (42.2 g) during *Rabi* 2018-2019. Chickpea *Desi* nursery 2018-19 comprised 20 genotypes were evaluated and two early maturing genotypes viz., PAO 3716R/20 (96 d) and PAO 3716R /14 (96d) were selected as compared to check JG 16 (115 d). Similarly, 64 entries for yield and 25 entries for early maturity are being evaluated in the *Rabi* 2019-20.

National Shuttle Breeding (Genomic selection) Programme in Chickpea:

A set of 310 unique breeding lines (identified through genome selection method) with checks were grown for evaluation in Central Zone. All lines germinated and crop expression is very good.

Station trials

In *Rabi* 2018-19, two station trials (of 35 and 33 breeding lines) with three checks were condected. In Station Trial-1, IPC 2017-174 (1.32 kg) , IPC 2017-247 (1.28 kg) and IPC 2017-03 (1.27 kg) compared with check JAKI 9218, JG 14 (1.38 kg), and JG 16 (1.38 kg) and in another Station Trial, IPC 2016-202 (1.59 kg) are found high yielding as against JG 14 (1.46 kg), JG 16 (1.49 kg) and JAKI 9218 (1.46 kg).

Total four station trials are being conducted during *Rabi* 2019-20 in chickpea for *Desi* rainfed (27 entries), desi timely sown (18 entries), kabuli timely sown (20 entries) and for *Desi* mechanical harvesting (20 entries) with 3 checks (JG 16, RVG 202 and JAKI 9218 and Kripa, KAK2 and Shubhra) in three replications. All the trials are in good condition as crop expression is excellent.

III. Grasspea (*Lathyrus sativus* L.)

Plant genetic resource management for low ODAP

One hundred and six genotypes is being evaluated for earliness and low ODAP.

Mutants of M_4 generation derived from three varieties (Ratan, Mahateora and Prateek) were grown for advancement and selection of unique lines for low ODAP analysis.

ICARDA International nursery: Three international trials for Low ODAP, (30 entries), early (36 entries) and high biomass (36 entries) are being conducted at the station and the expression of crop is very good.

Pre-breeding maintenance of wild genera/species

(i) Vigna: Eighteen wild accessions of 09 species are being maintained in wild pulse garden.

Pre-breeding garden

(ii) Pigeonpea: One hundred twenty eight accessions of 11 species belong to genera Cajanus and Rhyncosia.

(iii) Chickpea: Total ninety six accessions of 8 annual *cicer* species were grown in wild pulses garden.

Grasspea: two accessions of *Lathyrus cicera*.

(iv) NICRA: Experiments to identify drought and heat tolerant (timely and late sown condition) genotypes in lentil are being conducted.

SUFALAM Project (SPACE, ISRO Ahmedabad-MPCST, Bhopal-IIPR, Bhopal):

Field experiments are being conducted on Soybean-Chickpea cropping system in Madhya Pradesh with five popular varieties of soybean and chickpea with five different fertilizer treatments in three replications to assess the effect of climate and weather condions of that area. Experiment conducted in *Kharif* season were damaged due to heavy and consistent rainfall.

Soybean-chickpea cropping system based experiment under SUFLAM

IV Lentil

A total 1100 lentil germplasm lines were evaluated during *Rabi* 2018-19 and genotypes were identified for various ago-economic traits. Genotypes IC 560291,IC 428139, IC 428216 and IC 428210 for earliness (103-105d)), seven pods per peduncle in IC 428472 and lager seed size (100 seed wt.) in IC 428255 (4.0 g), IC 428252 (3.9 g), IC 428357 (3.9 g), IC 428566 (3.6 g), IC 428587 (3.5 g) against the 3.2 g, (check IPL 316). Similarly, in *Rabi* 2019-20, 800 lentil germplasm and 180 are being evaluated.

Station Trial: During *Rabi* 2018-19, out of 45 lines grown for yield potential, IPL-161435 gave highest yield (1.300 Kg /8.4 m^2) followed by IPL-161441 (1.140 Kg / 8.4 m^2) and IPL- 11718 (1.102 Kg/ 8.4 m^2) against the best check IPL 316 (0.816 g/8.4 m^2). Similary, in *Rabi* 2019-20, 15 entries were grown to evaluate yield attributes

Station trial in lentil

Station trial in Urdbean: In kharif, IPU 13-7 (250.5 g / m^2), IPU 11-6 (266.3 g / 6 m^2), IPU 10-33 (181.3 g /6 m^2), IPU 12-5 (204.3 g / 6 m^2), IPU 12-4 (203.7 g/ 6 m^2) were found best yielding lines out of 18 entries in evaluated for yield potential for Central region.

Breeder Seed Production

Breeder seed (BSP/EBSP) production in *Kharif* 2019-20 at IIPR RS, Bhopal

Crop	Target production (q)	Variety	Year of release
Pigeonpea	5.0	Rajeshwari	2013
Urdbean	4.0 5.0	IPU 2-43 IPU 11-02	2009 2018
Mungbean	2.0 2.0 2.0	Virat Shikha Varsha	2011 2016 2018

Breeder seed (BSP/EBSP) production in *Rabi* 2019-20 at IIPR RS, Bhopal

Crop	Target production (q)	Variety	Year of release
Chickpea	15.00	RVG 203	2012
Fieldpea	31.10	IPFD 10-12	2014
	20.00	IPFD 11-05	2016
	10.00	IPFD 12-2	2016
Lentil	60.00	IPL 316	2013

Pea var. IPFD 11-05

Seed Hub

Seed hub is operational at the station with the licence for seed business and registered at MPSSCA, Bhopal for quality seed production, certification and seed processing. Quality seeds were produced more than the given target in farmer's participatory mode and continuously monitored by DAC, Govt. of India.

Quality Seed Production under seed hub at IIPR, Regional Station, Bhopal

Crop	Production (q)	Varieties taken	Seed production in *Rabi*2019(q)
Mungbean	Production hampered by continuous & prolonged rains	Samrat	
Urdbean		IPU 2-43, Uttara	
Chickpea	Crop is in the field	RVG 202, Shubhra,	13,07
Lentil	" " "	IPL 316	05
Fieldpea	" " "	Aman, IPFD 10-12	
Pigeonpea	" " "	Rajiv Lochan, UPAS 120	
Total		On against target of 100 q.	513.0

Visit of farmers field by seed certification officer

Frontline demostrations

FLD, Urdbean

S.N	Village	Name of farmer	Area (ha)	Variety	Improved var. yield (q/ha)	Farmer's variety(local) Yield q/ha)
1	Thuna	Krishna Bai	1	Uttara	Crop damaged due to heavy rains	Crop damaged due to heavy rains
2	Raipur Nayakheda	Pannalal /Ramprasad	1	Uttara		
3	Nagour	Ramsingh Raghuwanshi	1	IPU 2-43		
FLD, Pigeonpea						
1	Thuna	Devalibai	1	Rajiv Lochan	Crop damaged due to heavy and prolonged rains	

Table 6 : 2. FLD conducted in *Rabi* season: 2019-2020 at IIPR, RS, Bhopal

S.N	Village	Name of farmer
Chickpea CV. Variety RVG 202		
1	Jahangeerpura	Praveen Shrivastava
2	Mangaraful	Laal Mohammad
3	Chaudi	Mahesh Mewada
4	Barwai	Durgaprasad Dhakad
5	Basoda	Dewabai/ Suratsingh
6	Jamani	Ramlal / Ratansingh
7	Shankarkhedi	Devendra Tyagi
8	Dhamanda	Ghanshyam/ Motilal
9	Basoda	Dharusingh/ Dinansingh
10	Bhad	Urmila Tripathi
Lentil CV. IPL 316		
1	Talen	Chandarsingh/ Shankarlal
2	Chaudi	Sanjay Mewada
3	Barwai	Sandip/ Durgaprasad
4	Nayakheda	Kanchanbai/Omprakash
5		Kuntabai/Ghanshyam
Fieldpea CV. IPFD 10-12		
1	Mundara	Dimansingh/Babulal
2	Gadla	Mohansingh
		Raghuwanshi
3	Syari	Rupesh/Omkar

III. Transfer of technology: Seeds on new varieties with full package of practices of chickpea, pigeonpea, lentil, mungbean and urdbean have been given to farmers. Besides, advice continuous visits have been arranged to nearby villages in Bhopal and Sehore districts. We have visited many farmers in Phanda and surrounding villages and now, they are taking interest to grow *Kharif* pulses instead of soybean.

VII. Visits of dignitaries

Officer's visits:

1. Director, IIPR, Kanpur
2. JS (Crops), DAC, Govt. of India
3. Director, ICARDA
4. Dr. Shiv Kumar, Lentil Breeder from ICARDA
5. Dr. G P Dixit, PC, Chickpea
6. Dr. Kuldeep Singh, Director, NBPGR visited along with Head, GED and Pulse Scientist
7. Dr. I.P. Singh, PC, AICRP On Pigeonpea IIPR, Kanpur
8. SE, CPWD
9. Former Chairman, NIH, Roorkee with Director, and Hydrologists, Bhopal
10. Executives on Mahindra & Mahindra (CSR Fund for Watershed Dev.)
11. ITC representatives
12. Director, Pulse Development Prog. M.P. Region, DAC, Bhopal
13. Seed monitoring team including RM, NSC, RM, Beej Nigam (M.P.) and Seed inspection officer, MPSSCA, Bhopal.

Joint Secretary (Crops), DAC, Govt. of India monitored the seed hub activity at station

Director IIPR, reviewed research and develomental works at station with CPWD officers

Director NBPGR visited lentil and chickpea fields

ICARDA scientists visited field

Farmers visit

Farmers visited under *Mukhyamantri Khet Tirth Yojana* of Govt. of M.P.

S.No	Place	No. of farmers	Date	S.No	Place	No. of farmers	Date
1	Vidisha	48	27/05/19	9	Thaneshwar	40	17/09/19
2	Vidisha	48	27/05/19	10	Kalapipal	13	23/09/19
3	Vidisha	70	28/06/19	11	Kalapipal	14	24/09/19
4	Vidisha	40	02/07/19	12	Shajapur	13	25/09/19
5	Shajapur	08	10/07/19	13	Khandwa	43	06/11/19
6	Shujalpur	12	11/07/19	14	Vidisha	29	19/11/19
7	Kalapipal	16	21/08/19	15	Thareshwar	39	27/11/19
8	Thaneshawar	40	06/09/19	16	Rajgargh	45	02/12/19

Students visited under excursion tour

Place	No. of students	Date
IIM, Indore	04	17/10/2019

Figure 14: (a) Farmers visited at station during 2019-20 (b) Seed distribution under SC subplan

Developmental activities:

1. Construction of new office building has been completed
2. Seed drying shed has been completed.
3. Widening and extension of existing CC approach road
4. Worker shed constructed.
5. Green house and Rainout Shelter, one each erected
6. Seed storage and Seed processing unit has been updated with Air ventilation system and gutter with Rain drainage channels
7. Cemented pots for growing wild species of Pulses has been purchased.
8. 12 Farm implements delivered and installed.
9. *Kachcha* Compost pit has been developed.
10. Dense Plantations have been done.
11. Generator shed is constructed.
12. Drainage channels have been extended upto small and medium ponds.
13. Laboratory equipments have been purchased.
14. Furnitures have been purchased.
15. Construction of main gate is under process.
16. Landscape of farm is developed.
17. New pond is being developed.

Swachchh Bharat Abhiyan

Newly constructed Admin. building

Workers rest room

(Drainage channel (e) Wideningof road (f) Main gate under construction

Regional Centre *cum* Off-Season Nursery, Dharwad

Crop Improvement

Plant Genetic Resources Management and its utilization through pre-breeding

Mungbean-mini-core: Two hundred ninety six accessions of mungbean-mini-core received in International Mungbean Improvement Network (IMIN) were rejuvenated and characterized for qualitative and quantitative traits during *Kharif* season. The genotypes such as VI001408BG, VI001419BG, VI001509AG and VI002529 B-BL were found resistant to MYMV, *Anthracnose*, powdery mildew and *Cercospora* leaf spot diseases.

Urdbean germplasm: 150 accessions of urdbean germplasm were maintained and evaluated for different quantitative traits during *Kharif* season. The entries PU-519 (64 days) and IPU-99-18 (65 days) were the earliest to mature followed by IPU-90-32 (67 days) and PLU-13-69 (70 days).

Cowpea germplasm: 100 accessions of cowpea received from ICAR-NBPGR, New Delhi were rejuvenated and evaluated for different quantitative traits during summer season. EC-738107 (68 days) and EC-109174 (71 days) were found to be the earliest maturing genotypes followed by IC-20482 (72 days) and IC-8966 (73 days).

Horsegram germplasm: 200 accessions of horsegram rejuvenated and evaluated for different traits during *Rabi* season.

Maintenance of wild species of pulses: Wild *Vigna* species such as *V. umbellata* (IC-251442), *V. aconitifolia* (LRM-2013-01), *V. trilobata* (LRM-2013-30, LRM-2013-34) and *V. stipulacea* (LRM-2013-36, LRM-2013-37) and wild chickpea accessions (25) were rejuvenated and evaluated for different traits during *Rabi* season.

Genetic enhancement of pulse crops for yield, stability and quality

Evaluation of advance breeding lines of pulses

Mungbean: Twenty four advance breeding lines of mungbean were evaluated in stationtrials during summer season. The entries such as IPM 14-9 (60 days) and IPM 9901-13 (62 days) were the earliest to mature. The genotypes such as IPM-14-6 (1240 kg/ha), IPM-14-10 (1090 kg/ha) and IPM-604-1-6 (1008 kg/ha) were found to be promising for summer cultivation in Karnataka.

Chickpea: Two station trials of chickpea (Total 52 advance breeding lines) were evaluated for seed yield and component traits during *Rabi* season. 16 genotypes (DTIL-trial) were evaluated for drought tolerance traits under rain out shelter during *Rabi*-2018-19.

Generation of breeding material

Fresh crosses (17 crosses) were made in cowpea and horsegram involving donor lines for yellow mosaic disease resistance, heat tolerance, photo-thermo insensitivity and bruchid tolerance. Segregating materials of cowpea, horsegram, chickpea and urdbean were advanced during *Kharif*/summer season.

Off-season generation advancement of pulses

During 2019-20, segregating materials for generation advancement were received from 8 centers of AICRP on chickpea such as Rahuri (15 lines), Sehore (30 lines), Jabalpur (11 lines), Sriganganagar (7 lines), Junagadh (7 lines), Coimbatore (3 lines), Ludhiana (75 lines) and Bijapur (19 lines). Chickpea (F_2 & Mapping populations) and lentil (105 lines) were received from ICAR-IIPR, Kanpur. The generation advancement was performed during the *Kharif* season and advanced breeding materials were sent to the respective centres. Fresh crosses were also successfully attempted in chickpea during off-season.

State multi-location trial: Promising entries of mungbean, urdbean and chickpea were put to state multi-location trial (MLT) to assess their suitability for cultivation in Karnataka during *Kharif*/*Rabi* season.

Off-season generation advancement of chickpea

Intercropping cowpea and maize

Breeder seed production

Seven hundred kg of breeder seed of mungbean (IPM-2-14) and urdbean (IPU-2-43) was produced during *Kharif* season.

Development of high yielding, drought and heat tolerant mungbean [*Vigna radiata* (L.) R.Wilczek] genotypes for spring/summer season

Generation and advancement of breeding material: In mungbean, the crosses IPM2K-14-9 X PM 2, IPM 2-14 X EC 426841, IPM 2-14 X EC 398889, IPM 2-14 X PM 2, IPM2K-14-9 X EC 426841, IPM 302-2 X PM 2, IPM 2-14 X *Vigna aconitifolia* were advanced to F_2 generation. Eight crosses were attempted involving diverse breeding lines or parents for breeding for drought and heat tolerance. The crosses were IPM 2-14 X EC 398889, IPM 2K-14-9 X EC 426841, IPM 2K-14-9 X PM 2, IPM 2K-14-9 X EC 398889, IPM 2-14 X EC 426841, IPM 302-2 X EC 398889, IPM 302-2 X EC 426841, IPM 2-14 X PM 2.

Crop Production

Enhancing productivity in diverse pulses based cropping systems through improved nutrient management in Peninsular India

Effect of intercropping and fertilizer management in pulse based cropping system

A field experiment was conducted in *Kharif* 2019 involving two cropping systems *viz.*, maize-chickpea and (maize+ cowpea) – chickpea with two fertlizer management levels *viz.*, 1) 100% RDF to *Kharif* crop and 100% RDF to *Rabi* crop [100K: 100 R] (2) 100% to *Kharif* crop and 50 % to *Rabi* crop [100K: 50 R]. Results revealed that grain yield of maize was 66 q/ha in maize+cowpea intercrop 1:1 and in maize-chickpea, the yield was 63.90 q/ha. The chickpea crop was sown on November 27, 2019 and the experiment is under progress.

CROP PROTECTION

Identification of resistant donor's against major diseases of pulses in the South India

Screening horsegram genotypes for resistance against powdery mildew disease caused by *Erysiphe polygoni*

Total 37 genotypes of horsegram germplasm lines were evaluated for resistance against powdery mildew caused by *Erysiphe polygoni* during early *Rabi* season under natural conditions. Among this, none of the entries were found resistant however, four entries *viz.*, HG 2, HG 10, HG 18 and HG 26 showed tolerant reaction.

Screening of horsegram lines for powdery mildew disease

Characterization of Emaravirus associated with pigeonpea sterility mosaic disease on a set differential cultivars

Pigeonpea Sterility Mosaic Virus (PPSMV) causes sterility mosaic disease in pigeonpea belonging to genus *Emara* virus. Considering pathogenic reactions, genetic background of pigeonpea genotypes, eleven differentials were constituted in AICRP pigeonpea viz., Bahar, BDN 1, BRG 1, BRG 2, BSMR 736, 1CP 2376, ICP 7035, ICP 8863, IPA 8F, Purple 1 and BRG3 to identify the strains of a virus. Based on reactions on these differential cultivars set, five strains of PPSMV reported from India (AICRP Pigeonpea Report, 2018-19). At Dharwad, reactions on these differential sets were recorded. The disease incidence was highly variable ranging from 0 to 100%

Nine genotypes were found resistants, two susceptible. Based on genotypic reactions, PPSMV of Dharwad belonged to strain 3. Knowledge generated will be utilized in resistance breeding programme and accurate phenotyping of mapping population.

Field view of differential genotypes

Establishment of sterility mosaic disease nursery and evaluation of pigeonpea genotypes: Pigeonpea sterility mosaic disease (PSMD) caused by *Pigeonpea Sterility Mosaic Virus* (*PPSMV*) causes major economic losses in southern India. Establishment of screening facility was done with susceptible check of pigeonpea (ICP 8863) by leaf stapling technique. Total 233 entries including differentials, AICRP and advanced breeding lines were screened. The disease incidence in the field ranged between 0-100 per cent. Among which, 86 entries were free from disease, 42 entries recorded disease incidence ranging between 0.1 and 10 per cent, 15 entries recorded incidence between 10.1 -20 per cent and in remaining entries > 20 per cent SMD incidence was observed.

Leaf staple technique inoculation

Project: Development of Ecofriendly Insect Pest Management Strategies in Mungbean, Urdbean, Cowpea and Horsegram for Peninsular India

Effect of planting time on the incidence of major insect pests of cowpea

A field experiment was carried out to study the

Field view of PSMD nursery

effect of different planting time on incidence of major insect pests of cowpea varieties viz., DC 14 and DC 15 during Kharif (2019). The three different dates of cowpea sowing were 27.6.19, 15.7.19 and 30.7.19. The experiment revealed that there was no significant effect of different planting time on the incidence of pod borer in cowpea. However, the crop sown during first fortnight of July recorded lowest pod damage of 17.73% as compared to the crop sown during the second fortnight of July (28.93%) and first fortnight of June (20.87%) by *M. vitrata*. Among two varieties of cowpea, DC-15 harbored less pod damage as compared to DC-47.

Evaluation of newer insecticides and biopesticides against cowpea pod borer

A field experiment was carried out to evaluate certain newer insecticides for control of pod borer in cowpea during *Kharif* 2019. There were six treatments including untreated control. First spray was done at 50% flowering stage and subsequent spray after 10-15 days. Among different newer insecticides and biopesticides evaluated against cowpea pod borer, foliar application of chlorantraniliprole 18.5 SC @ 0.4 ml/L was found effective and gave 70% reduction in pod damage over untreated control.

Screening of cowpea germplasms or lines against major insect pests

Different cowpea accessions/lines were screened against major insect pests particularly pod borer during summer season 2019 (DOS: 15.3.19). Out of 85 cowpea accessions/lines, 3 lines viz., IC 249141, EC 394779 and NBC 24 recorded 0 -10 % pod damage and 18 lines recorded 11-20 % pod damage. One line IC 249141 recorded 0% pod damage.

Extension Activities

Frontline demonstrations: Total 13 FLDs (Frontline demonstrations) on pulses (cowpea and horsegram and chickpea) were conducted in different farmer's field during *Rabi* season in Karnataka.

Farmers field visits: Scientists visited pulse growing farmers fields of Dharwad district during *Kharif* season and interacted with them.

Developmental works and facilities/ infrastructure created at IIPR-RRC Dharwad

- Construction of shed for diesel generator set of 63 KV capacity was completed by CPWD.
- Hi-tech green house with temperature, RH control was constructed for biotic stress screening activities.
- New rainout shelter for abiotic stress screening was installed and made operational.
- Insect proof net house was constructed and made operational for use.
- Digging of new borewell was completed by CPWD.
- Construction of CC road and drainage by CPWD in RRC farm near seed and implement store was completed.
- Construction work of new threshing and seed store building by CPWD completed.
- Construction of East side damaged boundary wall of the centre by CPWD completed.
- Strengthening of South side boundary wall and fixing of barbed wire fence by the CPWD completed.
- Furniture's like laboratory stools (4 Nos.) and office chair (1 No.) were purchased for the centre.
- Office computer, printer and UPS were procured for the newly joined scientists at the centre.
- Laboratory equipments like digital pH meter (2 No.), laminar air flow (1 Nos.), BOD incubator (1 No.), Double distillation unit (2 Nos.) and farm related items like hand held grass cutter machine (1 No.), disc harrow (1 No.) were purchased for the centre.

Figure 7: Rainout Shelter

- RCC spun cement ring pots (28 Nos) were procured and installed for growing wild germplasm at centre.
- Installation of new transformer (100 KVA) by CPWD is under progress.

Insect proof Net house

Figure 9: New seed store and Implement shed

Other Institutional Activities/Programmes at IIPR-RC Dharwad

- A training programme on "Summer mungbean cultivation and use of ICT tools" at RC, Dharwad was organized at IIPR-RRC Dharwad. Dr. P.M. Salimath, Former VC, UAS, Raichur; Dr. H.L. Nadaf, Director Research, UAS, Dharwad, Dr. Kajjidoni, Dean, CoA, UAS, Dharwad and Director, IIPR Kanpur graced the occasion.
- A newly constructed *Laboratory cum Office building* of ICAR-Indian Institute of Pulses Research-Regional Centre, Dharwad along with a Scientist-Farmer Interface Meeting was inaugurated by Dr. Trilochan Mohapatra, Hon'ble Secretary (DARE) & Director General ICAR on June 17, 2019 at Dharwad. Shri. N. H.

Shivashankar Reddy, Hon'ble Minister of Agriculture, Govt. of Karnataka; Prof. M.B. Chetti, Hon'ble Vice Chancellor, University of Agricultural Sciences, Dharwad; Dr. J.H. Kulkarni, Ex. Vice Chancellor, University of Agricultural Sciences and Shri Prasad Abhayya, Hon'ble MLA, Hubli- Dharwad.

- Van Mahotsav programme was organized on July 22, 2019 at 11 AM at ICAR-IIPR, RRC Dharwad. Dr. H.L. Nadaf, Director of Research UAS, Dharwad and Dr. K.T. Hanumanthappa, IFS, Conservator of Forest (Research), Dharwad Division attended the programme.

Training programme on "Summer mungbean cultivation and use of ICT tools"

- "Swachata Pakhwada" programme was organized at IIPR-RRC, Dharwad from september 25-October 2, 2019.
- Scientists of the centre participated in *Mera Gaon Mera Gaurav* programme organized by IGFRI, RS, Dharwad.
- Vigilance Awareness Week was organised at the centre.
- A MoU between ICAR-IIPR, Kanpur and UAS, Dharwad was signed on December 16, 2019 by Director, IIPR, Kanpur and Registrar, UASD for facilitating PG and Ph.D students' research works in presence of Hon. VC, Director of Research, Dean (PGS) of UAS, Dharwad, I/C and other staff members of IIPR-RRC, Dharwad.

Commissioner for Agriculture, Govt. of Karnataka Seed officer, UAS Dharwad and officials from state Dept. of Agriculture, Govt. of Karnataka visited IIPR, RRC, Dharwad on November 20, 2019 and had interaction with the staff members.

All India Coordinated Research Projects

Chickpea

Varieties Developed

- **AKG 1303**: The *desi* chickpea variety developed from cross SAKI 9516 x AKG 70 is suitable for timely sown irrigated condition of west central zone. It has tall and semi erect plant type with attractive medium seed size of 21.76 g/100 seeds. It has an average yield potential of 2481 kg/ha and matures in 111 days. The variety has been identified for release in western central zone comprising states of Gujarat, Maharashtra and western Madhya Pradesh
- **GL 13001:** The *desi* chickpea variety developed from cross GL 22044 x GL 24021 is suitable for timely sown irrigated condition of NEPZ. It has medium tall, semi erect plant type with green foliage and medium brown seeds of 25.0 g/ 100 seeds. It has an average yield potential of 1750 kg/ha and matures in 130-134 days. The variety has been identified for release in the North Eastern Plain Zone comprising of eastern Uttar Pradesh, West Bengal, Bihar, Jharkhand, Assam and Manipur under late sown condition.
- **Phule G 08108**: The *desi* chickpea variety developed from cross ICCV 10 x ICCL 87322 is suitable for timely sown irrigated condition of Central Zone. The variety is suitable for machine harvesting bearing the first pod at 25-30 cm above ground level. It has semi erect plant type with medium leaves and has attractive seed size of 21.6 g/100 seeds. It has an average yield potential of 2265 kg/ha and matures in 110 days. The variety has been identified for release in Central Zone comprising of Maharashtra, Gujarat, Madhya Pradesh, southern Rajasthan and Bundelkhand region of Uttar Pradesh.


Field View of proposed Chickpea Variety PDKV KANAK (AKG-1303)

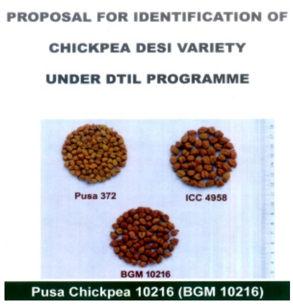

Field view of MABC-WR-SA1 Single plant

Fusarium wilt reaction


JG 24

Seeds of MABC-WR-SA1 and Annigeri-1

Single Plant view of BGM 10216 (Pusa Chickpea 10216)



- **JG 2016-24**: The *desi* chickpea variety developed from cross JG 74 x ICC 4958 is suitable for timely sown irrigated condition of Central Zone. The variety is suitable for machine harvesting bearing the first pod at 30-35 cm above ground level. It has medium tall and semi erect plant type and attractive seed size of 29.3 g/100 seeds. It has an average yield potential of 2237 kg/ha and matures in 110-115 days. The variety has been identified for release in Central Zone comprising of Maharashtra, Gujarat, Madhya Pradesh, southern Rajasthan and Bundelkhand region of Uttar Pradesh.

- **BG 3062**: The *Desi* chickpea variety developed from cross ICCV 10 x ICCL 87322 is suitable for timely sown irrigated condition of Central Zone. The variety is suitable for machine harvesting bearing the first pod at 28-30 cm above ground level. It has erect plant type and has attractive seed size of 23 g/100 seeds. It has an average yield potential of 2125 kg/ha and matures in 110-115 days. The variety has been identified for release in Central Zone comprising of Maharashtra, Gujarat, Madhya Pradesh, southern Rajasthan and Bundelkhand region of Uttar Pradesh.
- **Pusa Chickpea 10216 (BGM 10216):** It is a drought tolerant introgression line of chickpea variety Pusa 372 developed through introgression of "QTL hot spot" for drought tolerance from ICC 4958. It has excellent grain colour and weighs around 22.2 g per 100 seeds. The average duration is 110 days and an average grain yield of 1447 kg/ha with over 11% yield superiority over recurrent check variety Pusa 372 under moisture stress condition. It is moderately resistant to *Fusarium* wilt, dry root rot and stunt. The variety has been identified for release in Central Zone comprising of Madhya Pradesh, Maharashtra, Gujarat and Bundelkhand region of Uttar Pradesh.
- **Super Annigeri 1 (MABC-WR-SA1)**: It is a *Fusarium* wilt resistant introgression line of chickpea variety Annigeri 1 developed through introgression of *Fusarium* wilt resistant genes from WR 315. It has semi-erect plant type and has attractive seeds size of 18-20 g per 100 seeds. The variety matures in 95-110 days. It has an average grain yield of 1898 kg/ha showing over 6% yield superiority over the recurrent variety Annigeri-1. It has high resistance against *Fusarium* wilt. The variety has been identified for release in Andhra Pradesh, Karnataka, Maharashtra and Gujarat.

Research Highlights

Crop Improvement

- On the basis of three years of multi-location evaluation, the promising *Desi* chickpea genotypes were AKG 1303 (2481 kg/ha) in WCZ and GL 13001 (1750 kg/ha) in NEPZ. In mechanical harvesting trial, Phule G 08108 (2265 kg/ha); RVSSG 8102 (2250 kg/ha); JG 2016-24 (2237 kg/ha) and BG 3062 (2125 kg/ha) were the promising genotypes in CZ.
- In DTIL trial, BGM 10216 (1447 kg/ha); BG 3097 (1370 kg/ha) and RVSS 51 (1622 kg/ha) were the high yielding lines. In WRIL trial, MABC-WR-SA 1 (1898 kg/ha) and MABC-WR-SA 2 (1830 kg/ha) were the promising genotypes.
- Ten Thousand Two Hundred Sixty One germplasm lines were maintained at 19 centres under genetic resources activities. Some of these accessions were evaluated for various morphological characters.
- 13165.34 q of breeder seed of 70 chickpea varieties was produced against DAC indent of 9790.16 q.

Crop Production

Agronomy

- To optimize yield in chickpea through customized fertilizer based on nutrient uptake by pulses in respect of diverse nutrients (N, P, K, S, Zn, B & Mo), the study showed that Customized Fertilizer Grade 1 (CFG 1 with NPKSZnMo based on 100% recommendation) had higher grain yield and economics over rest of the treatments at Durgapura, Samba and Kalaburagi. This treatment was superior to both RDF (RD-NPK) and RD (NPKSZnBMo) thereby indicating saving of precious nutrients through CFG.
- Study involving combination of pre- and post-emergence broad spectrum herbicides revealed that pendimethalin 30 EC + imazethypr 2 % (RM 1.0 kg/ha) PE as a ready-mix followed by one hoeing was far superior to rest of the treatments under Ranchi condition, while pendimethalin 38.7 CS (0.75 - 1.0 kg/ha) PE + one hoeing at 30-35 DAS was optimum under Kalyani, Badnapur and Kota. Here, the major weed flora included *Cynodon dactylon*, *Cyperus rotundus*, *Chenopodium album*, *Phalaris minor*, *Circium arvense*, *Fumaria pariviflora* and *Polygonum* spp.
- In order to enhance chickpea productivity with higher nutrient and water use efficiency through hydrogel and foliar nutrition under rainfed/limited water condition, studies showed that application of 5 kg/ha pre-sowing soil application of hydrogel was beneficial at

Samba, Durgapura, Ludhiana and Raipur. In most of these locations, salicyclic acid at 100 ppm applied at flower initiation and pod development was beneficial (at par with NPK19:19:19::NPK at 0.5 %).

Plant Physiology

- Heat tolerant genotypes (ICCV 92944 and ICC 15614) and heat susceptible genotypes (ICC 10685 and Pant G 114) were used for visualizing *in-vivo* production of detrimental H_2O_2 and superoxide radical in the leaves under both normal as well as heat stress condition. As compared to normal condition, the production of hydrogen peroxide increased under heat stress and it was observed that the increase in hydrogen peroxide production was more in susceptible genotypes as compared to tolerant genotypes.
- Genotypes with high root biomass and high root length were identified such as PG 5, GNG 1581, GNG 1488, ICC 4958, Rajas, JG 63, ICCV 96030, BDG 75, GG 2, PG 96006 and Vijay. These genotypes are well adapted to dryland condition while genotypes Pusa 1003, BGM 408, Pusa Green 112, PG 186, JG 16, Pusa 240 had lesser root length and root biomass.
- Among thirty genotypes tested for cold tolerance at Kanpur, GL 28008 had maximum cold tolerance in terms of flower initiation and set pod below 50^0 C.

Microbiology

- Multilocation testing of 4 elite *Mesorhizobium* strains at 4 different centres showed that strain RVSGRS-121 out yielded all other strains by registering an increase in grain yield of 14.9% ,followed by LGR 2018 (Ludhiana) of 10.7%, LGR 14-2 (Reference, Ludhiana) of 8% over the control.
- Three microbial consortia developed at IIPR, Kanpur for alleviating moisture stress were evaluated for their performance at five locations. Three consortia inoculants gave 16.1 to 20.4 % more mean grain yield than the control across the locations. Pooled mean of different locations indicated the highest grain yield with Consortia III, being 20.4% followed by consortium II (18.4%) over the control. Enhancement in yield due to consortia III was 6.3% over 20 kg N/ha whereas, it was 9.5% and 8.5% over *Mesorhizobium* CR-13 (IIPR) and *Mesorhizobium* CH1233, respectively. Consortia III was found better than others at Ludhiana, Kanpur and Sehore, except at Durgapura where Consortia II was better than others in grain yield.
- Ten *mesorhizobia* and 263 endophytic bacteria isolated from chickpea nodules and root samples were subjected to various biochemical tests. Five *mesorhizobia* were selected on the basis of plant infectivity test. Two *Mesorhizobium* isolates LGR 5 and LGR 2 were found promising with the production of IAA, ACC-deaminase and P-solubilization. Four new endophytic bacterial isolates were identified and produced phytohormones (IAA and GA_3), P-solubilization, ACC-deaminase and siderophores. All four isolates were identified on the basis of partial 16Sr RNA sequence, as LCRE-9 (*Pseudomonas* protogens), RBR40 (*Acinetobacter pitti*), RBN 61 (*Acinetobacter paumanni*) and RBR 49 (*Alcaligenes faecalis*).

Crop Protection

Plant Pathology

- In Advance Varietal Trial (*Desi*), two chickpea entries, AKG 1303 and RLBG 2 were resistant or moderately resistant to wilt at 6 or more locations in different zones of India. In IVT (*Desi*) group, similar reaction to wilt was observed in entries RLBG 3, BDNG 2017-1, RKG18-1, NBeG 857, ICCV 171105, NBeG 798, and PBC 546-18 at six or more locations.
- Wilt resistance/tolerance was confirmed in 16 entries *viz*. NBeG 776, RKG 13-55, GNG 2325, PG 209, JG 74315-2, IPC 08-11, PG 211, JG 2017-50, Phule G 0819, JG 2017-49, GJG 0922, GNG 2391, GL 13037, IPC -07-28, NBeG 779 and H 12-63 for the second consecutive year.
- Seed treatment in combination of *Trichoderma harzianum* (Strain T-6) + Propineb (10 g + 1.5 g/kg seed) was significantly effective in minimizing collar rot incidence (13.04%) at Raipur, Jhansi, Shillongani and Jabalpur as compared to control (45.64%).

Entomology

- Surveillance on pest and natural enemy population in chickpea crops revealed that there was less larvae per meter row length in early and timely sown crop, hence recorded less pod damage and more grain yield than late sown crop. The population of larval parasitoid, *Campoletis chloridae* and spiders was also more under timely sown conditions than early and late sown conditions in all zones except in Durgapura and Pantnagar.

- Avoidable yield losses in chickpea against pod borer, *H. armigera* and *Spodoptera exigua* were recorded to be 0.69-49.00 % in NWPZ, 0.00-31.08% in NEPZ, 3.42-41.09% in CZ and 0.00- 52.78% in SZ.
- In compatability experiment, the insecticides Chlorantraniliprole 18.5% SC and Emamectin benzoate 5% SG and foliar nutrient Urea, DAP and KNO_3 alone and their combinations did not show any phytotoxic effect on the crop when they were mixed together. The foliar nutrient Urea, KNO_3 combination with Chlorantraniliprole 18.5% SC and Emamectin benzoate 5% SG was statistically effective in terms of higher larval reduction and lower pod damage translating into higher yield.
- In evaluation of ecofriendly approaches for the management of gram pod borer, *H. armigera* the treatment Chlorantraniliprole 18.5 SC % @ 0.25 ml/L, HaNPV (2 x109 PoBs) @ 250 LE/ha, Delfin WG @ 1 g/L and Bacillus thuringiensis kursataki, 127% SC @ 3 ml/L were statistically effective in terms of higher larval reduction and lower pod damage and thus higher grain yield of chickpea crop.

Frontline Demonstrations

- Three hundred and forty two demonstrations were conducted on package technology. On an average, 1606 kg/ha of yield was obtained through package technology against 1231 kg/ha by farmer's practice with an increase in grain yield by 30.5 per cent.
- Fifty five demonstrations were conducted on package technology in rice fallow. The overall mean grain yield of package technology in rice fallow was 1526 kg/ha and mean yield of local practice was 1121 kg/ha. The per cent increase in grain yield was 36.1%.
- Four hundred and eighty demonstrations were conducted in tribal areas under Tribal sub plan which gave an average yield of 1370 kg/ha which was 36.0% higher than yield obtained through traditional practices and varieties (1107 kg/ha).

Demonstrations conducted on chickpea under tribal sub plan (TSP) during 2018-19

For upliftment of tribal population, the Govt. of India formulated the tribal sub plan and separate budget was allotted during financial year 2018-19. AICRP on Chickpea organized the demonstration by providing seed of high yielding varieties and technical knowhow to raise the chickpea crop successfully. Besides, various field days were also organized by centres to raise awareness about chickpea cultivation among tribal farmers.

In seven chickpea growing states, 11 centres conducted demonstrations in districts having large tribal population. Overall, 480 demonstrations were conducted in different tribal districts. The mean yield obtained in demonstration plots with improved package of practice was 1370 kg/ha which was 36.0% higher than that obtained under local practices (1107 kg/ha).

In Andhra Pradesh, ARS, Nandyal conducted 50 demonstrations in Gundalanattu, Vempenta, L K Tanda, Kandananipalle, Juluthula, PP Thanda, Kondamanayanipalli, Harivaram and Mitnalavillages (Districts: Kurnool) and Sangam, K.Kondapalli, Sakirevu villages (District: Visakhapatnam) on full package of practices. The mean yield of 50 demonstrations was 1473 kg/ha and that of local practices was 1073 kg/ha. The per cent increase in yield was 37.3%. In Chhattisgarh, IGKVV, Raipur conducted 60 demonstrations in Kapasi village (District: Kanker) on full package of practices. The mean yield of 60 demonstrations was 1247 kg/ha and that of local practices was 967 kg/ha. The per cent increase in yield was 29.0%. ARS, Jagdalpur conducted 60 demonstrations for the tribal people in Belar, Chhapar, Bhanpuri, Dharmaur, Lamker, Tahkapal, Tandpal villages (District: Bastar). The average yield with full package of practices was 924 kg/ha and that of local practices was 616 kg/ha. Overall, 1086 kg/ha yield was realized in demonstration plots against 792 kg/ha in farmers field with an increment of 37.1%.In Jammu and Kashmir, PORS, Samba conducted 15 demonstrations with full package of practices in Ranjri, Bangla Rajinderpura, Naneter, Khorju Dhorda, Dhamar, Motalian, Sunjron, Pali villages (District: Samba). The mean yield of 15 demonstrations was 925 kg/ha and that of local practices was 715 kg/ha. The per cent increase in yield was 29.4%.In Jharkhand, BAU, Ranchi conducted 20 demonstrations with full package of practices. The mean yield of 20 demonstrations was 1105 kg/ha and that of local practices was 804 kg/ha. The per cent increase in yield was 37.4%. In Madhya Pradesh, CoA, Sehore CoA Indore and JNKVV, Jabalpur conducted 170 demonstrations with high yielding varieties RVG 202, JG 130 and JG 14. CoA, Sehore conducted 60 demonstrations in Tikariya, Talen, Gehukhedi, Khajuri, Mundla Reti, Bakha Khurram, Choma, Umari Roshla, Roshla, Kasrod, Mahua, Baredi, Bhilkhera, Sultania, Dhamanda, Omkarpura, Patakya, Bheshwa Mata, Gayan, Roshiya, Udpuriya, Ichchawar, Gudbhela, Phulmogra, Brijisnagar villages. The demonstrations were conducted on improved variety of chickpea RVG 202 following full recommended production technology of chickpea including improved varieties, seed treatment, fertilizer application and IPM. It recorded an average seed yield of 1514 kg/ha over farmer's practice 1188 kg/ha. Full package technology increased average seed yield by 27.4 % against farmer's practice. CoA, Indore conducted 60 demonstrations at Gugali, Kachhal, Bagred, Kakalpura and Morgaon of Dhar district. The mean yield of high yielding variety was 1678 kg/ha against the districts productivity of 1100 kg/ha. JNKVV, Jabalpur conducted 50 demonstrations at Dindori, Mandla, Umaria, Chhindwara and Harda district with chickpea variety JG 14. The mean yield of high yielding variety was 1357 kg/ha against the farmers yield of 758 kg/ha. In Maharashtra, MPKV, Rahuri organized 25 demonstrations in Dadegaon, Tambhere, Deolali Pravara, Valan, Pimpri Avghad, Sonai, Vilad, Rahuri Bk, Undirgaon, Ghargaon (District: Ahmednagar). The mean yield of demonstration plots was 1345 kg/ha and that of farmers variety was 1059 kg/ha. The percent increase in grain yield was 27.0%. In Rajasthan, RARI, Durgapura conducted 60 demonstrations in tribal areas of Abhaneri, Asalgoan, Uniyara, Bilota, Uniyara, Bishta, Uniyara, Delari, Devgav, Bassi, Dhingariya, Kalwar, Jaipur, Mitrawadi, Monabas Bandikui, Paly, Uniyara, Pichupara Khurd, Pratappura, Ram Nagar, Uniyara, Ramnagar,Uniyara, Shyam Singh pura, Shyopura, Uniyara, Sopra, Uniara, Thuni Mangaldas, Umarpura Aligargh. Improved varieties gave mean yield of 1486 kg/ha which was 19.7% higher than yield obtained in case of local varieties (1242 kg/ha). ARS, Banswara conducted 20 demonstrations in Badana, Kanpura, Tadi Mahudiand Ghatol villages by providing the seed of variety Pratap Chana 1. The mean yield of this variety was 2173 kg/ha which was 13.9% higher than the yield of varieties generally grown in tribal areas (1908 kg/ha).

Demonstrations conducted under tribal sub plan (TSP)

States	Centres	Variety	No. of FLD's	Grain yield (kg/ha)			Returns (₹)		
				IP	FP	% Increase	Cost of Cultivation (₹)	Gross Returns (₹)	C:B Ratio
Andhra Pradesh	ARS, Nandyal	NBeG 49	50	1473	1073	37.3	-	-	-
	State Total/Mean		**50**	**1473**	**1073**	**37.3**	-	-	-
Chhattisgarh	IGKVV, Raipur	JAKI 9218	60	1247	967	29.0	16800	56107	2.34
	ARS, Jagdalpur	JAKI 9218	60	924	616	50.0	8290	24916	2.01
	State Total/Mean		**120**	**1086**	**792**	**37.1**	**12545**	**12512**	**3.23**
Jammu & Kashmir	PORS, Samba	GNG 1958	15	925	715	29.4	-	-	-
	State Total/Mean		**15**	**925**	**715**	**29.4**	-	-	-
Jharkhand	BAU, Ranchi	-	20	1105	804	37.4	29244	48632	0.66
	State Total/Mean		**20**	**1105**	**804**	**37.4**	-	-	-
Madhya Pradesh	CoA, Sehore	RVG 202	60	1514	1188	27.4	20000	68111	2.41
	CoA, Indore	JG 130	60	1678	1100	52.5	13500	75525	4.59
	JNKVV, Jabalpur	JG 14	50	1357	758	79.0	-	-	-
	State Total/Mean		**170**	**1526**	**1030**	**48.1**	**16750**	**71811**	**3.29**
Maharashtra	MPKV, Rahuri	Digvijay	25	1345	1059	27.0	23312	56485	1.42
	State Total/Mean		**25**	**1345**	**1059**	**27.0**	**23312**	**56485**	**1.42**
Rajasthan	RARI, Durgapura	GNG 1581	21	1470	1226	19.9	-	-	-
		RSG 974	39	1494	1250	19.5	-	-	-
	Total/Mean		60	1486	1242	19.7			
	ARS, Banswara	Pratap Chana 1	20	2173	1908	13.9	21625	86900	3.02
	State Total/Mean		**80**	**1657**	**1408**	**17.7**	-	-	-
Overall Total/Mean			**480**	**1370**	**1007**	**36.0**	**16503**	**57190**	**2.47**

*FP: Full Package, IPC: Integrated Pest Management.

Pigeonpea

Crop Improvement

Varieties/Hybrid developed, released and notified

1. **Early maturing pigeonpea hybrid:** Pigeonpea hybrid IPH 15-03 was developed, identified in pigeonpea group meet and released and notified by CVRC for its cultivation in NWPZ. It matures in 145-150 days and suits for pigeonpea-wheat cropping system of NWPZ.

Pigeonpea Hybrid IPH 15-03

2. **Early maturing pigeonpea variety:** Pigeonpea variety PA 6 was developed, identified in pigeonpea group meet and released and notified by CVRC for its cultivation in NWPZ. It matures in 140-145 days and suits for pigeonpea-wheat cropping system of NWPZ.
3. **Mid early maturing pigeonpea varieties:**

(i) **WRGE 93:** Pigeonpea variety WRGE 93 was developed, identified in pigeonpea group meet and released and notified by CVRC for its cultivation in SZ. It matures within 160-165 days.

(ii) **GRG 152:** Pigeonpea variety GRG 152 was developed, identified in pigeonpea group meet and released and notified by CVRC for its cultivation in CZ. It matures within 160-165 days.

4. **Medium maturing Pigeonpea Variety:** Pigeonpea variety MPV 106 was developed, identified in pigeonpea group meet and released and notified by CVRC for its cultivation in CZ. It matures within 175-180 days. This is the first pigeonpea variety developed by other than NARS partner. It has been developed by Mahabeej company of Maharashtra state.

Pigeonpea hybrids promoted to advanced trials are

AHT 1: IPH 17-01; PAH 5; ICPH 3481; ICPH 4788; BDNPH 12-01

AHT 2: IPH 09-5

Genetic resources evaluation and management

A total of 4990 germplasm accessions including cultivated and wild species were maintained at 22 AICRP on pigeonpea centres as on date. The total set comprises of 295 new collections made through exploration. Evaluation of 1571 germplasm lines were carried out at different centres for yield and yield components, disease resistance, drought tolerance and morphological characters. Pigeonpea genotypes IPAC 79, DAC 08-15 and DAC 07-22 were found tolerant for water logging condition.

Breeder Seed Production

For crop season 2018-19, indent of 265.48 q of pigeonpea breeder seed was received for 44 varieties/hybrids from DAC. Against this indent allocation was done for 332.35 q and a total of 494.88 q of breeder seed was produced at different centres.

Crop Production

South Zone

It is concluded that irrigation scheduled at 75% CPE and spacing of 120 x 60 cm is optimum in Kalaburgi condition. Giving supplemental irrigation, resulted in higher growth and yield parameters that ultimately resulted in higher grain yield (1494 kg/ha) of pigeonpea as compared to rainfed treatment (1042 kg/ha). Further application of FYM @ 5 t/ha+ pusa hydrogel @ 2.5 kg/ha at the time of sowing and foliar application of 2% KH_2PO_4 at flowering fb 2% KNO_3 at pod development stage recorded significantly higher grain yield (1363 kg/ha) and net returns (₹ 50788/ha).

Nipping at 45 to 60 DAS recorded significantly higher grain yield over no-nipping. Application of 0.25% Borax at 50% flowering stage recorded higher grain yield of pigeonpea (1539 kg/ha) with higher net returns (₹ 64341) and B:C ratio (3.80).

Central Zone

Pigeonpea + soybean based intercropping (2:4) followed by wheat sequential cropping sequence is recommended for higher yield. Application of RDF + multi-micronutrient spray @ 2 ml/litre at flower bud initiation + Indoxacarb at flowering + one systemic insecticide 15 days after first spray was found significantly superior to manage pest menace.

Sowing of Pigeonpea at 120 x 60 cm spacing and drip irrigation at 50% CPE is recommended for obtaining higher yield. Application of pusa hydrogel @ 2.5 kg/ha + mulching with organic residue @ 5 t/ha is recommended for drought mitigation. Nipping at 45 DAS is recommended for higher yield

NEPZ

At Dholi, foliar application of multi-micronutrient 2 ml/litre of water at 50% flowering together with RDF and two spray of insecticides, *i.e*, indoxacarb at flowering followed by profenofos 15 days after first spray produced maximum grain yield (1981.5 kg/ha).

Crop Protection

Host plant resistance

Pigeonpea entries GJP 1606, GRG 152, MPV 106, PT 0723-102-3, TDRG 58, TRG 87, BDN 2018-41, AKTE 1701, BDN 2013-1, BRGL 18-1,IBTDRG 7, IPA 15-2, IPA 16-18, IPAM 16-3, KRG 224 ,KRG 244, LRG 229, RPS 2007 109-1, RPS 2008-5, TDRG 59, TRG 111 were found promising and exhibited R to MR reaction to wilt in more than 50 per cent of locations tested.

Pigeonpea genotypes MPV 106, PT 0723-1-2-3, BDN 2018-41, BDN 2013-1, BRGL 18-1, BRGL 18-2, IBTDRG 7, TDRG 59, TRG 111, DA 18-1, DA 18-2, Pusa 151, Pusa 171, ICPWS 1602-ICPWS 1604, ICPWS 1611, ICPWS 16112, CPWS 1615, ICPWS 1617, ICPWS 1618, ICPWS 1619, ICPWS 1623, ICPWS 1624, ICPWS 1626, ICPWS 1627, ICPWS 1632, ICPWS 1634- ICPWS 1638 and ICPWS 1640 showed resistance against sterility mosaic disease (SMD).

Five entries *viz.*, GRG 152, KRG 33, BDN 2013-41, RKPV 806, SKNP 1605 and DA 18-1 were recorded resistance reaction for *Phytophthora* stem blight at two locations out of four test centers.

Entries viz. BDN 2013-1, CRG-16-008, IPA 15-06, IPAM 16-3, RKPV 911, RVSA-15-7, RVSA 15-10 and TRG-111 showed resistant reaction against *Cercospora* leaf spot.

Two entries *viz.* KRG 33 and Bahar recorded resistance reaction against *Macrophomina* stem blight at Varanasi. Four genotypes GRG-152, IPA 206, WRGE 93 and PA 291 gave moderately resistance reaction at RAU, Pusa against *Meloidogyne incognita.* Pusa 151 and PA 291 were observed moderately resistant against *M. javanica* at both test locations and genotypes PA 291 was observed moderately resistant at all three locations against both *Meloidogyne incognita* and *M. javanica.*

Protection technology

The insecticide, Lambda- cyhalothrin 5 EC @ 25 g a.i/ha (1.0 ml/l) and flubendiamide 480 SC @ 30 g a.i/ha (0.3 ml/l) were found to be effective against blister beetle in pigeonpea

Frontline demonstrations

Frontline Demonstration on Pigeonpea was organized in 304 ha area on seven components *viz.*, Intercropping with soybean, Pusa Hydrogel, IPM, weed Control, planting on ridges, compatibility of growth promoter and insecticide and package technology on 340 ha demonstrations allocated and results of all 304 ha demonstrations were received.

- Intercropping of pigeonpea with soybean (2:4) resulted 24.75% more grain yield than farmers practice (Sole crop) with 21.72% higher net return in 34 ha demonstrations.
- Application of Hydrogel (2.5 kg/ha) resulted in

12.96% more grain yield than normal sowing with 32.72% higher net return in 5 ha demonstrations.

- Insect (Pod borers) management was the most beneficial and recorded 17.40% higher grain yields with 21.5% higher net return in 16 ha demonstrations.
- Planting on ridges recorded 24.24% higher grain yield as compared to flat sowing in 12.80 ha demonstrations.
- To control weed in pigeonpea, pre-emergence application of pendimethalin @1.25 kg a.i./ha was found most effective with 17.9% higher grain yield in three ha demonstrations with 17.5% higher net return.
- Compatibility of growth promoter and insecticide was tatest and by applying this 20.29% more grain was obtained than local practice with 25.30% higher net return.
- Integration of all components of production technology enhanced the productivity of pigeonpea by 29.56% with 35.20%, higher net return in 264 ha demonstrations.

DUS

Total 23 farmers' varieties have been planted for evaluation during *Kharif* 2019-20. Of these, 18 (Mardi Aghani, Murmu Aghani, Murmu Chaitali, Soren Aghani, Murmu Aghani-PS2, Tudu Chaitali, Mardi, Khandwal Guchha, Soren Maghi, Rajas, Maga Rahar, Sunil Rahar, Kapil Rahar, Chamara Rahar, Asiya Rahar, Pabiya Rahar, Manju Rahar and Khabarpur Arhar) varieties are in second year of testing and five (Reg. No. 2883/2705, 2883/2708, 2883/2710, 2883/2481 and 2881/3811) are in their first year of testing. Majority of the varieties are at flowering stage now, accordingly observations on the trials like flower petal colour, streak pattern on the petal, leaf shape and pubescence on the lower surface of leaf *etc.* have been recorded.

TSP and NEH Programm :

Under NEH, 11 entries in IVT early and about 100 germplasm and breeding lines have been evaluated in Medziphema, Nagaland and Tripura centres, five acres each of FLD was also demonstration on pigoenpea production package technology in the respective centres.

ZARS, Khargone (M.P.); IGKV, Raipur (CG); BAU, Kanke; Ranchi; Jharkhand are the centres working under TSP, Pigeonpea. Accordingly 40 acres of FLD has been allocated to three centres for demonstration of production technology. Under this scheme, total of 1114 farmers/beneficiaries were trainined on various aspects of pigeonpea production technologies.

MULLaRP

Varities Developed

Mungbean

MH 1142 : The candidate variety showed 11% superiority in yield over the best check of NWPZ and 8.1% superiority over best check in NEPZ. The variety is suitable for its cultivation in Kharif for both NEPZ (Eastern U.P., Bihar, Jharkhand, West Bengal, Assam) and NWPZ (Punjab, Haryana, Rajasthan, Uttarakhand and Delhi).

Urdbean

VBN 9 (VBG 12-111) : VBN 9 has shown 14.50% yield superiority over the best check LBG 787. The variety is suitable for rice fallow cultivation in SZ comprising states of Andhra Pradesh, Tamil Nadu, Karnataka and Odisha.

VBN 10 (VBG 12-034): The variety VBN 10 (VBG 12-034) is suitable for *Rabi season* in SZ. This exhibited 9.45% yield superiority over the best check LBG 787 of zone. The variety has also shown resistance to MYMV, ULCR and LC disease. The variety is suitable for SZ comprising states of Andhra Pradesh, Tamil Nadu, Karnataka and Odisha.

Fieldpea

Pant P 347 : The variety Pant P 347 of dwarf category was suitable for North West Plain Zone (NWPZ) comprising states of Punjab, Haryana, Delhi, North-West & Central Rajasthan, western U.P. and Plains of Uttarakhand and Jammu & Kashmir by the committee. The candidate variety has yield superiority 16.42 per cent over the best check and found moderately resistant to Powdery mildew, *Ascochyta* blight and rust diseases.

IPF 16-13 (Harit) : The IPF 16-13 of tall category of fieldpea is suitable for North East Plain Zone (NEPZ) comprising states of central and eastern Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal was considered by the committee. The candidate variety had yield superiority of 10.3 per cent over the best check and was found moderately resistant to rust and Powdery mildew.

IPFD 9-2:- Semi dwarf, tendril and white seeded fieldpea variety developed from the cross IPFD 98-1 x HUDP 15. It has the average potential of 1527 kg/ha in Uttar Pradesh State adaptive trials and exhibited more than 10 per cent yield superiority over the best check KPMR 522. In addition, it also has resistant to powdery mildew and tolerance to rust. Hence this variety has been released & notified in 2018 for whole Uttar Pradesh.

Lentil:

RKL 605-3: The lentil variety RKL 605-3 of large seed category were released and notified for central zone (CZ) comprising states of Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Bundelkhand region of U.P. and South-East part of Rajasthan.

L 4729 : The variety RKL 605-3 was released and notified for central zone (CZ) comprising states of Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Bundelkhand region of U.P. and South-East part of Rajasthan. This was found moderately resistant to wilt and rust.

IPL 315: The large seeded variety of lentil derived from PL 4 x DPL 62 is resistant to rust and tolerant to wilt. Its potential yield is 1235 kg/ha. It is released and notified for U.P. state.

IPL 321: The large seeded variety of lentil derived from DPL 62 x K 75 is resistant to wilt . It is released and notified for U.P. state.

Crop Improvement

Pre breeding and distant hybridization

In pre breeding programme good material has been developed at Badnapur and is being used as male parent in subsequent hybridization programme. The single plant progenies of cross BMG 75-1 (Mungbean) x BWU-9 (*V. sylvestris*) which has long pod and urdbean plant type are being used as female with mungbean and progenies having mungbean plant type are being used as female with urdbean. The purpose of these crosses is to enhance the pod length of urdbean. At IIPR, Kanpur, the pre-breeding activities have been initiated in urdbean and consequently twenty five inter-specific crosses viz., IPU 11-02 x *Vigna sylvestris*, IPU 02-43 x *V. sublobata*, IPU 02-43 x *V. umbellata*, IPU 11-02 x *V. umbellata*, IPU 11-02 x *V. sublobata*, KS-1 x *V. sublobata*, KS-1 x *V. umbellata*, KS-1 x *V. sylvestris*, IPU

02-43 x Pant M-6 (*V. radiata*), IPU 11-02 x Pant M6, and DPU 88-31 x LBG685 x *V. umbellata* were grown. Successful crosses were made between the elite mungbean lines (Varsha and Kanika) and 3 wild Vigna accessions (VBG 04-008, V. umbellata (PRR 2008-2 and PRR 2007-2), and V. sylvestris (IC 277039).

Mutation Breeding

To develop bruchid resistance, special emphasis has been given of mutation breeding. Consequently, superior progenies were isolated in F_2 and F_2M_2 segregating population derived from hybridization followed by irradiation. The female genotypes DDGV 2 and DGGV 7 are locally adapted and agronomical superiority genotypes but both are susceptible to bruchids. The male genotypes V-02-709 and V-02-802 are bruchids resistant varieties but low yielders. The F_2 seeds produced from the above crossing programme were subjected to irradiation with physical mutagen (gamma rays @ 100kR or 1000Grays) to create variability in the population. The F_2 mutagenic treated seeds were sown to raise the F_2M_1 population. Superior progenies were isolated in F_2 and F_2M_2 segregating population and are being stabilized through subsequent generations. The F_4 seeds derived from the crosses V-02-802 × DGGV-2 and V-02-802 × DGGV-7, were screened for bruchid (*Callosobruchus maculatus*) tolerance under laboratory condition and found to be resistant with very low susceptibility index. Very less number of eggs lay on these seeds and the adult emergence was less. These two lines can be screened stringently in the advanced generations to confirm their performance.

To develop genotypes amenable to mechanical harvesting emphasis has also been given on mutation breeding. Some of the tall and top branching mutants which were bred through mutation breeding from Sonamung (57-2 and 8-1) and IPM 2-03 (1-1, 1-2 and 1-4) were isolated. Mutant which posses sturdy stem, erect growth habit with plant height of 50-62 cm with ground clearance of 20 cm and top bearing plant are being evaluated in preliminary yield trials.

National Crossing Programme

In order to develop pool of segregating material, a national crossing programme was organized at 16 centres for mungbean and 14 centres for urdbean. A total of 559 crosses were attempted in mungbean. Similarly, 186 new crosses were attempted in urdbean. Besides, 19 interspecific crosses were also attempted by three centres. The seed of these crosses will be advanced and segregating material will be shared among various centres for varietal development.

In order to develop pool of segregating material, a national crossing programme was organized at 12 centres each for lentil and fieldpea and one centre for lathyrus. A total 318 crosses were attempted in lentil at IARI, New Delhi (65), ARS, Kota (12), ARS, Sehore (26), GBPUA&T, Pantnagar (32), IIPR, Kanpur (28), RARS, Sagar (8), RARI, Durgapura (5), IGKV, Raipuri (39), NDUAT, Faizabad (66), Ludhiana (15), BAU, Ranch (4) and BCKV, Mohanpur (18). Similarly, 175 new crosses were attempted in fieldpea at RARS, Sagar (8), IIPR, Kanpur (40), CCS HAU, Hisar (20), GBPUA&T, Pantnagar (21) , IGKVV, Raipur (24), RARI, Durgapura (6), Srinagar (8), S.K.Nagar (4), BHU, Varanasi (6), ARS, Kota (6), BAU, Ranchi (3), NDUAT, Faizabad (24) and ARS, Shillongani (5). In lathyrus, IGKV, Raipur attempted only 25 crosses and in rajmash, IIPR, Kanpur made 56 crosses. The seed of these crosses will be advanced and segregating material will be shared among various centres for varietal development.

Plant Genetic Resources

- A total of 4936 germplasm lines of mungbean and 3136 of urdbean were maintained at different centres. A total of 339 accessions of 21 wild *Vigna* species are also maintained at different centres.
- During *Rabi* 2018-19, a large number of cultivated germplasm of lentil (4272), lathyrus (2424), fieldpea (1721) and rajmash (605) were maintained at different centres and many of them were evaluated for different traits.

Breeder Seed Production

- In mungbean, the total breeder seed production was 700.94 q against the indent of 754.52 q for 49 indented varieties. A target total 106 q breeder seed production programme has been taken as compensatory seed production and seed production of summer varieties during summer/spring 2019.
- In urdbean, the breeder seed production was 640.93 q against the indent of 436.28 q for 41

indented varieties.

- The breeder seed production programme has been taken up in lentil and fieldpea. In lentil, the breeder seed production was 716.64 q for 41 varieties. Similarly, a total of 639.04 q breeder seed of 26 varieties of fieldpea was also produced. Besides, breeder seeds of lathyrus (115 q) and Rajmash (4.35 q) were also produced.

Agronomy

Mungbean

- Application of 100% recommended dose of fertilizer (18-25 N:40-50 P_2O_5: 20-25 K_2O: 20 S kg/ha) along with 5 ton FYM/ha and seed inoculation with combination of *Rhizobium* + LMn 16 was found better for higher grain yield.
- Raised bed (67.5 cm with 2 rows)/Broad bed furrow (105 cm with 3 rows) method of sowing at Aduthurai (856 kg/ha) and Imphal (1182 kg/ha) and flat bed sowing followed by ridge making at Ranchi (971 kg/ha), Samba (548 kg/ha) and Berhampur (1098 kg/ha) with foliar application of NPK (18:18:18) @ 2 % at flower initiation was found better for higher grain yield over flat bed method of sowing with water spray.
- Fortification through foliar spray of 0.5% $ZnSO_4$ + 0.5 % $FeSO_4$ at flower initiation at Dharwad (1058 kg/ha) and at flower initiation and pod initiation at Bhilwara (1191 kg/ha) recorded higher grain yield of mungbean.
- Application of Plant growth regulator GA_3 @ 30 – 45 ppm spray at flowering and pod initiation recorded higher grain yield at Akola (1488 kg/ha) and Mandor (1330 kg/ha).

Urdbean

- Urdbean AVT 2 genotype VBG 12-034 with closure planting geometry of 30 cm × 10 cm (33 plants/m^2) exhibited higher grain yield (648 kg/ha) at Dholi (NEPZ).
- Application of 100% recommended dose of fertilizer (18-25 N:40-50 P_2O_5: 20-25 K_2O: 20 S kg/ha) along with 5 ton FYM/ha and seed inoculation with combination of *Rhizobium* + LMn 16 was found better for higher grain yield.
- Raised bed (67.5 cm with 2 rows)/Broad bed furrow (105 cm with 3 rows) method of sowing with foliar application of NPK (18:18:18) @ 2 % at flower initiation was found better for higher grain yield at Raipur (1075 kg/ha), Bhilwara (1551 kg/ha), Sehore (757 kg/ha), Pantnagar (1335 kg/ha), Imphal (1154 kg/ha) and Keojhar (707 kg/ha) over flat bed method of sowing with water spray.

Lentil

Genotypes, RKL 605-3 (1734 kg/ha) and L 4729 (1573 kg/ha) sown up to 10th November were found promising for higher grain yield at Kota, Raipur and Sehore centres (CZ) under AVT.

Application of 75% recommended phosphorus dose along with basal application of 18.75 kg/ha $ZnSO_4$ + seed inoculation with biophos + biozinc @ 5 ml/kg seed was found effective for enhancing grain yield (1447 kg/ha) of lentil.

Conventional tillage (two harrowing + planking) with crop residue (30 cm) at Dholi, reduced tillage practice (one harrowing + planking) with crop residue (30 cm) at Mohanpur and Shillongani whereas, zero tillage (direct sown) with crop residue (30 cm) at Raipur was found better for higher lentil yield under rice-lentil cropping system.

Fieldpea

Fieldpea genotypes (Tall) VL 42 (Ch.) (1648 kg/ha) and IPF 16-13 (AVT 2) (1461 kg/ha) sown with lower seed rate (80 kg/ha) were found promising for higher grain yield at Shillongani, Mohanpur and Ranchi centres (NWPZ).

Fieldpea genotype (Dwarf) Pant P 347 (2456 kg/ha) sown with lower seed rate (80 kg/ha) was found promising for higher grain yield at Hisar and Pantnagar centres (NWPZ).

Application of 100% recommended dose of fertilizer (RDF) 20-17-16-20-5 kg NPKSZn/ha and seed inoculation with *rhizobium* + *PSB* + *PGPR (RB-2)* + 1.0 g ammonium molybdate/kg seed and two times foliar spray of NPK (19:19:19) @ 0.5 % at pre flowering and pod initiation gave higher grain yield (1800 - 1900 kg/ha) of fieldpea at NWPZ, NEPZ and CZ.

Fieldpea seeds treated with sodium molybdate @ 0.5 g/kg seed and two times foliar spray of NPK (19:19:19) @ 0.5% at branching and 15 days after 1st spray recorded higher grain yield (1000-1100 kg/ha) of fieldpea under rice-utera system.

Application of 75% recommended phosphorus dose along with basal application of 18.75 kg/ha $ZnSO_4$ + seed inoculation with biophos + biozinc @ 5 ml/kg seed was found effective for enhancing grain yield (2140 kg/ha) of fieldpea.

Lathyrus

Application of recommended dose of fertilizer (RDF) 20:17:16:20 – N:P:K:S kg/ha along with either soil application of 20-25 kg/ha $ZnSO_4$ as basal or foliar application of $ZnSO_4$ @ 0.5 % at pre flowering and pod initiation was found effective for enhancing grain yield (1270–1420 kg/ha) of lathyrus.

Microbiology

- An acid tolerant *Rhizobium* strain VMC (Vamban) expressed potential under field conditions
- Multifunctional rhizobacteria LPGR-16 (Ludhiana), PPFM(Coimbatore) and PUK-171 showed maximum grain yield in mungbean.
- Nutrient mobilizing rhizobacteria PNm2 (Pantnagar) outperformed other strains.
- Five rhizobacteria exhibiting potential functionality traits at 20^{0}C have been isolated.
- The nutrient mobilizers PNM1 (Pantnagar) and VNM1 (Varanasi) outperformed other rhizobacteria.
- New effective rhizobial isolate LRP3 has shown promise w.r.t symbiotic traits and yield.

Plant Pathology

Mungbean

- Entry VBG 16-055 showed multiple resistance against MYMV, ULCV, leaf curl virus, web blight, CLS, Powdery mildew and macrophomina blight during *Kharif*.
- Entries VGG 17-09, VGG 19-048 and LGG 630 showed multiple resistance to MYMV, leaf curl virus and urdbean leaf crinkle virus during *Rabi*.
- Seed treatment with imidacloprid 5g/kg seed followed by foliar spray of Tebuconazole 50%+Trifloxystrobin 25%wg @0.75g/lit on initial appearance of disease was highly effective against foliar fungal diseases.
- Entry SML 1906 showed highly resistance reaction to MYMV in national nursery.

Urdbean

- Entries PU 14-28, PU 15-41 and SBC 50 showed multiple resistance to MYMV, leaf crinkle , leaf curl, root rot and web blight during *Kharif*.
- The entries IPU 17-02, TBG 129, and VBG 12-110 showed multiple resistance to MYMV, leaf crinkle, leaf curl and CLS during *rabi*.
- Entries PU 1625, PU 1634, PU 1603, PU 1608, PU 1619, and PU 1626 showed highly resistance reaction to MYMV in national nursery

Lentil

- Entries PL-7, PL-254, PL-279, DPL-62 and VL-531 showed multiple resistances to rust and *Ascochyta* blight at all locations.
- Fungicides propiconazole and tebuconazole were effective for lowering the disease severity of rust and increasing the yield.

Fieldpea

- The entries Pant P 426 & Pant P 436 were moderately resistant at all the test locations .
- Entries, IPF 17-19, Pant P 426, IPF 18-14, IPF 5-19, IPF 99-125 and IPFD 2018-8 showed resistance reaction to powdery mildew at all the locations.
- Entry Pant P 426 showed multiple resistance against rust and PM at all locations.

Rajmash

- All the entries showed resistance reaction to BCMV, collar rot and leaf crinkle virus at all locations but RKR 1033, HUR137, and HUR 15 were susceptible to BCMV at Gwalior

Nematology

Mungbean

- SKNM 1504 was moderately resistant against *M. javanica* at all the locations.
- COGG 912, HUM-1, IPM 02-3, JAUM 0936, MH

1142 and RMB 12-07 were found moderately resistant against *M. incongita* at RAU, Pusa.

- Occurrence of root knot nematodes was 75% at Tonk and Asalpur and 33.3% at Chocmmu on mungbean/urdbean.

Urdbean

- VBG 12-034 gave moderately resistance reaction against *M. incognita* and *M. javanica* at RAU, Pusa and RARI, Durgapura, respectively.
- Entries PU 14-19 gave moderately resistance reaction against *M. javanica* at all the locations.

Lentil

- One lentil entry, LL 1427 gave resistance reaction against *Meloidogyne incognita* at one location and moderately resistance reaction at two out of five locations. Five lentil entries L 4757, IPL 233, IPL 234, JL 3 and LL 1427 were found moderately resistant to *M. javanica* at two out of three locations.

Fieldpea

- Two fieldpea entries, HUDP 1715 and IPF 17-19 were found moderately resistant against *M. incognita* at three out of five locations. Three fieldpea entries Pant P 399, RFP 2010-3 and RFPG 114 were found moderately resistant against *M. javanica* at two out of three locations.

Entomology

Mungbean (*Kharif*)

- Mungbean entries IPM 2-14 and MH 1142 were found promising against whitefly at Ludhiana. The entries SML 1901, JLM 707-5 and MH 1142 found promising against pod borer.
- In advance stage screening, entry IPM 2-14 and ML 2037 were identified promising against stem fly and the entries IPM 2-14, ML 2312 and DGG 1 against pod borer at Vamban.
- The seed treatment with Imidacloprid 600FS @ 5 ml/kg seed followed by foliar application of either Clothianidin 50 WDP 25 gm ai/ha or Pyriproxyfen 10 EC @ 110 g ai/ha was found effective against thrips.
- Evaluation of newer insecticide molecule against pod borer complex indicated that application of Chlorantraniliprole 18.5 SC @ 20g ai/ha at 50 per cent flowering stage of crop was effective against pod borer complex.
- The IPM modules comprises seed treatment, tall growing millet crop @ 2 thick row around the field as barrier crop, monitoring with yellow sticky trap @ 50 per ha, NSKE 5% spray on appearance of whitefly and need based application of diafenthiuron 50 WP @ 312.5 ai per ha/acetamiprid 20 SP @ 20g ai/ha rotation at 10 days intervals are found effective in reducing insect-pests incidence and giving more yield and net return.

Mungbean (*Rabi*)

- In rabi season, mungbean genotypes were screened at Lam and Berhampur against sucking insect pests and pod borer. The entries CO 6(Ch.) VGG 17-002 and VGG 17-048 were found promising.

Urdbean (*Kharif*)

- Thirty four entries were screened at ten locations and a lot of variation across location was observed. The entries PU-14-28 ,PU 14-19,Pant U 31,IPU 94-1,AKU 1608,GJU 1509,KU 479 and KPU 1720-140 were found promising at most of locations.
- In advance stage screening, entries KUG 673, DKU-11, AKU 11-8 and KUG 717 were found promising.
- Evaluation of newer insecticide molecule against pod borer complex indicated that application of Chlorantraniliprole 18.5 SC @ 20 g ai/ha at 50 per cent flowering stage of crop found effective against pod borer complex on urdbean.

Urdbean (*Rabi*)

- The fifteen entries of urdbean screened at Berhampur and Lam against sucking insect pests and pod borer, the entries VBG 12-110,LBG 904 and LBG 752 (Ch.) were found promising.

Lentil

- The lentil entries Pant L-8 (PL 063), L 4717, L 4751, L 4147, IPL 237, VL156, VL 157, RL 11, RKL 16-304, RVL 17-11, JL 3, WBL 77 and L 4727 found promising against aphid.
- Selection of tolerant varieties, seed treatment, intercrop with mustard, NSKE 5% spray at 40 DAS followed by spray of either indoxacarb @ 50g a.i./ha or rynaxypyr @ 20 g a.i./ha or spinosad 45 SC @ 73g a.i./ha at 50% flowering stage increased in yield lentil and reduced the insect incidences and gave maximum cost benefit ratio.
- Development of forecasting modules against insect pests indicated that maximum and minimum temperatures as well as wind speed had significant positive correlation with the aphid population and maximum and minimum relative humidity had non-significant negative correlation and bright sunshine hour had non-significant positive correlation with the aphid population at Mohanpur.

Fieldpea

- Management of black cutworm *Agrotis ipsilon* at Shillongani indicated that 34.82% increase in yield by application of mustard oil cake @30 kg/ha at the time of sowing, followed by mulching with rice straw after sowing.

Rajmash

- Entries Tripura Rajmash 1 and HUR 137 found promising against aphid and pod borer at SK Nagar.

Lathyrus

- Evaluation of biorationals against insect pests of lathyrus indicated that dusting of ashes of crop residues and fine sand @ 25+5=30 kg/ha at the time of pests appearance was quite effective in reduction of insect pests incidence and gave maximum yield.

Frontline Demonstrations

Mungbean

- Package technology in *kharif* witnessed 19.69 per cent higher grain yield and 23.09 per cent increment in net returns over local farmers practices.
- Adopting package technology in *Rabi* accomplished 50 per cent increase in grain yield along with 42 per cent monetary advantage.

Urdbean

- Package technology in *Kharif* depicted 19 per cent higher grain yield and 22 per cent increase in terms of monetary benefit over local practices.
- In *Rabi* urdbean, 34 per cent yield advantage was obtained and 38 per cent increase in net returns through package technology adoption.

Fieldpea and lentil

- A total of 150 frontline demonstrations were conducted with full technology packages in lentil and fieldpea which resulted in 32% and 27 % increase in yield, respectively. With the adoption of improved technologies, there was net monetary benefit of 33% and 37% in lentil and fieldpea cultivation, respectively.

Arid Legumes

Crop Improvement

Varieties Released

Bilasa Kulthi-1 (BSP 15-1): This variety has been developed through selection from landrace collected from Bilaspur district. The seed coat colour is black. It matures in 100-107 days. It is shattering tolerant and suitable for rainfed condition. The average yield is 900-1000 kg/ha, tolerant to cercospora, leaf blight and dry root rot under field conditions.

Varieties Identified

PGCP-24 (Pant Lobia-7): This variety has been developed from a cross PGCP-12 x PGCP-13 and identified for northern part of the country for spring/summer season. Plant is bushy type with broad and dark leaves. It matures in 70-75 days. The 100 seed weight is 12.5 g. It's average yield is 1100-1200 kg/ha and resistant to cowpea mosaic virus disease. Protein content is 27%.

Promising Entries

Based on 2018-19 yield data, the following entries out yielded the best check. The mean yield (kg/ha) of promising entries as well as check has been indicated in parenthesis

S. No.	Crop	Trial	Zone	Genotype
1	Cowpea	IVT	South	MC 17-2 (1125), PCP 1131 (1061), DC 15 (ch) (1036)
2	Cluster bean	IVT		RGr 18-1(1105), CAZG 1612 (1085), RGC 1066 (1033)
3.	Horsegram	AVT-I	North	BSP 17-2 (937), BSP 17-1 (930), BSP 17-3 (904), ATPHG 11 (846), VLG 15 (ch) (774)
		IVT	South	CRHG 29 (908), CRHG 22 (892)

Breeder Seed Production

In case of four Arid Legume Crops, BSP indent of 253.19 q was received. Total of 281.16 q of breeder seed was produced. In case of Clusterbean, 205.27 q of breeder seed was produced against the DAC indent of 185.74 q and allocation of 207.35 of 16 varieties. In case of cowpea, an indent of 22.75 q of 7 varieties was received and 23.00 q of breeder seed was produced. In case of Moth bean, DAC indent of 29.80 q of 5 varieties was received and 30.51 q of breeder seed was produced. In case of Horse gram, indent of 14.90 q of 6 varieties was received. Total 22.38 q of Breeder seed was produced.

Production Technologies:

Eight coordinated trials/experiments on agronomical aspects were planned on clusterbean and cowpea at different centres during 2018–19.

During the "Agronomic evaluation of promising genotypes of cowpea" (Medium to long duration) was conducted at GKVK, Bangalore the results of the experiment indicated that no significant difference was observed between the two varieties, spacing and nutrient doses. However, the spacings 45 x 10 cm (1489.20 kg/ha) has recorded higher seed yield over 30 x 10 cm (1438.47 kg/ha) and the nutrient dose application of 125% RDF (1444.02 kg/ha) recorded higher seed yield than 100 % RDF (1429.89 kg/ha).

At PRSS, Samba, one season study indicated that irrespective of the spacing and nutrient applications the variety PL-1 (1230 kg/ha) recorded significantly higher seed yield as compare to PL-3 (1062 kg/ha). The spacing of 45x10 cm recorded higher seed yield of 1236 kg/ha whereas nutrient application of 125% recorded higher seed yield of 1256 kg/ha as compared to 100% RDF.

While assesly "Enhancing resource use efficiency and productivity in cowpea" at RSKV, Gwalior, results showed reducing 25 % Plant population gave significantly higher seed yield (1350 kg/ha), net monetary return (₹ 65602/-ha) and B:C ratio (4.37) over all the treatments followed by application of FYM @ 2.5 t/ha.

Studies on "Enhancing resource use efficiency and productivity in clusterbean" conducted at RARI, Durgapura, CCSHAU Hisar and ARS, Bhilwara with following treatments.

At Durgapura, results of last three years recommended at national level and during *Kharif*-2018 revealed that pre- emergence application of Pendimethalin @ 0.75 kg a.i./ha + one intercultivation at 20-25 DAS resulted in seed yield (11.48 q/ha) and straw yield (54.07 q/ha) was statistically significantly superior over T_1, T_2, T_3, T_4, T_6, T_7 and weedy check.

T_1	One Intercultivation at 20-25DAS	T_6	T2+T3
T_2	Pendimethalin @ 0.75 kg a.i./ha as PE	T_7	T2+T4
T_3	Imazethapyr @ 40g a.i./ha at 2-3 leaf stage of weeds	T_8	Weed free check
T_4	Imazethapyr+ Imazamox@ 40g a.i./ha at 2-3 leaf stage of weeds (IP)	T_9	Weedy Check
T_5	T2+T1		

At Hisar, highest seed and straw yield were recorded with treatment T_{10} (weed free check) which was on par with T_3 (Imazethapyr @ 40 g *a.i.*/ha at 2-3 leaf stage of weeds), T_4 (Imazethapyr @ 70 g *a.i.*/ha at 2-3 leaf stage of weeds), T_5 (Imazethapyr + Imazamox @ 40 g *a.i.*/ha at 2-3 leaf stage of weeds), T_7 (Pendimethalin @ 0.75 kg *a.i.*/ha as PRE + 1 Intercultivation at 20-25 DAS), T_8 (Pendimethalin @ 0.75 kg *a.i.*/ha as PRE + Imazethapyr @ 40 g *a.i.*/ha at 2-3 leaf stage of weeds) and T_9[Pendimethalin @ 0.75 kg a.i./ha as PRE + {Imazethapyr + Imazamox @ 40g *a.i.*/ha at 2-3 leaf stage of weeds (improved practice)}].The maximum net returns (₹ 14857/ha) and BC ratio (1.65) were recorded with T_4 (Imazethapyr @ 70 g *a.i.*/ha at 2-3 leaf stage of weeds) followed by T_8.

A study on Integrated weed control in cowpea and it's phytotoxic effect on succeeding crop was conducted at RARI, Durgapura and on the basis of three years data, it is recommended that Pre-emergence application of Pendimethalin @ 0.75 kg a.i./ha PE + one intercultivation at 20 – 25 DAS resulted in seed yield (417 kg q/ha) and stover yield (1296 kg/ha) was statistically significantly superior over T_1, T_2,T_3, T_4 ,T_6,$T_7$and weedy check.

Experiment "Nutrient management in legume based cropping system under conservation agriculture (clusterbean –wheat cropping system) was conducted at Gwalior centre and results revealed that significantly higher clusterbean seed yield (1650 kg/ha), net return (₹ 44867 /ha) were obtained with conventional tillage + residue retention @ 3 t/ha followed by Minimum Tillage + residue retention @ 3 t/ha. Whereas free nutrient management, the higher clusterbean seed yield (1649 kg/ha), net return (₹ 51562 /ha) were recorded with the application of 75% RDF, which was at par with 100% RDF.

In case of wheat crop, significantly higher wheat seed yield (5127 kg/ha), net return (₹ 82939 /ha) were obtained with Conventional Tillage + residue retention @ 3 t/ha followed by conventional tillage. For nutrient management, higher wheat seed yield (5661 kg/ha), net return (₹ 99250 /ha) and B: C ratio (4.46) was recorded with application of 75% RDF, which was at par with 100% RDF.

Crop establishment method and weed control practices in clusterbean" was conducted atstudies RSKV Gwalior and RARI Durgapura. At Gwalior, significantly higher clusterbean seed yield (1652 kg/ha), net return (₹ 51800 /ha) and B:C ratio (3.81) were obtained with Broad bed sowing method. Whereas weed control practices, the higher clusterbean seed yield (1670 kg/ha), net return (Rs.53165 /ha) and B:C ratio (3.99) were recorded with the application of Pendimethalin 30 % + imazethapyr 2% @ 1000 g/ha as PE, which was at par with Imazethapyr @ 40 g a.i/ha as PoE.

At Durgapura, seed yield (798 kg/ha) with broad bed sowing which was statistically significantly superior over T_1, T_2, and at par with zero tillage sowing with mulch. Secondly weed control practices in clusterbean the highest seed yield was recorded with Pendimethalin 30% + imazethapyr 2% @ 1000 g/ha PE which was statistically significantly superior over other treatments of weed management.

"Integrated nutrient management in clusterbean/cowpea" studted at RARI, Duragpura and GKVK, Bangaluru. revealed that 100% RDF + seed treatment with *Rhzobium* + PSB + 1% 19:19:19 spray resulted in seed yield (1259 kg/ha) and Straw yield (2944 kg/ha) was statistically significantly superior over other treatments of nutrient management .

At Bangalore, 100% recommended dose of fertilizer with *rhizobium* and PSB seed treatment also along with Foliar spray of WSF 19:19:19 @ 1% at vegetative stage recorded significantly higher yield (1519 kg/ha), net returns (₹ 19220) and B:C ratio (1.73). However, it was found at par with 100 % RDF +seed treatment + 2 % urea spray @ 1% at vegetative stage (1472 kg/ha) and 100% RDF + seed treatment with *Rhizobium* + PSB (1413 kg/ha).

Plant Pathology

Evaluation of genotypes of arid legumes under different coordinated trials against important diseases

Clusterbean

Fourteen entries in IVT (N+S) were evaluated against important diseases *viz*; bacterial blight and root rot of cluster bean at ARS, Bikaner, SDAU, S.K. Nagar, CCSHAU, Hisar and RARI, Durgapura under field condition.

At Bikaner, all the entries were highly resistant (HR) to susceptible (S) against bacterial blight disease. However, six entries *viz*; HG 2-20 (ch), RGr 18-1, RGr 18-6, RGr 18-11, GC- 1609 and RGr 18-3 were found highly resistant against bacterial blight. Rest of the entries was found resistant to moderately resistant against disease. Maximum intensity of bacterial blight was recorded in CAZG 17-4 (21.67%) followed by GAUG 1612 (18.34 %) and X-16 (16.67 %). Root rot incidence was also observed and found that the disease incidence ranges from 0.00 to 8.33%. One entry *i.e.* GC-1609 was found free from root rot. However, rest of the entries were found highly resistant against root rot disease.

At S.K. Nagar, all the entries were found highly resistant against BLB. At Hisar, seven entries *viz*; RGC-1033 (ch), HG 2-20 (ch), RGr 18-6, GC-1609, CAZG 16-12, RGr 18-8 and CAZG-17-4 were found highly resistant.

At RARI Durgapura, seven entries *viz*; HG 2-20 (ch), RGr 18-11, CAZG 16-12, RGr 18-3, GAUG-1305, GAUG-1612 and CAZG-17-4 were found moderately resistant against BLB. Root rot incidence was also recorded and found that the eight entries *viz*; RGr 18-6, RGr 18-11, CAZG 16-12, X-16, RGr 18-3, GAUG-1305, GAUG-1612 and CAZG-17-4 were found free from disease.

Cowpea

Twenty six entries of AVT-1 and IVT trials were evaluated against important diseases of cowpea at ARS Bikaner, SDAU, S.K. Nagar and RARI, Durgapura.

At ARS Bikaner, it was observed that root rot incidence ranged from 0.00 to 26.67 %. Eight entries *viz*; VCP 14001, VCP 14005, PTBCP-5, TPTC 29 (ch), DC-15 (ch), PCP 0306 (ch), Phule PCP-1123 (AVT-1) and PGCP-67 were found free from root rot. However, eleven entries *i.e.* RC 101 (ch), GC 3 (ch), VCP 13-001 (AVT-1), CPD-293, MC 17-1, MC 17-2, GC -1603, PCP-1118, PCP-1131, VCP 12006 and Pant Lobia-4 (ch) were found highly resistant against root rot disease.

At S.K. Nagar, all entries were found highly resistant against cowpea yellow mosaic virus and *Cercospora* leaf spot disease. At RARI Durgapura, thirteen entries *viz*; VCP13-001(AVT-1), CPD-302, MC 17-1, MC 17-2, PCP-1118, PCP-1131, VCP 12006, VCP 14005, TPTC 29 (ch), DC-15 (ch), PCP 0306 (ch), PGCP-67 and PGCP-68 were found moderately resistant.

At IIPR RS, Dharwad, out of twenty four entries tested, only one entry GC-1603 was found free and one entry DC-15 (ch) was found moderately resistant against powdery mildew natural condition. Out of seventeen entries tested at Hisar, eleven entries *viz*; RC 101 (ch.), GC 3 (ch.), VCP 13-001(AVT-1), VCP 12-005(AVT-1), CPD-293, MC 17-2, GC-1603, VCP 12006, VCP 14001, VCP 14005 and SKAU-C-407 were found highly resistant against CYMV in natural condition.

Mothbean

Nine entries of mothbean in IVT trial were evaluated against important diseases *viz*; mungbean yellow mosaic virus and root rot under field condition at ARS, Bikaner, SDAU, S.K. Nagar and CCSHAU Hisar.

At Bikaner, seven entries *viz*; RMO 225 (ch), RMO 257 (ch), CZM 2 (ch), RMO 3-5-70, VMB 101, MBS 803 and MBS 605 were found highly resistant against MYMV. The maximum intensity of MYMV was recorded in RMO 4-1-6-09 (11.67 %). Root rot incidence ranged from 0.00 to 13.33 %. One entry (MBS-803) was found free from root rot disease. However, five entries (RMO 225 (ch), RMO 257 (ch), CZM 2 (ch), RMO 3-5-70 and VMB 102) were found highly resistant against root rot disease.

At S.K. Nagar, all entries showed highly resistant reaction against both the diseases. At Hisar, five entries *viz*; RMO 225 (ch), CZM 2 (ch), RMO 3-5-70, VMB 101 and VMB 102 showed highly resistant reaction against MYMV disease.

Horsegram

At S.K. Nagar, total twenty entries of horsegram were screened against root rot disease in natural condition and all were found highly resistant against root rot disease

At IIPR RS, Dharwad, total eighteen entries of horsegram were screened against powdery mildew disease under natural condition and all the entries were found highly susceptible.

Evaluation of promising genotypes of cowpea for resistance against dry root rot under artificial inoculation condition

At Gwalior centre, all twenty six entries of cowpea were evaluated against dry root rot under artificial inoculated condition. It was observed that dry root rot incidence ranged from 8.44 to 45.08 %. No entry was found free or highly resistant against dry root rot. However, two entries *viz*; PGCP-67 and PGCP-68 were found resistant and fourteen entries *viz*; RC 101 (ch), GC 3 (ch), CPD-293, CPD-302, MC 17-1, GC -1603, PCP-1118, PCP-1131, VCP 12006, SKAU-C-407, DC-15 (ch), PCP 0306 (ch), Phule PCP-1123 (AVT-1) and Pant Lobia-3 (ch) were found moderately resistant against root rot disease.

At Pattambi centre, total twenty six entries of cowpea were evaluated against important diseases. Out of these, only three entries *viz*; VCP 12-005 (AVT-1), MC 17-2 and Pant Lobia-4 (ch.) were found free from anthracnose disease. However, only one entry Phule PCP-1123 (AVT-1) was found highly resistant and three entries {GC-3 (ch), MC 17-1 and PCP-1118} were found resistant. As far as collar rot is concerned, seven entries *viz*; VCP 12-005 (AVT-1), MC 17-2, PCP-1131, VCP 12006, VCP 14005, PTBCP-5 and TPTC -29 (ch) were found free from disease. However, five entries {RC 101 (ch), CPD-293, MC 17-1, SKAU-C-407 and Pant Lobia-4 (ch)} were found highly resistant against disease.

Management of root rot/stem rot of cluster bean through local isolated bio-agents

This experiment was conducted at ARS, Bikaner & SDAU, S.K. Nagar and RARI, Durgapura.

At ARS, Bikaner, results showed that all the bio-agents were found significantly superior in reducing the root rot disease over control during both the years as well as in pooled results. However, in both the individual years as well as in pooled results, the minimum root rot disease incidence was recorded in the treatment combination of *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) followed by *T. harzianum* seed treatment 8 g/kg seed + soil application of *T. harzianum* 2.5 kg in 100 kg FYM/ha. In pooled data, the minimum root rot incidence 6.17 % was recorded in the treatment T_4 *i.e.* treatment combination of *T. harzianum* + *P. fluorescens* seed treatment 4+4 g/kg seed + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) followed by treatment T_2 *i.e.* *T. harzianum* seed treatment 8 g/kg seed + soil application of *T. harzianum* 2.5 kg in 100 kg FYM/ha (8.83%). The results pertaining to grain yield of cluster bean revealed that the maximum grain yield 16.52 q/ha was recorded in the same seed treatment with combination of *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) followed by *T. harzianum* seed treatment 8 g/kg seed + soil application of *T. harzianum* 2.5 kg in 100 kg FYM/ha (15.44 q/ha).

At S.K. Nagar, results showed that all treatments were found effective against root rot disease of cluster bean over control. Treatment combination *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha.) was found most effective among all treatments tested with disease incidence (2.36 %) was recorded in pooled. Maximum seed yield (550.33 kg/ha) was recorded in treatment T_2 *i.e. T. harzianum* seed treatment (8 g/kg seed) + soil application of *T. harzianum* (2.5 kg in 100 kg FYM/ha.) which was at par with treatment T_4 (550.00 kg/ha.).

At RARI, Durgapura, results revealed that all treatments were found effective against root rot disease over control. Treatment combination *T. harzianum*+ *P. fluorescens* seed treatment (4g + 4 g /kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25+ 1.25 kg in 50 kg FYM for each/ha) was found the most effective among all treatments tested with diseases incidence (4.67%). Maximum grain yield (8.82 q/ha) was also recorded in the same treatment.

Evaluation of native *Rhizobium* cultures on cowpea

This experiment was conducted during *Rabi* 2017-18 and 2018-19 at Pattambi centre. The two years mean data revealed that treatment T_9 (COA, TVM- released culture) followed by T_6. (COA, TVM -RH2) was found effective and gave maximum grain yield of 997.41 and 931.81 kg/ha, respectively

Entomology

Evaluation of genotypes in coordinated varietal trials

Cowpea

IVT entries of cowpea were screened against leaf hopper, pod borer and aphids at SKRAU, Bikaner; SDAU, S.K. Nagar and PARS, Pattambi

At Bikaner centre, the minimum incidence of leaf hopper was observed in Pant Lobia 4 (1.2 leaf hopper/leaf) followed by PCP 1131 (1.3 leaf hopper/leaf) and PGCP 68 (1.5 leaf hopper/leaf) however, in case of whitefly, it was minimum in Pant Lobia- 4 (1.0 whitefly/leaf) and VCP 12006 (1.0 whitefly/leaf) followed by CPD-293 (1.1 whitefly/leaf). The pod borer damage was minimum in GC 1603 (3.0%) followed by RC 101 (3.5%), PCP 1118 (3.8%) and PGCP-67 (4.0%).

At SK Nagar, the incidence of pod borer was minimum in PCP 1118(5.0%) followed by VCP-14005 (6.5%), GC-1612 (7.0%) and CPD-302 (8.0%). Rest of the entries showed the average incidence.

At Pattambi centre, no infestation of aphid was observed on GC-3, VCP-12-005, CPD 293, MC 17-1, MC 17-2, GC-1612, GC-1603, PCP-1118, VCP 12006, VCP 14001,VCP 14005, PTBCP-5 SKAU-C-407, TPTC-29, DC-15, PCP 0306, PhulePCP-1123, Pant Lobia-4, PGCP-67 and PGCP-68, however, minimum incidence of aphid was observed in RC 101 (3.33 aphid/leaf), PCP-1131(3.33 aphid/leaf) and Bidoli local (3.33 aphid/leaf).

Clusterbean

Fourteen IVT entries of clusterbean screened against major insect pest like leaf hopper and white fly at SKRAU, Bikaner and SDAU, S.K. Nagar centre.

At Bikaner centre, data revealed that the leafhopper population was minimum in CAZG 16-12 (1.4 leafhopper/leaf) followed by RGC-1066 (1.5 leafhopper/leaf) and GAUG-1612 (1.6 leafhopper/leaf). However, the whitefly population was minimum in RGC-1033 (1.1 whitefly/leaf), HG 2-20 (1.1 whitefly/leaf) followed by RGr-1811 (1.2 whitefly/leaf).

At SK Nagar centre, minimum population of leafhopper was observed in RGC1066 (0.36 leaf hopper/leaf) followed by RGr-18-11 (0.41 leaf hopper/leaf) and RGC-1033 (0.45 leaf hopper/leaf). However, whitefly population was minimum in RGr 18-11 (0.78 whitefly/leaf) followed by RGr-18-6 (0.89 whitefly/leaf) and HG 2-20 (0.89 whitefly/leaf).

Mothbean

Nine IVT entries of mothbean screened against major insect pest like leaf hopper and white fly At SKRAU, Bikaner and SDAU, S.K. Nagar centre.

At Bikaner centre, data revealed that the leafhopper population was minimum in RMO 225 (1.4 leafhopper/leaf) followed by CZM-2(1.5 leafhopper/leaf) and RMO 4-1-6-09 (1.5 leafhopper/leaf). However, the whitefly population was minimum in RMO 3-5-70 (1.2 whitefly/leaf) followed by CZM-2 (1.3 whitefly/leaf) and RMO-257 (1.03 whitefly/leaf).

At SK Nagar centre, minimum population of leafhopper was observed in VMB 102 (0.02 leaf hopper/leaf) followed by RMO 225 (0.22 leaf hopper/leaf) and RMO-257 (0.22 leaf hopper/leaf). However, whitefly population was minimum in VMB 102 (0.02 whitefly/leaf) followed by VMB-101 (0.20 whitefly/leaf) and RMO 4-1-6-09(0.20 whitefly/leaf).

Horsegram

At SK Nagar centre, the screening of 11 genotypes of IVT and 9 genotypes of AVT-1 was carried out against insect pests. The data revealed that in IVT the entry VLG 47 had minimum incidence of leaf hopper (0.89/leaf) followed by BSP 18-1 (0.91/leaf) and VLG-48 (0.96/leaf) however, in case of whitefly the minimum incidence was observed in VLG 47 (0.62/leaf) followed by BSP 18-1 (0.63/leaf) and VLG-15 (0.65/leaf). However, in AVT-1, the minimum incidence of leaf hopper was observed in VLG-15 (0.88/leaf) followed by BSP 17-2 (0.89/leaf) and

BSP 17-1 90.91/leaf), however, in case of whitefly the minimum incidence was observed in BSP 17-3 (0.29/leaf), VHG-15 (0.29/leaf) and VHG-935 (0.29/leaf).

Management of sucking pests of mothbean

This trial comprised of eight treatments *viz*., seed treatment with Fipronil 5% SC @ 4ml/kg of seed, seed treatment with Imidacloprid 600FS @ 5 ml/kg of seed, Foliar spray with Acetamiprid 20 SP @ 0.2 g/litre, Foliar spray with Thiamethoxam 25 WG @0.3 g/litre, seed treatment with Imidacloprid 600FS @ 5 ml/kg of seed + Foliar spray with Neem oil 10000 ppm @ 1 ml/litre, Seed treatment with Fipronil 5% SC @ 4 ml/kg of seed+ Foliar spray with Acetamiprid 20 SP @ 0.2 g/litre, Seed treatment with Imidacloprid 600FS @ 5 ml/kg of seed+ Foliar spray with Thiamethoxam 25 WG @ 0.3 g/litre and control was conducted at SKRAU, Bikaner and SDAU, S.K. Nagar .

At Bikaner, the analyses of pooled data of three years revealed that the minimum population of whitefly (0.81) and leaf hopper (1.01) was recorded in the treatment of seed treatment with Imidacloprid 600FS @ 5ml/kg of seed+ Foliar spray with Thiamethoxam 25 WG @ 0.3 g/litre and this treatment also gave maximum yield (10.24 q/ha) and net return (₹ 9744/ha) followed by seed treatment with Fipronil 5% SC @ 4 ml/kg of seed+ Foliar spray with Acetamiprid 20 SP @ 0.2 g/litre in which the white fly and leaf hopper population was (0.89 and 1.12/ leaf, respectively and yield was 9.98 q/ha and net return (₹ 9185/ha).

At S.K. Nagar, the analyses of pooled data of three years revealed that the minimum population of whitefly (0.63/leaf) and leaf hopper (0.71) was recorded in the treatment of Seed treatment with Imidacloprid 600FS @ 5 ml/kg of seed+ Foliar spray with Thiamethoxam 25 WG @ 0.3 g/litre and this treatment also gave maximum yield (818.79 kg/ha) and net return (₹ 13549/ha) followed by seed treatment with Fipronil 5% SC @ 4 ml/kg of seed+ Foliar spray with Acetamiprid 20 SP @ 0.2 g/litre in which the white fly and leaf hopper population was 0.87 and 0.92/leaf, respectively and yield was 755.21 kg/ha and net return (₹ 11,862.8/ha).

It is recommended that seed treatment with Imidacloprid 600FS @ 5 g/kg seed followed by one spray of Thiamethoxom 25WG @ 0.3 g/lt of water 30 DAS is effective and economical for the management of sucking pests in cluster bean (White fly and leafhopper).

Management of sucking pests of cluster bean

This trial was comprised of eight treatments T_1: Cow urine 5 % @ 50 ml/lit, T_2: NSKE 5% @ 50 g/lit., T_3: Neem leaf Extract 10% @ 100 g/lit, T_4: *Lantana camera* 10% @ 100 g/lit, T_5: *Azadiracht*in 1500ppm@ 4 gm/lit,T_6: *Beauveria bassiana* @ 4g/lit, T_7: *Lecanicillium lecani* @ 4 g/lit. and T_8: Control was carried out at SKRAU, Bikaner and SDAU, S.K. Nagar.

At Bikaner, minimum population of whitefly (1.61/leaf) and leaf hopper (1.91) was recorded in the treatment of T_2: NSKE 5% @ 50 g /lit followed by T_4: *Lantana camera* 10% @ 100 g/lit in which the whitefly and leaf hopper population was 1.70 and 1.96/leaf, respectively at 3 DAS. At 7 DAS, minimum population of whitefly (1.49/leaf) and leaf hopper (1.71) was recorded in the treatment of T_2: NSKE 5% @ 50 g /lit followed by T_5: *Azadiracht*in 1500 ppm@ 4gmllit in which the whitefly and leaf hopper population was 1.54 and 1.79/leaf, respectively. However, at 10 DAS, minimum population of whitefly (154/leaf) and leaf hopper (1.72) was recorded in the treatment of T_6: *Beauveria bassiana* @ 4 g/lit. followed by T_7: *Lecanicillium lecani* @ 4g/lit. in which the whitefly and leaf hopper population was 1.55 and 1.75/leaf respectively. The maximum grain yield was recorded in the treatment of NSKE 5% @ 50 g /lit.(1229 kg/ha) followed by *Beauveria bassiana* @ 4g/lit.in which the grain yield was 1225 kg/ha.

At S.K. Nagar, the bioefficacy result revealed that 3 days after spray (DAS) the foliar spray with NSKE 5%(T_2) , *Lantana camera* 10%(T_4), Azadiractin 1500 ppm (T_5) and *Beauveria bassiana* (T_6) were found significantly superior(0.11/leaf) in reducing the whitefly population ,.Whereas, 7 DAS only T_4 and T_6 maintained their significant superiority(0.00/leaf) as compared to others. However at 10 DAS, T_6 was significantly effective (0.11/leaf) as compared to rest of the treatments. The leafhopper population at 3 DAS significantly reduced (1.40/leaf) in T6 and was at par with T_2 and T_5. Seven DAS also T_6 (0.85/leaf) was found to be significantly better than rest of treatments and was at par with T_5. Treatment 6 maintained its significantly lead (2.16/leaf) even after 10 DAS and and was at par with T_2 and T_5. Significantly maximum (516.67 kg/ha) yield was also recorded again in T_6 and par with T_5

Management of spotted pod borer, *Maruca vitrata* (Geyer) on cowpea

At S.K. Nagar, foliar spray with Chlorantraniliprole 18.5 SC @ 0.3 ml/ litre (T_2) water was found significantly superior (7.28%) in reducing the pod borer damage in cowpea which was at par with treatments T_1(Foliar spray with Flubendiamide 480 SC @ 0.3 ml/ litre water) and T_3 (Foliar spray with Emamectin benzoate 5 SG @ 0.5 ml/ litre water). Significant and maximum (778 kg/ha) yield was also recorded in T_2 treatment.

Quality Characters

Clusterbean

- Mean Protein content was maximum in RGr 18-1 (29.13%).
- Mean value of carbohydrate content was maximum in the RGC 1066 (ch) (45.23%).
- Maximum mean endosperm content was observed in RGC 1066 (ch) (35.23%).

- Maximum mean gum content was observed in GAUG-1612 (30.93%).
- Maximum mean viscosity was observed in RGr 18-1 (3188 cp).

Cowpea

- Mean value of protein content was maximum in the VCP 14001 (26.29%)
- Trypsin inhibitor activity was minimum in PCP-1131 (1960 TUI/g).
- Minimum tannin content was observed in the VCP 14001 (0.341 mg/g).
- Phytic acid content was minimum in RC-101 (ch) (5.82 mg/g).

Horsegram

Initial Varietal Trial

- Mean protein content was maximum in the CRHG 29 (29.65 %).
- Trypsin inhibitor activity was minimum in AK 42(ch) (6685 TUI/g).
- Mean minimum tannin content was observed in the BSP 17-3 (5.95 mg/g).
- Phytic acid content was minimum in VHG 935 and CRHG 19(ch) (7.16 mg/g).

Mothbean

- Mean protein content was maximum in the VMB 101 (23.27 %).
- Trypsin inhibitor activity was minimum in VMB 102 (38 TUI/g).
- Mean minimum tannin content was observed in the MBS 605 (5.40 mg/g).
- Phytic acid content was minimum in VMB 102 (0.420 mg/g).

Frontline Demonstrations

Cowpea

Total 85 frontline demonstrations were allotted to seven centres. Eighty Four demonstrations were organized by six centres. Over all mean yield of high yielding varieties with improved technology was 692 kg/ha and yield of local practices was 576 kg/ha. 20.14 per cent increase in yield was recorded in demonstrations.

Horsegram

In horsegram, 65 Frontline Demonstrations were allotted to six centres. All centres implemented the programme and organized 71 FLD's. The average yield of demonstrations with improved practices was 647 kg/ha which was 17.64% higher than the yield of farmers practices (550 kg/ha).

Moth bean

In Gujarat state, SDAU, S.K. Nagar organized five demonstrations with improved Variety GMO 2 and recommended package of practices. The yield of high yielding variety and improved package of practices was 495 kg/ha which was 21.3% higher than the Farmers' practices. In Rajasthan, SKRAU, Bikaner organizined 40 demonstrations with newly released variety RMO 2251. Variety RMO 2251 with improved management practices gave average yield of 394 kg/ha as against the yield of 270 kg/ha in case of old/traditional varieties.

Tribal Sub Plan

Bhilwara organized the demonstration on all the three crops *i.e.* cowpea, guar and horse gram. In case of cowpea, 9 demonstrations were conducted with variety RC 101. Mean yield obtained in improved variety was 722 kg/ha which was 67.5 per cent higher than farmers variety (431 kg/ha). In case of *guar*, ARS, Bhilwara organized, 27 demonstrations with varieties RGC 1055 and RGC 936. The mean yield was 1043 kg/ha in case of improved variety against the yield 746 kg/ha in case of local variety. The per cent increase in yield was 39.8%, fifteen demonstrations with variety RGC 936 gave 37.3% higher yield (1016 kg/ha) against local variety (746 kg/ha). Another *guar* variety, RGC 1055 gave 1077 kg/ha of yield which was 44.37% higher than yield of the local variety (746 kg/ha).

This centre also organized 11 demonstrations on horsegram by giving the seed of varieties AK 53, AK 42 and AK 21. The mean yield of high yielding varieties was 441 kg/ha which was 86.8% higher than the yield of local variety (236 kg/ha). The highest yield of 509 kg/ha was obtained in case of variety AK 42.

In Chhattisgarh state, ARS, Bilaspur organized 40 demonstrations in tribal areas with improved variety Indira Kulthi-1. The mean yield of improved variety was 668 kg/ha. The yield of local variety/ practices was 534 kg/ha. In this way, farmers got 19.8 per cent higher yield by adopting new varieties and production & protection technologies.

Transfer of Technology

For effective dissemination of new pulse production technologies among farmers and other stakeholders, following training and extension activities were organized during April 2019 to December 2019.

Sl. No.	*Activity*	*Duration*	*No. of participants*
A	*Extension officers*		
1	Pulse Production Technology for Extension official sponsored by ***Sameti, Rahmankheda, Lucknow***	22-26 July, 2019	35
2	Integrated crop Management in Pulse Crops for Extension officials sponsored by ***MANAGE, Hyderabd, Telangana***	19-23 August, 2019	12
3	Model Training Course on Improved Pulse Production Technology for Enhancing Farmers Income for Extension official sponsored by ***Directorate of Extension, Ministry of Agriculture & Farmer Welfare, New Delhi***	02-09 September,2019	20
4	Training programme on Improved Technologies for Sustainable Pulse Production CFA Training Programme Sponsored by MANAGE, Hyderabad	10-24 October, 2019	14
B	*Farmers Training*		
5	Training programme on improved technologies for Pulses Production and Agricultural Management sponsored by ATMA, Gwalior, Madhya Pradesh	27-31 August, 2019	23
6	Training programme on improved technologies for Pulses Production crops sponsored by ATMA, Sitamarhi, Bihar	16-20 September, 2019	24
7	Training programme on Integrated crop Management in Pulses crops sponsored byMobile agriculture School and Sewa Sansthan, Ranchi, Jharkhand	04-06December, 2019	30
8	Training programme Pulse Production technology to improve farmers income sponsored by Pragya Gramothan Sewa Samiti, Fatehpur, Uttar Pradesh	19-20 December, 2019	36
9	Training programme Pulse Production technology to improve farmers income sponsored by ATMA, Singhbhumi, Jharkhand	23-27 December, 2019	25

Participation in Agril. Exhibition & *Kisan Mela*

Sl.no.	*Activity*	*Duration*	*No. of participants (Approx.)*	*Participants*
1	*Akhil Bhartiya Kisan Mela Evam Krishi Udyog Pradarshani* held at CSAUA&T Kanpur	16-19 October, 2019	1500	Farmers, Entrepreneurs, Extension Personnel
2	Farmers fair held at Agricultural Department, Ballia	22-26 November 2019	500	Farmers, Entrepreneurs, Extension Personnel

Exposure visit stakeholders from the different States of Country

	Activity	*Participants (Number)*	*Date*
Exposure visits at IIPR, Kanpur	Farmers of Unnao, U.P	22	18/07/2019
	Farmers of Jabalpur, M.P.	24	03/08/2019
	Farmers of Damoh, M.P.	42	04/08/2019
	Farmers of Jabalpur, M.P.	30	07/08/2019
	Farmers of vidisha, M.P.	15	07/08/2019
	Students Pacific Collage of Agriculture, Udaipur, Rajasthan .	18	29/08/2019
	Farmers of Satana, M.P.	33	09/09/2019
	Farmers of Guna , M.P.	19	09/09/2019
	Farmers of Umariya, M.P.	21	13/09/2019
	Farmers of Unnao,U.P.	15	20/09/2019
	Farmers of Fatehpur, U.P.	23	17/10/2019
	Students R.R.Inter Collage , Sultanpur , U.P	75	18/10/2019
	Farmers of Chandauli, U.P.	85	18/10/2019
	Farmers of Mirmanoor, M.P.	120	19/10/2019
	Farmers of Jabalpur, M.P.	22	04/11/2019
	Farmers of Datiya, M.P	24	19/11/2019
	Farmers of Sheopur, M.P.	08	19/11/2019
	Farmers of Vijaypur, Sheopur, M.P.	18	20/11/2019
	Farmers of Sidhi, M.P.	30	20/11/2019
	Farmers of Datiya, M.P	24	26/11/2019
	Farmers of Unnao,U.P.	40	02/12/2019
	Student of Banda.U.P.	41	02/12/2019
	Farmers of M.P.	36	03/12/2019
	Farmers of Barabanki,U.P..	50	10/12/2019
	Farmers of Tikamgarh, M.P.	54	10/12/2019
	Farmers of Fatehpur, U.P.	15	18/12/2019
	Farmers of Satana, M.P.	35	18/12/2019

Mera Gaon Mera Gaurav (My Village My Pride)

Under MGMG program various villages were visited in Fatehpur, Kanpur Dehat and Kanpur Nagar districts of Uttar Pradesh. The demonstrations on Chickpea, Field pea, lentil, Pigeonpea and Mungbean have been conducted for dissemination of technologies, enhancing the income and creating employment to the rural youth and women. Interactive meetings were organized with farmers, communication of pulse production technology advisories in the form of text message was done this was founded and received feedback on various aspects, distributed extension literature, monitoring of demonstrations in fields. Majority of farmers have been provided Farmer FIRST Diary literature. Farmers were also encouraged for adoption of summer mung bean for additional income in summer season. Farmers have been linked with different development agencies to get benefit of state and central government schemes. Farmers were also facilitated for marketing of produce through FPOs. Rural youth has been trained for seed production in pulses. Farmers were given training on crop and live stock to upgrade their and knowledge and skill. Farmer-scientist interaction and Field Day programmes have been organised to disseminated popular pulse production technologies among farming community. Entrepreneurial activities such as motivating and facilitating the rural youth was organised for establishment of Retail input outlets of agriculture pesticides seed and fertilizer inputs through home delivery marketing approach.

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Conference/symposia/workshop

Attended International Workshop on Agribusiness Trade at TERI School of Advanced Studies, New Delhi during NOV 14-15, 2019.

Attended IAC meeting of CRP-GLDC at Nairobi, Kenya during Nov. 25-29 2019.

Attended workshop on 'Million Farmers Schools in Uttar Pradesh: Evolution, Impact and Way Forward' at Lucknow, Utar Pradesh, during Sep 12, 2019.

Deo Man Mohan, Prasoonverma and C.S. Praharaj 2019. Physical and engineering properties of chickpea (Cicerarietinum L.) varieties for planter design (T-8/P-11). 13th International Conference on Development of Drylands(Converting dryland areas from grey to green) organized by IDDC and AZRAI held at ICAR-CAZRI, Jodhpur during Feb 11-14, 2019. p281(Abstract).

Hemant Kumar attended Annual group meet of AICRP of chickpea at Birsa Agricultural University, Ranchi during August 27-29, 2019.

Hemant Kumar, G.P.Dixit, A.K. Srivastava and N.P. Singh (2019). Simultaneous Selection Index for Yield and Stability for Desi Chickpea Genotypes in South Zone of India. “International Conference on Recent Advance in Statistics and Data Science for Sustainable Development and XXXIX annual convention of Indian Society of Probability and Statistics” during December 21-23, 2019 at Utkal Univerisity .

Kumar Rajesh, Shripad Bhat, C.M. Tripathi, P.Kumar, C.S. Praharaj and N.P. Singh 2019. Sustainable livelihood support of small holders farmers through crop and livestock enterprises under firmer first project in Uttar Pradesh. International Conference on Global initiatives for sustainable development: Issues and Strategies, Bangkon, Thailand, June 23-27, 2019, Pp. 27-29.

Kumar Rajesh, Shripad Bhat, C.M. Tripathi, P.Kumar, C.S. Praharaj and N.P. Singh 2019. Sustainable livelihood support of small holders farmers through crop and livestock enterprises under firmer first project in Uttar Pradesh. International Conference on Global initiatives for sustainable development: Issues and

Strategies (Lead paper) held at Bangkon, Thailand during June 23-27, 2019, pp. 27-29.

Kumar Narendra, C.P. Nath, K.K.Hazra and C.S.Praharaj 2019. Weed management in pulses in India: Historical persepecutives, accomplishments and way forward. In : International Seminar on Agriskills for convergence in research, industry and livelihood (ACRIL)" by The Crop and Weed Science Society Nov 28 to Dec 01, 2019, Kalyani, West Bengal , India, p. 22.

Narendra Kumar, CP Nath, KK Hazra and CS Praharaj. 2019. Weed management in grain legumes: issues and strategies. In Abstract (Oral presentation): 27th Asia Pacific Weed Science Society Conference-2019 on 'Weed Science for Sustainable Agriculture and Environment' at Kuching, Sarawak Malaysia during September 3-6, 2019. Pp. 72.

Praharaj C.S., PS & Head participated in a workshop on Impact Assessment of ICAR Technologies organized by ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi on 28.11.2019.

Praharaj C.S., PS & Head participated in 13th IMC meeting og ICAR-Indian Institute of Seed Research, Mau, Uttar Pradesh on 02.12.2019.

Praharaj C.S., PS & Head participated in Annual Group Meet of All India Coordinated Improvement Project on Chickpea held at BAU, Ranchi, Jharkhand during Aug 27-29, 2019 and presented Annual Progress report (PI of Agronomy) for 2018-19 and Technical Programme for 2019-20.

Praharaj C.S., PS & Head participated/presented ICAR-Indian Institute of Pulses Research Plan and Interventions in Annual Workshop and Planning Meeting of Inter-Institutional Colloborations on rice Fallow Characterization and Management at Krishi Bhawan, Bhubaneswar, Odisha organized by IRRI, Philiphines and Government of Odisha on September 09, 2019.

Praharaj C.S., PS & Head participated in First meeting of Core Committee on preparation of policy Document on Futuristic Crop (Pulses) Planning for 2030/2050 at NASC, New Delhi organized by IIFSR, Modipuram (U.P.) during May 14-15, 2019.

Rajesh Kumar attended MULLaRP Annual group meet on kharif Pulses being held at RARS, Lam, Guntur from 19-21 May 2019

Rajesh Kumar attended SFAC meeting at New Delhi on 10-11 May 2019-12-24

Rajesh Kumar attended state level Kharif Production Gosthi at Lucknow on 14.05.2019

Rajesh Kumar attended the Million farmers school workshop at lucknow on 12.09.2019

Rajesh Kumar attended Kisan Utpadakta Gosthi organized Agricultural Department at unnao on 26.09.2019

Rajesh Kumar attended meeting at project proposal submitted under SCSP, DST, New Delhi during 18-21Novemeber 2019

Rajesh Kumar attended 2nd international Conference on Global Initiatives for sustainable Development: issue and Strategies during June 23-27, 2019 held at Hotel Howard Square boutique, Bangkok, Thailand

Rajesh Kumar attended meeting related project proposal at UPCAR, Lucknow on 28.11.2019

Rajesh Kumar attended MULLaRP Annual group meet on kharif Pulses being held at RARS, Lam, Guntur from 19-21 May 2019

Rajesh Kumar attended SFAC meeting at New Delhi on 10-11 May 2019-12-24

Rajesh Kumar attended state level Kharif Production Gosthi at Lucknow on 14.05.2019

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Rajesh Kumar attended meeting related project proposal at UPCAR, Lucknow on 28.11.2019

Singh SK and C.S.Praharaj 2019. Pulses for nutritional security and ecological sustainability. National Seminar on Socio-digital approaches for transforming Indian Agriculture held during 20-22 November, 2019 at CCSHAU, Hisar, Haryana, pp 62-65.

Singh N.P. Director and C.S. Praharaj, PS & Head participated in a workshop on "Achievement and future strategy on pulses and oilseed production under Targeting rice fallow areas (TFRA) in Eastern India" at Taj Bengal Hotel, Kolkata-27, West Bengal organized by DAC & FW, MOA and FW, Government of India on Oct. 21, 2019.

Invitee Lecture 2nd international Conference on Global Initiatives for sustainable Development: issue and Strategies on June 23-27, 2019 at Hotel Howard Square boutique, Bangkok, Thailand

Invitee Lecture and Oral Presentation Award entitle sustainable livelihood support of small Holders farmers through Crop and livestock enterprises under Farmer FIRST in Uttar Pradesh, India during June 23-27, 2019

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Prepared documentary film on Farmer FIRST Project and released on foundation day.

Foreign visits:

Dr. Archana Singh visited Ethiopia (Oct. 9-12, 2019) for BMS training under BMGF project and Tanzania under NARS parterner visit cum training programme on Excellence in Breeding during Oct. 12-18, 2019.

Dr. Rajesh Kumar visited and attended 2nd international Conference on Global Initiatives for sustainable Development: issue and Strategies on June 23-27, 2019 at Hotel Howard Square boutique, Bangkok, Thailand

Dr Narendra Kumar, PS participated and presented a paper on "Weed management in grain legumes: issues and strategies"at the 27th Asia Pacific Weed Science Society at Kuching, Sarawak, Malayasia during September 03-06, 2019 organized by Asia Pacific Weed Science Society.

Papers presented

Kodandaram MH, Revanappa B, Sabale PR and Venkatesh MS 2019. Evaluation of cowpea genoptypes and biorational insecticides for management of legume pod borer, Maruca vitrata Geyer (Pyralidae: Lepidoptera) In: XIX International Plant Protection Congress (IPPC) on Crop Protection to Outsmart Climate Change for Food Security & Environmental Conservation. 10-14 November 2019, Hyderabad, Telangana, India. pp271.

Saabale PR, Jyotirmay Dubey, Manjunatha L, RK Mishra, Naimuddin, Revanappa, and NP Singh 2019. Chlorate phenotypes and molecular characterization of Rhizoctonia bataticola, the dry root rot pathogen of chickpea. In: XIX International Plant Protection Congress (IPPC) on Crop Protection to Outsmart Climate Change for Food Security & Environmental Conservation. 10-14 November 2019, Hyderabad, Telangana, India.

Technical Folders

PR Saabale, Revanappa, Manjunath L Kodandaram, Venkatesh, Nikhil, Pawan shinde, Guljar and Channamma 2019. Major diseases of chickpea and their integrated management.

Venkatesh MS, Ganajaxy math, Revanappa SB, Saabale, Kodandaram MH, Sudhavati D, Guljar ID, Pawan Shinde, Channamma Kamati, Suma, Gurupad and Nikhil Mohite 2019. Hurali Beleya Besaaya Kramagalu (Horsegram cultivation practices in Kanada).

Venkatesh MS, Ganajaxy math, Revanappa SB, Saabale PR, Kodandaram MH, Sudhavati D, Guljar ID, Pawan Shinde, Channamma Kamati, Suma, Gurupad and Nikhil Mohite 2019. Alasandhi Beleya Besaaya Kramagalu (Cowpea cultivation practices in Kanada).

Venkatesh MS, Ganajaxy math, Revanappa SB, Saabale PR, Kodandaram MH, Sudhavati D, Guljar ID, Pawan Shinde, Channamma Kamati, Suma, Gurupad and Nikhil Mohite 2019. Hesaru mattu uddina Beleya Besaaya Kramagalu (Greengram and blackgram cultivation in Kanada).

Venkatesh MS, Ganajaxy math, Revanappa SB, Saabale PR, Kodandaram MH, Sudhavati D, Guljar ID, Pawan Shinde, Channamma Kamati, Suma, Gurupad and Nikhil Mohite. 2019. kadale Beleya Besaaya Kramagalu (Chickpea cultivation practices in Kanada)

Technical Bulletin :

Bohra A, Singh IP, Satheesh Naik SJ, Patil PG, Mishra RK, Singh F, Datta S, Das A, Singh NP (2019). Hybrid Technology for Pigeonpea Improvement, ICAR-Indian Institute of Pulses Research, Kanpur

Arhar Ki Unnat Kheti, Mung Ki Unnat Kheti and Urd Ki Unnat Kheti were published and distributed to farmers under Seed distribution programme under SC sub plan of Govt. of India.

Training and Capacity Building

Seminars/Training/Meetings etc. attended

- Dr. A. Pratap attended the Annual Review and planning meeting, UPCAR, Lucknow, April 12, 2019.
- Dr. A. Pratap attended the Annual Group Meet of AICRP on MULLaRP, ANGRAU, Lam, Guntur, May 17-18, 2019.
- Dr. A. Pratap attended the Review-cum-planning meeting of DBT project on minor pulses, NIPGR, New Delhi, May 19, 2019.
- Dr. A. Pratap attended the Project Review Meeting, CRP Molecular Breeding-Chickpea, ICAR-IARI, New Delhi, June 15, 2019.
- Dr. A. Pratap attended the Uttar Pradesh State Variety Release Committee meeting, Krishi Bhawan, Lucknow, July 10, 2019.
- Dr. A. Pratap attended the Uttar Pradesh State Variety Release Committee meeting, Krishi Bhawan, Lucknow, August 20, 2019.
- Dr. A. Pratap acted as the Expert, APART training programme, World Vegetable Centre, Guwahati, August 26, 2019.
- Dr. A. Pratap carried out the Roaming survey and collection of YMD samples, Bengaluru, Dharwad, Vamban and Coimbatore, August 27-31, 2019
- Dr. A. Pratap organized the Mungbean and mothbean field day, CAZRI, Jodhpur, Sept. 21, 2019.
- Dr. A. Pratap organized the Annual Group Meet of mungbean, urdbean and rabi/rice fallow pulses, AICRP on MULLaRP, BARC, Mumbai, Nov. 11-13, 2019.
- Dr. A. Pratap attended the Annual Review meeting, NICRA, NASC, Pusa, New Delhi, Dec., 17-18, 2019.
- Dr. Manjunatha L. participated 21 days winter school training programme on “Novel techniques in mass culturing of smart microbial biocontrol agents for the development of biopesticides” from 03 December 2019 to 23 December 2019 at ICAR-NBAIR, Bangalore, Karnataka
- Dr. Anup Chandra participated in a 10-day short course training programme on “Molecular Identification and DNA Barcoding of Insect-pests and Natural enemies including Invasive species” from 18th to 27th November 2019 at ICAR-NBAIR Bengaluru.
- Dr. Anup Chandra participated in a 2-day DST-SERB sponsored workshop on “Genotyping of Whitefly Species Complex and its Associated Endosymbionts” organized by Division of Entomology, IARI New Delhi on 5th & 6th December 2019.
- Dr. Kiran Gandhi B. participated XIX International Plant Protection Congress (IPPC 2019) on 'Crop protection to outsmart climate change for food security and environmental conservation' held from 10-14th November 2019 at Hyderabad, Telangana, India.
- Dr. Naimuddin participated National Conference on “Plant Health Management for Eco friendly and Sustainable Agriculture at CSA Kanpur U.P. dated on Nov, 25-26. 2019.
- Dr. Manjunatha L. participated XIX International Plant Protection Congress (IPPC 2019) on 'Crop protection to outsmart climate change for food security and environmental conservation' held from 10-14th November 2019 at Hyderabad, Telangana, India.
- Dr. Mohd, Akram participated National Conference on “Plant Health Management for Eco friendly and Sustainable Agriculture at CSA Kanpur U.P. dated on Nov, 25-26. 2019.
- Dr. R. Jagadeeswaran participated XIX International Plant Protection Congress (IPPC 2019) on 'Crop protection to outsmart climate change for food security and environmental conservation' held from 10-14th November 2019 at Hyderabad, Telangana, India.
- Dr. R.K. Mishra participated National Conference on “Plant Health Management for Eco friendly and Sustainable Agriculture at CSA Kanpur U.P. dated on Nov, 25-26. 2019.
- Farmer FIRST Project was awarded the “Best Team Award -2019” in the Institute Foundation Day on 05 September, 2019
- Distinguished Scientist Award was given for his outstanding contribution in the field of Agricultural Extension on the occasion of 2nd international Conference on Global Initiatives

for sustainable Development: issue and Strategies on June 23-27, 2019 at Hotel Howard Square boutique, Bangkok, Thailand

- Dr. M H Kodandaram and Dr. Revanappa attended Annual Group Meet of AICRP on MULLaRP and AINP-Arid Legumes at Lam Guntur held on 19-21 May 2019
- Dr. Revanappa and Dr. B Manu, attended germplasm field day on cowpea organised jointly by ICAR-NBPGR and UAS, Bengaluru on 16th October 2019, at UAS GKVK Campus, Bengaluru
- Dr. B Manu attended Group Meet on Mungbean, Urdbean, Cowpea and Guar for Spring, Summer & Rice Fallow Cultivation" during November 11-12, 2019 at BARC, Trombay, Mumbai
- Dr. B Manu attended germplasm field day on Horsegram organized by ICAR-NBPGR RS Ranchi on 10th December 2019, at UAS GKVK Campus, Bengaluru
- Dr. PR Saabale attended AICRP Pigeonpea Group Meet held at Kota University, Rajasthan from 25-27th May 2019.
- Dr. PR Saabale and Dr. Revanappa attended Monitoring of Arid Legume Breeding Trials at SDAU. S.K.Nagar, RARI, Durgapura from 11-14th October 2019.
- Dr. Yogesh Kumar & Dr. AK Srivastava, participated in Annual Group Meet of Chickpea from 27-29 August 2019 at BAU, Ranchi
- Dr. A Bohra, Dr. B Mondal and Dr. AK Srivastava attended the project Launch meeting of the ICAR-BMGF funded mega project on "Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops" on 25.01.2019 at NASC Complex, Pusa, New Delhi.
- Dr. A Bohra, Dr. AK Srivastava and Dr. B Mondal attended the Technical Workshop on Excellence in Breeding Platform and Breeding Management System under the ICAR-BMGF project "Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops"on 24-25 April, 2019 at IARI, New Delhi.
- Dr. A Bohra, Dr. Archana Singh and Dr Revanappa attended the Technical Workshop on Digitalization of Historical Data, Breeding Pipeline, Development of Product Profile and Breeding Management System under the ICAR-BMGF project "Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops" on 12-17th August, 2019 at ICRISAT, Hyderabad.
- Dr. A Bohra, Dr. AK Srivastava and Dr. B Mondal attended the Technical Workshop on "Breeding pipeline"under the ICAR-BMGF project "Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops" on 29th November, 2019 at IARI, Pusa, New Delhi.
- Dr. A.K. Parihar, Dr. D. Sen Gupta, Dr. J. Kumar and Dr. Basavaraja attended the Annual Group Meet of AICRP on "Rabi Pulses (MULLaRP crops)" on Sept 12-13, 2019 held at CAU, Imphal, Manipur
- Dr. J. Kumar attended the 3rd International Legume Society Conference on Legumes for Human and Plant Health, May 21-24, 2019, Poznan, Poland
- Dr A.K. Singh attended the Annual Group Meeting of AICRP on Pigeonpea during 25-27 May, 2019 and to present the Seed Hub Progress Report as Co-Nodal Officer at Kota Agricultural University, Kota (Rajasthan), India.
- Dr A.K. Singh attended the Annual Joint Annual Group Meeting of AICRP – National Seed Project (Crops) during 07-09 April, 2019 at CCS Haryana Agricultural University, Hisar (Haryana), India.
- Dr. A.K. Parihar attended Annual Group Meet on *kharif* pulses (2018-19) on AICRP on MULLaRP at ANGRAU, Lam, during May 19-21, 2019.
- Dr. A.K. Parihar attended Rabi Annual Group Meet on AICRP on MULLaRP at CAU, Imphal during September 12-13th 2019.
- Dr. A.K. Parihar attended Group Meet on Mungbean, Urdbean, Cowpea and Guar for spring, summer & rice fallow cultivation at BARC, Mumbai during November 11-12, 2019.
- Dr Basavaraja T. participated in one-day Germplasm Field Day on Lentil and Linseed

crop organized by NBPGR, New Delhi on 14th March, 2019

- Dr Basavaraja T. participated participated in Annual Group Meet on *Rabi* Pulses of AICRP on MULLaRP jointly organized by CAU, Imphal & IIPR, Kanpur on September 12-13, 2019 at CAU, Imphal
- Dr Shanmugavadivel PS attended 21 days ICAR sponsored CAFT course on "Nest generation sequencing and its application in crop sciences" at ICAR-NIPB, New Delhi from 03-09-2019 to 23-09-2019.
- Dr Sujayananda participated in 3rd National Workshop on "Applications of Electron Microscopy in Life Sciences" 16th to 18th July 2019 at CSIR-CDRI, Lucknow.
- Dr Neetu Singh Kushwah attended training on "CRISPR-Cas9 based precise genome editing" at CSIR-Institute of Genomics and Integrative Biology, New Delhi during April 8-12, 2019.
- Dr. Alok Das attended 8th Training cum Workshop for IBO, 20 September, 2019, NIPB, New Delhi
- Dr. Alok Das attended International Hands-On-Training on Genome Editing Technologies, 14-25 October, 2019, ICRISAT, Hyderabad
- Dr. Alok Das participated in Second Round of National Bio-Entrepreneurship Competition, 4-5 November, 2019, Regus Caddie, New Delhi
- Dr. Alok Das participated in Final Round of National Bio-Entrepreneurship Competition, 11-14 December, 2019, C-CAMP, Bengaluru
- Dr. Shallu Thakur attended 5-days Workshop on "Genome Editing in Plants" at University of Delhi South Campus, Dhaula Kuan, New Delhi on 27-31 May 2019
- Dr. Shallu Thakur attended 4 day Workshop on "Genome Editing mediated by CRISPR/Cas9; tools, experimental design and applications" NABI, Mohali, 2-5 Nov 2019.

Institutional building/support:

- Dr. Yogesh Kumar, Course-Coordinator of 'Model Training course' on "Contemporary approaches in quality seed production of pulse crops for enhancing productivity and nutritional security"sponsored by Directorate of Extension, Ministry of Agriculture & Farmers Welfare, New Delhi and organized by ICAR-IIPR Kanpur from 13-20 November 2019.
- Institute Research Council meeting was organized by Dr. A. Pratap as IRC Secretary on May 29 to June 01, 2019.
- Institute Research Council field visit for kharif season was organized by Dr. A. Pratap as IRC Secretary during Oct. 2-3, 2019.

Organization of meetings / events / seminar / symposia

- Dr. A. Pratap organized the Annual review-cum-planning meeting of ACIAR funded International Mungbean Improvement Network, Sept. 8-10, 2019 at Hotel Regenta Central: The Crystal, Kanpur.
- MTC training programme on Contemporary approaches in quality seed production of pulse crops for enhancing productivity and nutritional security was organized by Dr. A.K. Singh from 13-20 November, 2019 at IIPR, Kanpur.

Education and training:

- A training and Seed distribution programme under SC Sub Plan of Govt. of India was organized on 25th June 2019 at station. In view of coming *Kharif* season 2019, quality seeds of pigeonpea and urdbean with package of practices, proper training and exposure to about 430 farmers were distributed.

Awards/Recognition

Awards/Honors

- Dr. Aditya Pratap received Best Centre Award on behalf of ICAR-IIPR for outstanding contributions in development of high yielding varieties of greengram. The award was presented by Honorable Vice President Sh. M. Venkaiah Naidu, May 18, 2019 at ANGRAU, Lam, Guntur, Andhra Pradesh.

- Dr. A.K. Parihar was selected as Fellow of Indian Society of Genetics and Plant Breeding (ISGPB)
- Dr. A.K. Parihar was selected as Associate of the National Academy of Agricultural Sciences (NAAS).
- Dr. B Mondal received 'Young Scientist award' by Dr. Ramawatar Shiksha Samiti, UP, in the "Scientist Award Ceremony" organized in Lucknow University on 12.07.2019.
- Dr. Basavaraja received 'Young Scientist award' by Dr. Ramawatar *Shiksha Samiti*, UP, in the "Scientist Award Ceremony" organized in Lucknow University on 12.07.2019.
- Got Best presentation awards during National Symposium cum Zonal Meeting on 25-26 Nov, 2019 entitled Production of cell wall degrading enzymes by Trichoderma isolates and their biocontrol potential for the management of wilt of major pulses authored by Sonika Pandey, Monika Mishra, R.K.Mishra, Naimuddin and Bansa Singh.
- Got Best presentation awards during National symposium cum zonal meeting Dated on 25-26 Nov, 2019 at CSAUAT, Kanpur entitled "Identification, pathogenicity and characterization of Sclerotinia sclerotiorum (Lib.) de Bary causing stem rot disease of pulse crops authored by Mishra Monika, R.K. Mishra, Naimuddin, Sonika Pandey, K.B.M. Tripathi and Bansa Singh.
- Got Best presentation awards during National symposium cum zonal meeting on 25-26 Nov, 2019 entitled Influence of weather parameters on Wilt incidence of Pigeon Pea in Bundelkhand region of Uttar Pradesh authored by Mishra, R.K., Kul Bhushan Mani Tripathi, Monika Mishra, Sonika Pandey, Deepak Kumar, Uma Sah, Sanjay M. Bandi, Shripad Bhatt and Krishna Kumar (2019).
- Dr. R.K. Mishra got Best Scientist Award during 26th Foundation day of ICAR-IIPR, Kanpur on 05.09.2019.
- Farmer FIRST Project was awarded the "Best Team Award -2019" in the Institute Foundation Day on 05 September, 2019
- Distinguished Scientist Award for his outstanding contribution in the field of Agricultural Extension on the occasion of 2nd international Conference on Global Initiatives for sustainable Development: Issue and Strategies on June 23-27, 2019 at Hotel Howard Square Boutique, Bangkok, Thailand

Recognitions:

- Dr Narendra Kumar, PS received International Travel Grant by Science and Engineering Board, DST, GOI for attending 27th Asia Pacific Weed Science Society Conference-2019 on 'Weed Science for Sustainable Agriculture and Environment' at Kuching, Sarawak, Malaysia during September 3-6, 2019
- Dr Narendra Kumar, PS presented an Oral presentation on title 'Weed management in grain legumes: issues and strategies' in 27th Asia Pacific Weed Science Society Conference-2019 on 'Weed Science for Sustainable Agriculture and Environment' at Kuching, Sarawak Malaysia during September 3-6, 2019.
- Dr Narendra Kumar, PS, presented a Lead paper on title 'Weed management in pulses in India: Historical perspective, accomplishments and way forward' International Seminar on "Agriskills for Convergence in Research, Industry & Livelihood" at BCKV, Kalyani, West Bengal during November 28 – December 1, 2019.
- Dr Sujayanand, G.K. in December 2019 Pesticide Research Journal published by Society of Pesticide Science has awarded "Certificate of excellent contribution in reviewing".
- Dr. Neetu Singh Kushwah received ICAR Early Career Scientists support by The Institute for International Crop Improvement at the Donald

Danforth Plant Science Center for participation in the 7th Annual South Asia Biosafety Conference held at the Westin Dhaka, Bangladesh, from September 14-16, 2019.

- Mr. Aravinda K Konda received "Distinguished Scientist Award" for the year 2018, from the Society of Bioinformatics and Biological Sciences (SBBS), (R.No. 631/2014-2015) on April 5, 2019 at AKS University, Satna, Madhya Pradesh.
- Dr. Rajesh Kumar, Principal Scientist participated in the 2nd International Conference on Global Initiative for Sustainable Development: Issue and Strategies during 23-27 June 2019 at Bangkok, Thailand.

- Dr. C.S. Praharaj, P.S. and Head nominated as the Member of IMC for ICAR-Indian Institute of Seed Science, Mau, Uttar Pradesh for three years (2018-21)

Dr. C.S. Praharaj, P.S. and Head was nominated as a member of IMC for ICAR Indian Institute of Pulses research Kanpur, Uttar Pradesh for three years (2018-21).

Deputation abroad:

- K. Neetu Singh Kushwah, Scientist in Division of Plant Biotechnology received support from "The Institute for International Crop Improvement at the Donald Danforth Plant Science Center" to participate and present an Oral Paper on "Towards development of β-ODAP-free grass pea (*Lathyrus sativus* L.)" at the 7th Annual South Asia Biosafety Conference, Dhaka, Bangladesh during September 14-16, 2019.
- Dr. Shallu Thakur, DST INSPIRE faculty awardee in Division of Plant Biotechnology received the Jerome P. Miksche Travel Grant Award to attend PAGXVIII.

On-going Research Projects

DIVISION OF CROP IMPROVEMENT

S No.	IIPR Code	Mega Project/ SubProject	PI	Co-PI	Period
1.	CRSCIIPRSIL 201700100140	**Genetic enhancement of pulse crops for yield, stability and quality**	**Coordinator: Dr. Shiv Sewak**		**2017-20**
		Chickpea : SP 1: Breeding for yield enhancement in *Desi* chickpea	Dr. Yogesh Kumar	Dr. A.K. Srivastava Dr. L. Manjunatha	
		SP 2: Breeding for higher yield and enhance resistance against abiotic resistance in chickpea	Dr. A.K. Srivastava	Dr. U.C. Jha Dr. L. Manjunath	
		SP 3: Breeding for high yield and enhance resistance against abiotic stresses resistance in chickpea	Dr. U.C. Jha	Dr. Archana Singh Bhopal	
		SP 4: Improving seed protein content in chickpea	Dr. B. Mondal	Mr. Vaibhav Kumar	
		SP 5: Genetic enhancement of *Kabuli* chickpea for grain yield and seed size	Dr. Yogesh Kumar	Dr. Manjunatha	
		Pigeonpea : SP 6: Genetic improvement for yield and disease resistance in early duration pigeonpea	Dr. Dibendu Datta	Dr. Abhishek. Bohra	
		SP 7: Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance-medium maturing pigeonpea	Dr. Archana Singh Bhopal	Dr. P.K. Katiyar	
		SP 8: Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance-late maturing pigeonpea	Dr. Satheesh Naik, SJ	Dr. Farindra Singh	
		Mungbean : SP 9: Genetic enhancement for yield, stability and quality in mungbean	Dr. Aditya Pratap	Dr. T. Basavraj Dr. Revenappa Dharwad	
		SP 10: Development of high yielding, drought and heat tolerant mungbean [*Vigna radiata* (L.) R. Wilczek] genotypes for spring/ summer season in North India	Dr Manu B	Dr. Aditya Pratap, Dr. T.N. Tewari	
		Urdbean : SP 11: Genetic enhancement of pulses for yield and biotic stresses resistance in urdbean	Dr. P.K. Katiyar	Dr. Debjyoti Sen Gupta Dr. Revenappa-Dharwad Dr. Archana Singh Bhopal	
		SP 12: Biofortification for quality traits in urdbean (*Vigna mungo* L. Hepper) and lentil (*Lens culinaris* Medik.)	Dr. Debjyoti Sen Gupta	-	
		SP 13: Genetic improvement of urdbean (*Vigna mungo* L. Hepper) for abiotic stresses	Dr. Awnindra Kumar Singh	Dr. Debjyoti Sen Gupta, Dr. P.S. Basu, Dr. Revenappa	
		Lentil : SP 14: Genetic	Dr. Jitendra Kumar	Dr. Debjyoti Sen Gupta	

S No.	IIPR Code	Mega Project/ Sub-Project	PI	Co-PI	Period
		enhancement of pulse crops for yield, quality and stability: Lentil component			
		Fieldpea : SP 15: Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance: fieldpea	Dr. A.K. Parihar	Dr. R. K. Mishra	
		Cowpea : SP 16: Plant genetic resource management and genetic improvement in cowpea	Dr. A.K. Parihar	Dr. Revanappa B.	
2.	CRSCIIPRSIL 201700200141	**Plant genetic resources: Management and its utilization through pre-breeding**	**Coordinator: Dr. Farindra Singh**		2017-20
		Urdbean		Dr. P.K. Katiyar Dr. Debjyoti Sen Gupta	
		Pigeonpea		Dr. Debendu Datta Dr. Satheesh Naik SJ	
		Mungbean	Dr. Aditya Pratap	Dr. Revenappa B Dr. Baasavraje T	
		Lentil		Dr. Jitendra Kumar	
		Chickpea (Bhopal)		Dr. Archana Singh	
		Fieldpea		Dr. A.K. Parihar	
		Chickpea		Dr. B. Mondal	
		Rajmash PGR management and genetic enhancement for grain yield, quality and multiple stress resistance-Rajmash	Dr. T. Basavraj	Dr. L. Manjunath	
		Grasspea PGR Management and improvement of grass pea for low ODAP	Dr. Archana Singh	Dr. Neetu Singh Kushwah	
		Horsegram & Cowpea Management of plant genetic resources and genetic enhancement for grain yield and resistance to multiple diseases in cowpea and horse gram (2015-20)	Dr. Revenappa-Dharwad	Dr. M. H. Kodandaram	
3.	CRSCIIPRSIL 201700300142	**Seed production and quality enhancement**	**Coordinator: Dr. P.K. Katiyar**		
		SP 1: Impact of climatic variables (rainfall and elevated CO2) on seed quality of pulses	Dr. A. Lamichaney	Dr. P.K. Katiyar Dr. Kalpana Tiwari Mr. Alok Kumar	
		SP 2; To enhance field emergence of extra large seeded *Kabuli* chickpea	Mr. Alok Kumar	Dr. A. Lamichaney Dr. P.K. Katiyar	

DIVISION OF CROP BIOTECHNOLOGY (2)

S No.	IIPR Code	Mega Project/ Sub-Project	PI	Co-PI	Period
4	CRSCIIPRSIL 201700400143	**Genomics enabled pulse improvement**	**Co-ordinator : Dr. K.R. Soren**		2017-20
		SP 1: Marker-assisted gene pyramiding for pod borer resistance and drought tolerance in elite chickpea	Dr. K.R. Soren	Dr. Alok Das Dr. Shanmugavadivel P. S. Dr. Sujayanand, G.K. Dr. Biswajit Mondal (wef Jun.. 2016)	June 2014 to May 2019

S No.	IIPR Code	Mega Project/ SubProject	PI	Co-PI	Period
		SP 2: Molecular dissection of response to terminal heat in chickpea	Dr. Shanmugavadivel P. S	Dr. K.R. Soren Dr. S. K. Chaturvedi (wef June 2017)	Nov. 2014 to May 2019
		SP 3: Trait mapping for developing plant ideotype in pigeonpea	Dr. Shanmugavadivel P. S	Dr. Abhishek Bohra Dr. Satheesh Naik SJ	July 2016 to June 2019
		SP 4: Molecular Mapping of Loci for MYMV, MYMIV, Powdery Mildew Resistance and Photo-thermo insensitivity in Urdbean	Dr. Sudheer Kumar	Dr.Debjyoti Sen Gupta, Dr. P. R. Sabale	2018-2021
		SP 5: Molecular dissection of genomic regions for wilt response in chickpea	Poornima KN	Dr. K.R. Soren, Mr. Aravind Kumar Konda, Dr. Manjunatha L	2019-20
5.	**CRSCIIPRSIL 201700500144**	**Transgenic technology for Crop Improvement**	**Coordinator : Dr. Meenal Rathore**		**2017-20**
		SP1. Genetic engineering for development of pod borer resistant chickpea using multigene approach	Mr. K. Aravind Kumar	Dr. Alok Das Dr. Sujayananad G.K	2015-20
		SP 2: Development of regeneration and transformation protocol in grasspea (*Lathyrus sativus*).	Dr. Neetu Singh Kushwah	Dr. Alok Das Dr. Archana Singh Dr. Shanmugavadivel P. S	2017-20
		SP 3: Development of whitefly tolerant genetically transformed green gram (*Vigna rediata*)	Dr. Meenal Rathore	Dr. Alok Das Dr. Neetu Singh Kushwah	2017-20
		SP 4: Rapid generation advancement in chickpea (Cicer arietinum L.) and pigeonpea (Cajanus cajan L.)	Dr Alok Das	Mr Sudhir Kumar	2019-20

DIVISION OF CROP PRODUCTION (2)

S No.	IIPR Code	Mega Project/ Sub-Project	PI	Co-PI	Period
6.	CRSCIIPRSIL 201700600145	Development of resource-use efficient agro-technologies involving pulses and its cropping systems under diversified agro-ecologies	**Coordinator :Dr. C.S. Praharaj**		2017-20
		SP 1: Long-term effect of pulse in cropping systems on soil health and crop productivity in Indo-Gangetic plains	Dr. C.S. Praharaj	Dr. Narendra Kumar Dr. Ummed Singh Mr. K.K. Hazra Dr. C. P. Nath Dr. R. K. Mishra	
		SP 2: Soil-plant-nutrient dynamics for efficient nutrient management in pulses (Assessment of soil plant nutrient dynamics for strategic nutrient management in pulse based cropping system – June 2015- May2018)	Mr. K.K. Hazra	Dr. Ummed Singh Dr. C. P. Nath	
		SP 3: Evolving strategic nutrient supply for higher productivity in pulses systems	Dr. Ummed Singh		
		SP 4: Precision irrigation scheduling for higher water productivity in pulses-based cropping systems	Dr. C.S. Praharaj	Dr. Ummed Singh Dr. Ram Lal Jat	

S No.	IIPR Code	Mega Project/ SubProject	PI	Co-PI	Period
		SP 5: Scaling productivity and nutrient use efficiency in pulses-based cropping systems in central India (Improving productivity and nutrient use efficiency through micronutrient management in soybean – chickpea cropping system in Central India (2016-19)	Dr. R.L. Jat	Dr. C.S. Praharaj	
		SP 6: Enhancing productivity in diverse pulses based cropping systems through improved nutrient management in Peninsular India	Dr. M. S. Venkatesh	Dr (Mrs) Ganajakshi Math, Professsor (Agron), UAS Dharwad	2017-2020
		SP 7: Development of climate resilient RCTs for pulses-based cropping systems		Dr. Narendra Kumar Dr. Lalit Kumar Dr. DN Borase Dr. RP Dubey (DWR, Jabalpur)	Dr. CP Nath
		SP 8: Weed management strategies for enhancing productivity and sustainability of pulses systems (Weed management in rice–chickpea cropping system under conservation practices (2016-21)	Dr. C.P. Nath	Dr. Narendra Kumar Dr. R.P. Dubey (DWR, Jabalpur)	
		SP 9: Farm mechanization suitable for pulses	Er. Man Mohan Deo	Dr. Prasoon Verma Dr. C. S. Praharaj	
		SP 10: Sustainable cropping intensification with pulses under conservation agriculture practices in arid ecosystem	Dr. R.L. Jat	Dr. C.P. Nath, Dr. C.S. Praharaj Dr. Asik datta	
		SP 11: Soil phosphorus dynamics and its release kinetics under pulse based cropping system for sustainable P management in an Inceptisol	Dr. Asik Datta	Mr. K.K. Hazra	
7.	CRSCIIPRSIL 201700700146	Post-harvest management of pulses, value addition and by-product utilization.	**Coordinator ; Dr. Prasoon Verma**		2017-20
		SP 1: Determination of milling characteristics for pulse cultivars	Dr. Prasoon Verma	Er. Man Mohan Deo	
	CRSCIIPRSIL 201600500129	SP 2: Enhancing efficiency of abrasive dehusking unit of IIPR mini *dal* mill for different pulses	Dr. Prasoon Verma	Er. Man Mohan Deo	Oct. 2016 to Sept. 2019

DIVISION OP CROP PROTECTION (2)

S No.	IIPR Code	Mega Project/ Sub-Project	PI	Co-PI	Period
8.	CRSCIIPRSIL 201700800147	Characterization of pest and pathogens and host plant resistance in pulses	PI : Dr. Naimuddin		2017-20
		Chickpea	Dr. Manjunatha, L.	Dr. Bansa Singh, Dr. Devendrappa M	
		Lentil	Dr. Naimuddin	Dr. Mohd. Akram, Dr. Bansa Singh, Dr. Devendrappa M	
		Mungbean and Urdbean	Dr. Mohd. Akram	Dr. Naimuddin, Dr. Bansa Singh, Dr. Devendrappa M	
		Pigeonpea	Dr. R.K. Mishra	Dr. Naimuddin, Dr. P.R. Sabaale, Dr. Mohd.Akram	
		Cowpea and Horsegram (Dharwad centre) Identification of resistant donor's against major diseases of pulses in South India	Dr. Sabaale, P.R. P.R. Sabale	Dr. Mohd.Akram	
		Characterization and host plant resistance studies of important nematodes of pulse crops	Dr. Bansa Singh	Devindrappa, M.	
		Bio-intensive management of major pests and pathogens of pulse crops	Dr. Bansa Singh	Devindrappa, M.	
9.	CRSCIIPRSIL 201700900148	Bio-intensive management of major pest and pathogens of pulse crops	PI : Dr. Krishna Kumar		2017-20
		SP 1: Bio-intensive management of major diseases of pigeonpea	Dr. R.K. Mishra	Dr. Naimuddin	June 2014 to May 2019
		SP 3: Potentials of fungal bio-agents for management of parasitic nematodes of pulses	Dr, R. Jagadeeswaran	Dr, Bansa Singh	June 2014 to May 2019
		SP 3: Development of multi-trait *Trichoderma* sp. formulation for the management of dry root rots of chickpea	Dr. Krishna Kumar	Dr. Manjunatha L. Dr. R.K. Mishra	July 2016 to June 2019
		SP 4: Development of micro-encapsulated formulation of *Helicoverpa armigera* NPV (HaNPV) to improve its photostability	Dr. Sanjay Bandi	Dr. S.K. Singh Dr. Lalit Kumar	July 2016 to June 2019
		SP 5: Management of major foliar diseases of chickpea through host resistance and phylloplane microbes	Dr Manjunatha, L.	Dr. Krishna Kumar	June 2016 to June 2019
		SP 6: Harnessing the bio-compounds of actinomycetes against *Helicoverpa armigera*	Dr. Kiran Gandhi B.	Dr. Krishna Kumar Dr. Lalit Kumar Dr. D. N. Borse	Oct. 2016 to June 2019
		SP 7: Characterization and enhancement of shelf life of Entomo-pathogenic Nematodes (EPNs) for management of *Helicoverpa armigera* in chickpea	Mr. Devindrappa M	Dr. Krishna Kumar Dr. Sanjay Bandi	July 2016 to June 2019
		SP 8: Bio-efficacy of Bistrifluron 10%EC against *Helicoverpa armigera* on pigeonpea	Dr Kiran Gandhi B	Dr Sanjay M. Bandi	

S No.	IIPR Code	Mega Project/ Sub-Project	PI	Co-PI	Period
		SP 9: Eco-friendly management of spotted pod borer, *Maruca vitrata* Fabricius in short duration pigeonpea	Dr. Sujayanand, G.K.	Dr. S. K. Singh (wef June 2015)	July 2013 to June 2018
		SP 10: Studies on the host plant resistance and bio-ecology of key nematode pests of pulses along with their eco-friendly management	Dr. Bansa Singh	Dr. R. Jagdeeswaran Mr. Devindrappa M	
		SP 11: Development of Ecofriendly insect pest management strategies in mungbean, urdbean, cowpea and horsegram for Peninsular India	Dr. M.H. Kodandaram		2018-21
		SP 12: Pre- and post harvest management of bruchids in mungbean and cowpea	Dr. Revansiddha	Dr. Prasoon Verma	
		SP 13: Management of white fly in mungbean and urdbean	Dr. Anup Chandra	Dr. Mohd. Akram	

DIVISION OF BASIC SCIENCE (4)

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
10	CRSCIIPRSIL 201701000149	Management & analysis of production constraints in pulses as influenced by different abiotic stresses and photo-thermoperiods	Coordinator: Dr. P.S. Basu		2017-20
		SP 1: Development of diagnostic model to identify stress tolerant genotypes based on non-invasive monitoring of nutrient & water status dependent crop spectral indices of chickpea	Dr. P.S. Basu	Mr. K.K. Hazara	2017-2021
	CRSCIIPRSIL 201402200116	SP 2: Biochemical basis of heat tolerance in chickpea (*Cicer arietinum* L.) (Old Project - Biochemical characterization of heat shock proteins (HSPs) and antioxidative defense mechanism in chickpea genotypes. 2014-17)	Mr. Vaibhav Kumar	Mrs. Kalpana Tewari	2017-2020
		SP 3: Strategies for improving yield stability in urdbean through photo-thermo –insensitivity- Co-PI,	Dr. Vijay Laxmi	Dr. D.P. Patel	2017-2020
		SP 4: Physiological basis of salt tolerance in blackgram	Dr. Vijay Laxmi		
		SP 5: Identification and physiological characteristic of high-temperature and drought tolerant genotypes of lentil (*Lens culinaris* Medik) for improving productivity and resilience	Dr. D.P. Patel	Dr. Jitendra Kumar	2017-20
		SP 6: Identification and physiological characterization of pigeonpea genotypes for cold tolerance	Dr. T.N. Tewari		

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
		SP 7: Stem reserve mobilization (SRM) trait for yield improvement in chickpea	Gurumurthy, S	Dr. P.S. Pasu	
11	CRSCIIPRSIL 201701100150	Harnessing symbiotic efficiency of germplasm of major pulses for improving biological nitrogen fixation	Coordinator: Dr. M. Senthilkumar		2017-2020
		SP 1: Harnessing symbiotic efficiency of germplasm of major pulses for improving biological nitrogen fixation	Dr. M. Senthilkumar	Dr. Krishnashis Das	
	CRSCIIPRSIL 201402300117	SP 2: Interactive effect of lentil genotypes - Rhizobia on biological nitrogen fixation		Dr. Krishnashis Das	Dr. M. Senthilkumar
		SP 3: Improving nodulation potential of *Rajmash*	Dr. Krishnashis Das	Dr. M. Senthilkumar Mr Vaibhav Kumar	
12.	CRSCIIPRSIL 201701200151	Nutritional enhancement of pulse grains with special emphasis on increasing bioavailability of micronutrients	Coordinator: Ms. Kalpana Tiwari		2017-2020
		SP 1:Nutritional and phyto-chemical profile of cowpea (*Vigna unguiculata*) and fieldpea (*Pisam sativum*) with emphasis on their bio-availability and health promoting properties	Ms. Kalpana Tiwari	Mr. Vaibhav Kumar	
13.	CRSCIIPRSIL 201701300152	Development of nano-polymer based micro-encapsulated formulation of imazethapyr for weed control in pulses and minimizing residue dynamics to the environment	Coordinator: Dr. Lalit Kumar		2017-2020
		SP 1: Development of nano-material based micro-encapsulated formulation of imazethapyr for weed control in pulse crop and minimizing residue dynamics to the environment	Dr. C.P. Nath Dr. Lalit Kumar	Sobha Sondia Scientist from ICAR-CIRCOT, Mumbai	

DIVISION OF SOCIAL SCIENCE (3)

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
14	CRSCIIPRSIL 201701400153	Development of extension methodologies to disseminate the pulse production technologies for raising socio-economic condition of the pulse farmers	**Coordinator- Dr. Rajesh Kumar**		2017-20
	CRSCIIPRSIL 201301600095	SP 1: Enhancing pulses production for food, nutritional security and livelihoods of tribal farming community through demonstration and training	Dr. Rajesh Kumar		July 2013 to Mar 2020
	CRSCIIPRSIL 201601200136	SP 2: Study on farmers adoption behaviour towards sustainable pulse production practices in Bundelkahnd region of Uttar Pradesh	Mr. K Ravi Kumar	Dr. Rajesh Kumar	Nov. 2016 to June 2019
15	CRSCIIPRSIL 201701500154	Development of data management platform for pulse crops	**Coordinator: Dr. Devraj**		2017-20
	CRSCIIPRSIL 201500300119	SP 1: Development of web-based commodity profile for chickpea and pigeonpea	Dr. Devraj	Dr.Uma Sah	June 2015 to May 2018
	CRSCIIPRSIL 201601100135	SP 2: Assessing suitability of chickpea genotypes in multi-environment testing	Dr. Hemant Kumar	Dr. G.P. Dixit Dr. A. K. Srivastava	July 2016 to June 2019
		SP 3: Development and validation of digital platforms for dissemination of information on pulse production technologies	Dr. Uma Sah	Dr. Rajesh Kumar Collaborators: PC Chickpea PC PC PigeonpeaPC MULLaRP	
		SP 4: Estimation of Acreage and Production of Pulses in Bundelkhand region of Uttar Pradesh using Remotely sensed data and Geo-spatial Technologies	Dr. Devraj	Dr. P.S. Basu, Dr. Hemant Kumar and Dr. Rajesh Kumar Upadhyay (Remore Sensing Application Centre, Lucknow)	2019-22
16	CRSCIIPRSIL 201701600155	Assessment of consumer preference, marketability, cost-effective pulse cultivation and policy support for stabilizing pulse production	**Coordinator: Dr. Shripad Bhat**		2017-20 2017-20
	CRSCIIPRSIL 201601300137	SP 1. Farm-retail price behaviour and transmission in Indian pulses market	Dr Shripad Bhatt	Dr. Hemant Kumar	Nov. 2016 to June 2019
		SP 2: Impact analysis of project “Creation of seed hubs for increasing indigenous production of pulses in India”	Dr Shripad Bhatt	Dr. P. K. Katiyar	2019-20

Externally Funded Projects

CROP IMPROVEMENT DIVISION (18)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
1	Development of lentil cultivar with high concentration of iron and zinc	ICARDA	Dr. N.P. Singh	Dr. Jitendra Kumar	Jan.2013 to Dec, 2019	US$ 10000
2	Seed production in agricultural crops	DAC	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	2005-06 to March 2020	
3	ICAR (NSP) crops	DAC	Dr. P.K. Katiyar	Dr. A.K. Singh Dr. Amrit Lamichaney	April 2007 to March 2020	
4	CRP on molecular breeding for improvement of tolerance to biotic and abiotic stresses, yield and quality traits in crops-chickpea	ICAR	Dr. Aditya Pratap	Dr. K.R. Soren Dr. P S Basu	2015-20	80
5	Introgression of photo-thermo insensitivity in mungbean (*Vigna radiata* L.) and its rapid fixation through doubled haploidy breeding	Lal Bahadur Shastri Outstanding Young Scientist Award 2014	Dr. Aditya Pratap		Aug. 2016 to July 2019	30.55
6	Genomic data analysis to elucidate the regulatory network and candidate genes underlying cytoplasmic male sterility in pigeonpea	ICAR	Dr. Abhishek Borha		2017-20	41.07
7	CRP on hybrid technology 88.00	ICAR	Dr. Abhishak	Dr. Satheesh Naik S.J.		2015-16 to
	in pigeonpea		Bohra	Dr. Alok Kumar	2019-20	
8	Establishing the International Mungbean Improvement Network	AVRDC	Prog. Coordinator : Dr. N.P. Singh PI: Dr. Aditya Pratap	Dr. Sanjeev Gupta	2017-2019	150.10 (Aus $ 1,62,000)
9.	Improving livelihood for small holder farmers: Enhanced grain legumes productivity and production in sub Saharan Africa and South-Asia (TL III)	Bill and Melinda Gates Foundation (ICRISAT Collaborative)	Project Coordinator : Dr. N.P. Singh Dr. G.P. Dixit	Dr. Rajesh Kumar Dr. P.K. Katiyar Dr. Uma Sah Dr. Archana Singh	2016 to 2020	US$ 57050
10.	Characterization, mapping and transcryptome analysis of seed protein, β carotene and mineral contents in chickpea (*Cicer arietinun* L.)	NASF	CC-PI : Dr. Biswajit Mondal	CC-CoPI: Dr. Meenal Rathore Dr. Vaibhav Kumar	Jan. 2017 to Dec. 2019	19.21
11	CRP on Agro-biodiversity 1. Pigeonpea 2. Chickpea	ICAR	Dr. I. P. Singh Dr. G.P. Dixit	Dr. Archana Singh Dr Manjunath L	2014 - 2017 2017 - 2020	47.35 40.90
12	Widening of genetic base in pigeonpea (*Cajanus cajan* L. Mill. Sp.) through pre-breeding efforts for deve-loping next generation wilt resistant and photo-insensitive early pigeonpea	ICAR (Extramural Research Projrct)	ICAR-IIPR PJTSU-RARS Warangal SDAU, S K Nagar VNMKV-ARS, Badnapur · NAU-Navsari	Dr. Farindra Fingh (Centre PI)	2015-16 2016-17	15.00 30.00
13	Delivering more produce and income to farmers through enhancing genetic gains for chickpea and pigeonpea	NFSM	Chickpea: Dr. Yogesh Kumar Pigeonpea: Dr. Abhishek	Dr. K. R. Soren Sh. Shanmugavadivel. P. S.	2017-18 to 2019-20	71.20

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
14	Genetic enhancements in pigeonpea (*C. Cajan* L Millisp.) through pre-breeding efforts for developing phytophthora stem blight resistant/tolerant and photo-thermal insensitive early genotypes	SERB (DST)	Borha Dr. Satheesh Naik SJ		2018- 2021	36.68
15.	Development of improved Indian common bean (*Phaseolus vulgeris* L) lines resistant to *Anthracnose* diseases by employing molecular breeding	SERB (DST)	Dr. Basavaraja T		2019-22	35.085
16	Institute Technology Management Unit	ICAR (NAIF)	Dr. Aditya Pratap		2016-2020	
17.	Association mapping of nutritional quality traits (protein, iron and zinc) in chickpea under CGIAR Research Programme on Grain Legumes and Dry land Cereals (CRP-GLDC)	ICRISAT	Dr. B. Mondal		2018-19	US$ 15238 Fund not transfered from Council to IIPR
18.	Application of Next Generation Breeding, Genotyping and Digitalization Approaches for Improving the Genetic Gain in India Staple Crops (TL III)	ICAR-Bill and Melinda Gates Foundation Project	Dr. G. P. Dixit	AICRP-Dr. A. K. Srivastava Institute-Pigeonpea CC-PI Dr. Abhishek Borha Dr. Archana Singh Chickpea CC-PI: Dr. B. Mondal Dr. Archana Singh	2018-2022	

PLANT BIOTECHNOLOGY DIVISION (4)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
19.	Transgenic in chickpea and pigeonpea for pod borer resistance	NPTC-TG (ICAR)	Dr. Alok Das (from 17.11.14) Dr. S. Datta (up to 17.11.14)	Dr. Sujayanand G.K.	Sep.2005 to March 2020	X Plan: 93.11 XI Plan:90.78 XII Plan: 90.78 2017-18 : 6.50
20.	Functional genomics in chickpea	NPTC-FG (ICAR)	Dr. K.R. Soren (from 17.11.14) Dr. S. Datta (up to17.11.14)	Dr. K.R. Soren (up to 17.11.14)	Sep.2005 to March 2021	X Plan :93.11 XI Plan:96.40 XII Plan : 44.19
21.	Incentivizing research in agriculture : Molecular genetic analysis of resistance/ tolerance to different stresses in chickpea	ICAR-CRRI	Dr. K.R. Soren	Dr. B. Mandal	2015 to 2020	15-16 : 26.35
22.	Functional genomics in pigeonpea (Genetic mapping of *Fusarium* wilt and SMD in pigeonpea)	NPTC-G(ICAR)	Dr. Shanmuga-vadivel, P. S.	Dr. Abhisekh Bohra Dr. P.R. Saable	2015-20	2015-18-7.00 2018-19- 5.30

CROP PRODUCTION DIVISION (2)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
23	Utilization of pulse milling by-product for edible use	Min. of Food Processing Industries (GOI)	Er. Prasoon Verma	1. Er. Man Mohan Deo (On Study Leave) 2. Mr. Vaibhav Kumar 3. Dr. Krishnashish Das	Dec. 2018 to Nov. 2021	54.00
24	Development of protocols for procurement, safe storage and milling outturn of major pulses	Dept. of Consumer Affairs, Min. of Consumer Affairs, Food and Public Distribution (GoI)	Er. Prasoon Verma	Dr. Kiran Gandhi Bapatla Mr. Revanasiddha	March 2019 - February 2021	32.45

CROP PROTECTION DIVISION (8)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
23.	Crop pest surveillance and advisory project (CROPSAP)	RKVY, Maharashtra	Dr. Kiran Gandhi (From April 2017) Dr.Shiva Kant Singh (up to March 2017)	--	Oct. 2013 to March 2017	3.74
24	Development of microbial based formulations and their consortia for management of pigeonpea wilt diseases	CST, UP	Dr. R.K. Mishra	Dr. Naimuddin Dr. P.R. Saabale	2016-19	11.94
25	Transcriptome dynamics in host viruses interaction to identify multi virus resistant genotypes in mungbean	SERB (DST)	Dr. M Akram	Dr. Naimuddin	April 2017 to March 2020	31.57
26	Identification of potential Plant Growth Promoting Rhizobacteria's (PGPRs) against *Fusarium* wilt and dry root rot for enhancing chickpea productivity	SERB (DST)	Dr. Krishna Kumar	Dr. Manjunatha L.	2017-2020	30.49
27.	Nematophagous Bacteria: Identification and profiling of host specificity of *Pasteuria penetrans* infecting Meloidogyne spp. in pulses	SERB (DST)	Dr. R. Jagadeeswaran		21.02.2017 to 20.02.2021	37.48
28	Virulence profiling of *Ascochyta rabiei* and deciphering molecular interactions with chickpea	SERB (DST)	Dr. Manjunatha L.	Dr. K. Arvind Kumar	2017-2020	35.56
29.	Bio-prospecting plant essential oils for insecticidal properties against pulse beetle infesting stored legumes	SERB (DST)	Dr Sanjay M. Bandi		2018-21	29.34
30	Innovative and contextual agromet advisory services for climate smart agriculture	IITM	Dr. R.K. Mishra	Dr. Sanjay M. Bandi Dr. Uma Sah Dr. Shripad Bhat Dr. Krishna Kumar Dr. Kiran Gandhi B.	2018-21	80.7984

BASIC SCIENCE DIVISION (2)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
31.	Rhizosphere micribiome for improving symbiotic nitrogen fixation and yield in lentil in North Eastern State of India	Biotech Consortium India Limited	Centre PI: Dr. M. Santhilkumar		2016-2019	24.76
32.	Identification and characterization of nodule –specific cysteine rich (NCR) peptide in chickpea	DBT	Dr. M. Santhilkumar	Dr.. Shanmugavadivel, PS Mr. Arvind Kumar	2018-2021	56.30

SOCIAL SCIENCE DIVISION (2)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹in lakh)
34.	Integrated approaches for food, nutrition and livelihood security for rural household in Fatehpur district of Uttar Pradesh (Farmers FIRST).	ICAR	Dr. Rajesh Kumar	Dr. C.P. Nath (from May 18) Mr. Shripad Bhat Dr. Subhash Chandra (CSAUA&T) Dr. M.P.S. Yadav (CSAUAT), Dr. K. Ravi Kumar (w.e.f. July 2018), Dr. Purshottam (upto June 2018) Dr. Ummed Singh (up to April 18)	2016-20	46.00
36.	mKrishi Platform in collaboration with Tata Consultancy Services		Dr. D.R. Mishra	G.P. Dixit, I.P. Singh, Rajesh Kumar, C.S. Prahraj, Farindra Singh, Aditya Pratap, Yogesh Kumar, R.K. Mishra, Archana Singh, M.S. Venkatesh, Sujyanand G.K., Biswajit Mandal	2018-20	

EXTERNALLY FUNDED MEGA- PROJECT (7)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
35	National Initiative on Climate Resilient Agriculture (NICRA)	ICAR	Prog. Coordinator : Dr. N.P. Singh PI: Dr. Sanjeev Gupta	Dr. P.S. Basu Dr. Aditya Pratap Dr. Dibendu Datta Dr. Jitendra Kumar Dr. Debjyoti Sen Gupta Mr. U.C. Jha	I - 2011-2016 II - 2017-2020	567.00
36	Implementation of PVP legislation, DUS test	Chickpea	Dr. G.P. Dixit	Dr. A.K. Srivastava	2007 to Continued Project)	PPV & FRA Budget
37	Implementation of PVP legislation, DUS test	Pigeonpea	Dr. I.P. Singh	Dr. Farindra Singh	2007 to Continued Project)	PPV & FRA Budget
38	Implementation of PVP legislation, DUS test.	MULLaRP	Dr. Sanjeev Gupta	Dr. A.K. Parihar	2007 to Continued Project)	PPV & FRA Budget

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (Rs. in lakh)
39	Creation of Seed hubs for increasing indigenous production of pulses in India	ICAR & DAC (NFSM)	National Coordinator : Dr. N.P. Singh Nodal Officer Dr. P. K. Katiyar	Kanpur: Dr. A. K. Singh Bhopal: Dr. Archana Singh Bhubneswer: Dr. CS Praharaj	2016-2019	22531.08
40	Enhancing breeder seed production for increasing indigenous production of pulses in India	ICAR & DAC (NFSM)	National Coordinator : Dr. N.P. Singh Nodal Officer: Dr. P. K. Katiyar	Kanpur: PI- Dr P. K. Katiyar Co-PI-Dr. A. K. Singh Bhopal: PI-Dr. Archana Singh	2016-2019	2039
41	Genetic enhancement of minor pulses: characterization, evaluation, genetic enhance-ment and generation of genomic resources for accelerated utilization and improvement of minor pulses- Sub Proj. 4: genetic enhancement of minor pulse	DBT (Min of Science & Technology)	Dr. N.P. Singh	Dr. Mohd. Akram, Dr. Aditya Pratap Dr. Meenal Rathore Dr. A.K. Singh Dr. Naimuddin Dr. A K Parihar Dr. Deb Jyoti Sen Gupta Dr. Sudhir Kumar Dr. Revannasadda Dr. P R Sabaale Dr. Revanappa B	2018-2021	441

YOUNG SCIENTIST PROJECT (1)

S No	Name of the Project	Funding Agency	Principal Investigator	Associate	Period	Budget (Rs. in lakh)
43	Agrobacterium tumefaciens-mediated gene editing in chickpea (*Cicer arietinum*) using CRISPR-Cas9 system	DST (INSPIRE)	Dr. Shallu Thakur		2017-2022	1,27,000/= per month + 35 lakh Res grant.

Institute Management Committee

As on 31.12.2019

Dr. N.P. Singh Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
Asstt. Director General (O&P) ICAR Krishi Bhawan, New Delhi	Member
Mr. T.C. Sharma Finance and Accounts Officer ICAR-PDFSR, Modipuram, Meerut	Member
Dr. Ram Awatar Sharma Principal Scientist ICAR-CAZRI, Jodhpur (Raj.)	Member
Dr. C. Bhardwaj Principal Scientist ICAR-IARI, New Delhi	Member
Dr. S. Natarajan Principal Scientist ICAR-IARI-RBGRC, Aduthurai (TN)	Member
Dr. C.S. Praharaj P.S. & Head ICAR-IIPR, Kanpur	Member
Dr. Rama Shankar Katiyar Billhore, Kanpur Dehat (U.P.)	Member
Mr. Shiv Poojan Chandel Mirzapur (U.P.)	Member
Dr. A.N. Sharma Principal Scientist ICAR-Directorate of Soybean Research, Indore	Member
Additional Director (Agril.) Govt. of U.P., Krishi Bhawan, Lucknow	Member
Joint Director (Agril.) Pant Krishinagar Bhawan, Jaipur	Member
Director Research JNKVV, Jabalpur	Member
Mr. Kumar Vivek Senior Administrative Officer ICAR-IIPR, Kanpur	Member Secretary

Research Advisory Committee

As on 31.12.2019

Dr. S.K. Sharma Ex. Vice-Chancellor CSK Himachal Pradesh Krishi Vishwavidylaya, Palampur, H.P.	Chairman
Dr. S.K. Rao Director Research Services Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	Member
Dr. P.K. Singh Sr. Scientist, Plant Biology & Genetic Engineering, CSIR-NBRI, Lucknow	Member
Dr. V.G. Malathi Emeritus Scientist TNAU, Coimbatore	Member
Dr. Subhash Chander Professor, Division of Entomology ICAR-IARI, New Delhi	Member
Dr. Jayent Deka Principal Scientist DWSRC, Assam Agricultural University, Jorhat, Assam	Member
Dr. Baldev Singh Ex-Head, Division of Extension ICAR-IARI, New Delhi	Member
Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
Dr. N.P. Singh Director, ICAR-Indian Institute of Pulses Research, Kanpur	Member
Dr. Rama Shankar Katiyar Vill. & PO-Billhore, Kanpur Dehat (U.P.)	Member
Mr. Shiv Poojan Chandel Vill- Mohlar (Barkar Chakki), PO- Buwar, Mirzapur (U.P.)	Member
Dr. Mohd. Akram Principal Scientist, Division of Crop Protection ICAR-Indian Institute of Pulses Research, Kanpur	Member Secretary

Institute Research Council

As on 31.3.2019

Dr. N.P. Singh Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
All Scientists of the Institute	Member
Dr. Aditya Pratap Principal Scientist, Division of Crop Improvement, ICAR-IIPR, Kanpur	Member Secretary

As on 31.12.2019

Important Committees of the Institute

1.	Monthly Review Committee	Chairman	:	Director
		Members	:	All Project Coordinators, All Heads of Divisions, All Scientists, Sr. AO., F&AO, AAOs, Chairmen of various committees, Secretary- IJSC, Architect and I/c of various activities
		Member Secretary	:	Dr. Naimuddin
2.	Farm Advisory Committee	Chairman	:	Dr. C.S. Praharaj
		Members	:	All HoDs, I/c Farms, I/c Security & Dr. P.K. Katiyar, Nodal Officer (Seed)
		Member Secretary	:	Dr. Narendra Kumar
3.	Estate Management Committee	Chairman	:	Dr. Prasoon Verma
		Members	:	Dr. Ummed Singh, Dr. R.K. Mishra, Er. Manmohan Deo, Dr. Omkar Nath, Sr. Administrative Officer, F. & A.O. , Mr. S.K. Garg, Mr. R.M. Pal
		Member Secretary	:	Sh. D.N. Awasthi
4.	Publication Committee	Chairman	:	Director
		Members	:	Dr. Krishna Kumar, Dr. P.S. Basu, Dr. (Mrs.) Meenal Rathore, Dr. Mohd. Akram and Dr. Aditya Pratap
		Member Secretary	:	Dr. Rajesh Kumar Srivastava
5.	Purchase Advisory Committee	Chairman	:	Dr. Naimuddin
		Members	:	Dr. Krishna Kumar, Dr. Shiv Sewak, Dr. Prasoon Verma, Dr. Narendra Kumar, Dr. P.K. Katiyar, Dr. Senthil Kumar, Dr. K.R. Soren, Sr. AO. and F&AO
		Member Secretary	:	AAO (S)
6.	Results Framework Document Committee	Chairman	:	Director
		Members	:	Dr. Shiv Sewak, Dr. C.S. Prahraj, Dr. Jagdish Singh, Dr. Krishna Kumar, Dr, Rajesh Kumar, AO and F&AO
		Nodal Officer Co-Nodal Officer	: :	Dr. Mohd. Akram Dr. Senthil Kumar
7.	Institute Technology Management Committee	Chairman	:	Director
		Members	:	Dr. Shiv Sewak, Dr. Jagdish Singh, Dr. C.S. Praharaj, Dr. Krishna Kumar, Dr. Rajesh Kumar, Dr. Aditya Pratap, Dr. Devraj, Mr. Udai Chandra Jha
		Ex-Officio Member	: :	Dr. Sanjeev Gupta, Dr. I.P. Singh & Dr. G.P. Dixit
		Member Secretary	:	Dr. Aditya Pratap
8.	Resource Generation and Farm Produce Price Fixation Committee	Chairman	:	Dr. Krishna Kumar
		Members	:	Dr. Devraj, Sr. Administrative Officer, Finance & Accounts Officer and

				Dr. (Mrs.) Uma Sah
		Member Secretary	:	Dr. Ummed Singh
9.	Prioritization Monitoring and Evaluation Cell (PME Cell)	Chairman	:	Director
		Members	:	Dr. R.K. Mishra, Dr. Senthil Kumar, Dr. (Mrs.) Meenal Rathore, Dr. Uma Sah, Dr. (Mrs.) Archana Singh RS, Bhopal, Dr. M.S.Venkatesh, RS, Dharwad, Dr. Sripad Bhatt, Dr. Abhishek Borah
		Member Secretary	:	Dr. C.S. Praharaj
10.	Library Committee	Chairman	:	Director
		Members	:	All HoDs, Sr. AO and F&AO
		Member Secretary	:	Dr. (Mrs.) Uma Sah
11.	Institute Bio-safety Committee	Chairman	:	Director
		Members	:	Dr. Mohd. Akram, Dr. (Mrs.) Meenal Rathore, Dr. Senthil Kumar, Dr. Sujanand G.K., Dr. Jonaki Sen, IIT, Kanpur, Dr. Amaresh Chandra, IISR, Lucknow, Dr. P.K. Singh (GSVM Medical College, Kanpur)
		Member Secretary	:	Dr. Alok Das
12.	Germplasm & Genotype Identification Committee	Chairman	:	Director
		Members	:	Dr. Shiv Sewak, Dr. Sujayanand G.K. Dr. Aditya Pratap, Dr. Mohd. Akram, Dr. Jitendra Kumar
		Member Secretary	:	Dr. Aditya Pratap
13.	Academic and HRD Committee	Chairperson	:	Dr. (Mrs.) Meenal Rathore
		Members	:	Dr. R.K. Mishra, Dr. Neetu S Kushwah Dr. Senthil Kumar, Dr. Abhisek Bohra, Dr. Sripad Bhatt, Dr. Debjyoti Sen Gupta
		Member Secretary	:	Dr. Alok Das
14.	Grievance Cell	Chairman	:	Dr. Rajesh Kumar
		Members	:	Dr. Jitendra Kumar, Dr. (Mrs.) Archana Singh (RS, Bhopal), Dr. Revanappa (Dharwad) and Dr. Omkar Nath
		Member Secretary	:	Sr. Administrative Officer
15.	Computer/ ARIS Cell & Instrumentation Committee	Chairman	:	Dr. P.S. Basu
		Members	:	Dr. Senthil Kumar, Dr. Hemant Kumar, Dr. Prakash G. Patil, Dr. Abhisekh Bora and Dr. Manmohan Deo
		Member Secretary	:	Dr. Devraj
16.	Consultancy Processing Cell	Chairman	:	Dr. Bansa Singh, Pr. Scientist
		Members	:	Dr. Rajesh Kumar, Dr. Farindra Singh, Dr. Ummed Singh, Dr. A.K. Parihar, Dr. K.R. Soren and Dr. A.K. Srivastava
		Member Secretary	:	Dr. R.K. Mishra
17.	Guest House Management Committee	Chairman	:	Dr. Shiv Sewak
		Members	:	Dr. Rajesh Kumar, Dr. Farindra Singh, Dr. Lalit Kumar and Dr. Ummed Singh

		Member Secretary	:	Sr. Administrative Officer
18.	**Vehicle Maintenance Committee**	**Chairman**	:	Dr. Lalit Kumar
		Members	:	Dr. Naimuddin, Dr. Ummed Singh, Dr. Revanappa, (RS, Dharwad), Dr. (Mrs.) Archana Singh (RS, Bhopal) Sr. A.O., F&AO and AAO(S)
		Member Secretary	:	Sh. Sukdeo Mahto
19.	**Sports Committee**	**Chairman**	:	Dr. Bansa Singh
		Members	:	Dr. (Mrs.) Vijay Laxmi, Dr. K.R. Soren, Dr. Jagdeeswaran, Dr. M.P. Singh and Mr. Yashwant Singh, Secretary IJSC
		Member Secretary	:	Dr. Ummed Singh
20.	**Rajbhasha Implementation Committee**	**Chairman**	:	Director
		Members	:	All HoDs, Dr. (Mrs.) Uma Sah, Dr. R.K. Mishra and Mr. A.P. Singh
		Member Secretary	:	Dr. Rajesh Kumar Srivastava
21.	**Technical Advisory & Proprietary Committee**	**Chairman**	:	Dr. P.S. Basu
		Members	:	Dr. Mohd. Akram, Dr. Lalit Kumar Dr. Senthil Kumar
		Member Secretary	:	Dr. (Mrs.) Meenal Rathore
22.	**Local Purchase Committee**	**Chairman**	:	Dr. Lalit Kumar
		Members	:	Dr. Rajesh Kumar, Dr. Farindra Singh, Dr. R.K. Mishra, Dr. K.R. Soren, Dr. Omkar Nath and F & AO
		Member Secretary	:	AAO (S)
23.	**Co-ordination Committee**	**Chairman**	:	Dr. Aditya Pratap
		Members	:	Dr. Omkar Nath and Mr. Rajendra Kumar Nigam
24	**Women Grievance Cell**	**Chairperson**	:	Dr. (Mrs.) Uma Sah
		Members	:	Dr. (Mrs.) Meenal Rathore, Dr. (Mrs.) Archana Singh, RS (Bhopal) and Mrs. Kirti Singh
		Member Secretary	:	Sh. Rajeev Nigam
25.	**In-charges**	Dr. Aditya Pratap, PS – Member Secretary, IRC Dr. Mohd. Akram, PS - Member Secretary, RAC Dr. P.K. Katiyar, PS- I/c Seed, Farms and NRC Dr. Rajesh Kumar, PS (Extn.)- I/c Photography Mr. Kumar Vivek, Sr. A.O.- I/c Guest House Dr. Devraj, PS - I/c Computer Dr. Ummed Singh, Sr. Scientist- I/c Farm (Main) Dr. Narendra Kumar, PS - I/c New Research Campus (NRC) Dr. Jitendra Kumar, PS - I/c Cold Module Dr. (Mrs.) Uma Sah, PS - I/c Library & Convener Seminars Mr. S.K. Garg, ACTO I/c Farm Machinery & Seed Processing Machines Mr. S.K. Garg, ACTO- I/c Maintenance of Power Supply & other electrical works related to NRC under the supervision of I/c NRC, Incharge EPABX		

Dr. Omkar Nath, ACTO-I/c Security
Mr. R.K. Singh, STO-Farm Manager (Main Farm)
Mr. S.P.S. Chauhan, ACTO-Farm Manager, NRC
Mr. Shukdeo Mahto, AAO-I/c Vehicles
Mr. R.M. Pal-I/c Electricity
Mr. H.N. Maurya-I/c Horticulture under Supervision of Dr. Shiv Sewak
Mr. Shiv Saran Singh, I/c Sanitation under supervision of Sr. A.O.

ICAR - IIPR Regional Research Centre, Dharwad

Dr. G.P. Dixit, PS, Link Officer

1.	Farm Produce Auction & Purchase Committee	**Chairman**	:	Dr. M.S. Venkatesh, PS (RRC-Dharwad)
		Members	:	Dr. B.S. Patil, Dr. Jayanth Bhat (ICAR-IARI, RRS)
			:	Dr. (Mrs.) Ganajakshi Math (MULLaRP Scheme, UASD)
			:	Dr. Vinod Kumar (ICAR-IGFRI-Dharwad)
		Member Secretary	:	Dr. Ravanappa
2	Seed, Security & Farm Development Committee	**Chairman**	:	Dr. M.S. Venkatesh, PS (RRC-Dharwad)
		Members	:	Dr. Shiv Kumar, BG Head (ICAR-IGFRI-SRRS)
			:	Dr. Suma Mogali (MULLaRP Scheme, UAS, Dharwad)
			:	Sh. Jayanth Bhat (ICAR-IARI, RRS)
		Member Secretary	:	Dr. Ravanappa

ICAR - IIPR Regional Research Station, Phanda, Bhopal

Link Officer : Dr. P.K. Patiyar, Principal Scientist

1.	Purchase Committee	**Chairperson**	:	Dr. (Mrs.) Archana Singh, Pr. Scientist
		Members	:	Dr. R.P. Singh, PS, AICRP-MULLaRP, College of Agriculture, Sehore
			:	Dr. Ram Lal Jat, Scientist
		Member Secretary	:	Mr. Mayank Mishra
2.	Seed/Grain Auction Committee	**Chairman**	:	Dr. P.K. Katiyar, Principal Scientist & Nodal Officer
		Members	:	Dr. S.C. Gupta, PS, College of Agriculture, Sehore
			:	Dr. (Mrs.) Archana Singh, Principal Scientist
		Member Secretary	:	Dr. Ram Lal Jat

In-Charges at IIPR, Regional Research Station, Phanda, Bhopal

I/c Sanitation and Landscaping	:	Dr. (Mrs.) Archana Singh, Principal Scientist
I/c Farm	:	Dr. Ram Lal Jat, Scientist
I/c Vehicles & I/c Security	:	Dr. (Mrs.) Archana Singh, Pr. Scientist
Farm Manager	:	Sh. Anand Kumar Yadav, Tech. Asstt.

Panorama

Dr Trilochan Mohapatra, Secretary (DARE) & DG (ICAR) Inaugurates Laboratory-cum-Office Building of ICAR-IIPR Regional Centre at Dharwad

The Laboratory-cum-Office building of ICAR-Indian Institute of Pulses Research-Regional Centre, Dharwad was inaugurated by Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) on June 17, 2019 at Dharwad. Shri. N.H. Shivashankar Reddy, Hon'ble Minister of Agriculture, Govt. of Karnataka; Prof. M.B. Chetti, Hon'ble Vice Chancellor, University of Agricultural Sciences, Dharwad, Dr. J.H. Kulkarni, Ex-Vice

Chancellor, University of Agricultural Sciences and Shri Prasad Abhayya, MLA, Hubli, Dharwad were present on the occasion. Dr. N.P. Singh, Director, ICAR-IIPR was the Chairman of the function. The dignitaries visited the laboratories and other facilities of Regional Centre, Dharwad and interacted with Director of the Institute and staff members of the Regional Centre on the occasion. Around 150 farmers participated in the inaugural function. Mungbean and urbean seeds were also distributed to the farmers. Institute published folders were also released on the occasion.

In his inaugural address, Dr. Mohapatra lauded the efforts of ICAR-IIPR in achieving near self-sufficiency in pulses production and its contribution in pulses revolution in the country. While reiterating the role of varieties and technologies in gaining stability in pulses and other foodgrain production, he opined that the novel technologies should reach the farming community in time and called upon scientists to work in integration for the benefit of farmers. Prof. M.B. Chetti, Hon'ble Vice Chancellor, UAS, Dharwad, while describing the role of pulses and the centre in the region, advised pulses scientists of University and IIPR to work in synergy for the benefit of farming community of the region. He assured for all kind of support and cooperation in development of IIPR - Regional Centre at UAS, Dharwad.

Mr. Shivashankar Reddy, Hon'ble Agril. Minister, Karnataka and Mr. Abbayya Prasad, Hon'ble MLA, Hubli-Dharwad district asked farmers to take full benefit of the scientific technologies and varieties developed by ICAR-IIPR. They appreciated the efforts of ICAR-IIPR team in establishing the centre within a short period to serve the farming community of the state and the region. Dr. J.H Kulakarni, Ex-VC of UAS, Dharwad also joined Hon'ble VC, UASD in congratulating ICAR-IIPR team for opening the Regional Centre of IIPR at Dharwad and offered his best wishes for a bright future for the centre. Dr. N.P. Singh, Director, ICAR-IIPR, welcomed all the dignitaries and farmers on this special occasion. He thanked Dr. Trilochan Mohapatra; Prof. M.B. Chetti, Hon'ble VC, UASD

and others for their support and guidance for establishment of the centre. Dr. M.S. Venkatesh, Principal Scientist & Incharge, Regional Centre, Dharwad proposed vote of thanks. Dr. C.S. Praharaj, PS & Head Coordinated the programme. In farmers-scientists interface meeting, varietal information, crop production and protection technologies for pulses were disseminated to the farmers by the scientists from the Centre and IIPR Headquarters, Kanpur. Farmers also shared their experiences of cultivation of pulse crops in their fields.

Vice- President of India Inaugurates the Annual Group Meet on Mungbean, Urdbean and Arid legumes

The Hon'ble Vice President of India, Shri M. Venkaiah Naidu inaugurated the 24th Annual Group Meet on Mungbean and Urdbean under All India Coordinated Research Project on MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajmash and Pea) and Cowpea, Clusterbean and Mothbean under All India Network Project on Arid Legumes the group neet was held at Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh during May 19-21, 2019. Addressing the audience, he emphasized the need of paradigm shift in agricultural research using innovative science, alternative policies and institutional changes for increasing production and productivity of crops in the country. A bilingual android–based smartphone application was also launched on the occasion which aims at larger masses of farmers in providing them latest technical-how of mungbean cultivation. Hon'ble Chief Guest awarded the research centres of mungbean and urdbean with the 'Best AICRP Centre Award'.

Dr. V. Damodar Naidu, Hon'ble Vice-Chancellor of ANGRAU advised to make pulse production remunerative that would attract farmers to grow more pulses. Dr. D.K. Yadav, ADG (Seeds), ICAR, briefed about the efforts made by ICAR in increasing pulses area and production in the country. Dr. Sanjeev Gupta, Project Coordinator (MULLaRP) briefed the audience about the progress made in MULLaRP crops. He elaborated on how new varieties and technologies record production of pulses in recent times.

Dr. N.P. Singh, Director, ICAR-IIPR, Kanpur briefed about the national priorities and programmes in pulses research and urged the group to reorient the research activities at respective centres to address problems of the region. The results of *Kharif* experiments 2018 were discussed and the technical programme for *Kharif* 2019 was finalized. Improved varieties of urdbean for rice- fallow cultivation, VBN 9 & for *Rabi* cultivation, VBN 10, mungbean variety for NEPZ and NWPZ, MH 1142 and of cowpea variety for summer cultivation PGCP 24 were also identified for release by CVRC.

Mung Advisor: An Android based Application for the Farmers in India

A need was felt since long for an information and communication technology (ICT) based platform for farmers, which could act as a one-stop solution to all their queries related to mungbean cultivation. The ICAR-Indian Institute of Pulses Research, Kanpur developed an interactive application tool, "Mung Advisor" which is now available on Android smartphones through Google play store. This app is currently bilingual in English and Hindi and is free to download. This app covers all the three seasons (Spring/Summer, *Kharif* and *Rabi*/Rice fallow) and provides information on improved varieties, cultural practices, insect-pest and disease management, post-harvest technology, marketing, *etc*. The app also provides information on plant architecture, weather advisories, latest statistics and nutritional profile of mungbean besides having an integrated seed calculator. Mung Advisor was dedicated to farmers by the Hon'ble Vice-President of India, Shri M. Venkaiah Naidu ji on 19 May 2019 during the 24th Annual Group Meet on Mungbean and Urdbean held at Acharya NG Ranga Agricultural University (ANGRAU), Lam, Guntur, Andhra Pradesh, India. This app is supported by ACIAR through International Mungbean Improvement Network (IMIN) and will be upgraded to cover all IMIN partner countries and be multi-lingual for each region in future.

Mung Advisor can be accessed on Google Play store at the following link:

https://play.google.com/store/apps/details?id=com.mungadvisor&hl=en

24th Annual Pigeonpea Group Meet

The 24th Annual Group Meet of All India Coordinated Research Project on Pigeonpea was held during May 25-27, 2019 at Agriculture University, Kota, Rajasthan. About 125 delegates from cooperating centres of SAUs and ICAR Institutes attended this group meet. Dr. Neelima Singh, Hon'ble Vice-Chanceller, AU Kota, Rajasthan; Dr. G. L. Keshwa, Ex Vice Chancellor, AU, Kota; Dr. D.K. Yadav, ADG (O&P); Dr. N.P. Singh, Director, ICAR-IIPR; Dr. Pratap Singh Director Research, (AU, Kota); Dr. R.K. Singh, Head, ICAR-IISWAR, Kota; Dr. I. P. Singh, Project Coordinator (Pigeonpea) were present in the inaugural session.

In his welcome address, Dr. Pratap Singh, Director of Research, AU, Kota highlighted the importance and scope of pigeonpea. Dr. I.P. Singh, (Pigeonpea) briefed the progress of AICRP pigeonpea and highlighted the rise in pigeonpea productivity over the years. He informed that poor rainfall, uneven distribution, early withdrawal of precipitation and no rain during the reproductive phase resulted in reduced productivity (832 kg/ha). Dr. Singh also added that irrigation at pre-flowering stage resulted in significantly higher yield as compared to podding stage and nipping in pigeonpea was found promising when performed at 45 days after sowing.

Dr. N.P. Singh, Director, ICAR-IIPR deliberated on the latest breakthroughs that were achieved in terms of pulse production over the last five years. He informed that increasing adoption of modern pulse technologies led to a quantum jump in pulses production. The efforts were complemented with Government policy support of enhanced MSP. Recent progress in seed system also contributed significantly to this and resulted in significant improvement in seed replacement rate (SRR) and variety replacement rate (VRR). Dr G.L. Keshwa, Ex. VC, AU, Kota highlighted the challenges of feeding burgeoning Indian population in the phase of alarmingly declining resources like arable land, irrigation water *etc*. Dr. R.K. Singh, Head, IISWR, Kota stressed upon the need to long-term impacts on land use system in addition to seeking immediate economic gains at farmers' field. Dr. D.K. Yadav, ADG (O&P) highlighted the increasing relevance of climate resilient and nutrient rich pulse crops. Dr. Neelima Singh, Vice Chancellor, AU, Kota, emphasized on quality improvement parameters including cooking and milling qualities of pulses.

Six new varieties and one hybrid of pigeonpea were identified in the Varietal Identification Committee Meeting.

Best Centre Award in Mungbean

ICAR-IIPR, Kanpur received Best Centre Award-2018 for 'Outstanding contribution in development of high yielding varieties of greengram' jointly with CCS Haryana Agricultural University, Hisar during the Annual Group Meet on MULLaRP and Arid Legumes. The award was given by Shri M. Venkaiah Naidu ji, Hon'ble Vice President of India during the Inaugural session of the Group Meet on May 19, 2019. It is noteworthy that till now, ICAR-IIPR, Kanpur has developed 10 high yielding and widely adaptable varieties of mungbean including the landmark varieties *viz*., IPM 205-7 (Virat), IPM 2-3, Samrat and IPM 2-14. IIPR varieties currently meet more than 40% of the breeder seed indent in the country. CCS HAU, Hisar has also developed outstanding varieties such as MH 421 and Sattya which are highly popular among the farmers. Both these centres have also developed other superior lines which have been shared with different NARS partners. The award was received by Dr. Aditya Pratap from ICAR-IIPR, Kanpur and Dr. Rajesh Yadav from CCS HAU, Hisar.

Farmers' Day on Summer Mungbean organized

A 'Farmer's Day' on summer mungbean was organized on June 14, 2019 at ICAR-IIPR, Kanpur. On this occassion, Scheduled Caste Sub Plan (SCSP) was also implemented for increasing socio-economic condition of farmers through pulses production. The farmers were provided with critical inputs such as seeds of urdbean and mungbean along with literature related to improved production and management practices in pulses. In this programme, 130 farmers of Fatehpur and Unnao districts participated. Farmers they also visited mungbean field in Institute. While highlighting role of pulses in food and nutritional security, Director, ICAR-IIPR, Kanpur, Dr. N.P. Singh reiterated for cultivation and promotion of pulses. Dr. Nand Kishore, Deputy Director Agriculture, Unnao explained the role of quality seed and its production for higher income realization. Earlier in the meeting, Dr. Rajesh Kumar, Head, Social Science Division welcomed the dignitaries and farmers and briefed about the purpose of Farmers

day and SCSP programme. The meeting ended with vote of thanks by Dr. Awinendra Kumar Singh.

Honourable Cabinet Minister, Sadhvi Niranjan Jyoti, Minister of State for Rural Development also provided seed as a critical input under Farmer FIRST project and SCSP plan to woman farmers of Karchalpur and Shahpur Village of Fatehpur district on June 30, 2019.

ICAR North Zone Sports Tournament 2019

ICAR-Indian Institute of Pulses Research, Kanpur was entrusted with the responsibility of organizing the ICAR North Zone Sports Tournament 2019 during December 12-14, 2019 for the third time. In this tournament, about 850 participants from 23 ICAR Institutes took part with enthusiasm and in true sportsman spirit. This definitely reflected in the conduct and discipline of the sports persons and officials associated with this great event.

Under the able guidance and encouragement of the Director of the Institute, Dr N.P. Singh, the three day ICAR North Zone Sports Tournament 2019 was perfectly organized & performed during December 12-14, 2019. Prof. Onkar Dikshit, Dean of Administration, IIT, Kanpur was the chief guest at the Inaugural Ceremony of the Tournament and Dr. Sushil Soloman presided over the Closing Ceremony as the Chief Guest. Dr Rajesh Kumar, Head, Social

Science Division was Organising Secretary of the Tournament, Dr Naimuddin was Chef-de-Mission of IIPR team and Dr Aditya Pratap anchored Inaugural Ceremony as well as Closing Ceremony. IIPR, Kanpur bagged two Gold Medals in different events. ICAR-CPRI, Shimla was declared the most disciplined as well as declared the overall champions in the Tournament. Sri Naresh Kumar of ICAR-IIWBR, Karnal was declared the Best Athlete (Men) while Mrs. Bhagya Vijayan from ICAR-CSSRI, Karnal was declared the Best Athlete in Women category. The Tournament was organised successfully at Sports Stadium, IIT, Kanpur

Personnel

As on 31.12.2019

A. Research Management

1. Dr. N.P. Singh — Director

B. AICRP on Pigeonpea

2. Dr. I.P. Singh — Project Coordinator (In-charge)

C. AICRP on Chickpea

3. Dr. G.P. Dixit — Project Coordinator

D. AICRP on MULLaRP

4. Dr. Sanjeev Gupta — Project Coordinator (In-charge)

E. AINP-Arid Legumes

5. Dr. Shiv Sewak — Nodal Officer, AINPAL

F. Scientific

Crop Improvement

6. Dr. Shiv Sewak	Plant Breeding	Pr. Scientist & Head (In-charge)
7. Dr. Sanjeev Gupta	Plant Breeding	Principal Scientist
8. Dr. Farindra Singh	Plant Breeding	Principal Scientist
9. Dr. P.K. Katiyar	Plant Breeding	Principal Scientist
10. Dr. Awnindra Kumar Singh	Plant Breeding	Principal Scientist
11. Dr. Jitendra Kumar	Plant Breeding	Principal Scientist
12. Dr. Aditya Pratap	Plant Breeding	Principal Scientist
13. Dr. Dibendu Datta	Plant Breeding	Principal Scientist
14. Dr. Yogesh Kumar	Plant Breeding	Principal Scientist
15. Dr. A.K. Srivastava	Plant Breeding	Scientist (Senior Scale)
16. Mr. Udai Chand Jha	Plant Breeding	Scientist
17. Mr. Debjyoti Sen Gupta	Plant Breeding	Scientist
18. Mr. Abhishek Bohra	Plant Breeding	Scientist
19. Dr. Ashok Kumar Parihar	Plant Breeding	Scientist
20. Mr. Biswajit Mondal	Plant Breeding	Scientist
21. Mr. Amrit Lamichaney	Seed Science & Technology	Scientist
22. Dr. Satish Naik S.J.	Genetics & Plant Breeding	Scientist
23. Dr. Basavaraja T.	Genetics & Plant Breeding	Scientist

Plant Biotechnology

24. Dr. (Mrs.) Meenal Rathore	Biotechnology	Pr. Scientist & Head (In-charge)
25. Dr. Khela Ram Soren	Biotechnology	Scientist (Senior Scale)
26. Dr. Alok Das	Biotechnology	Scientist (Senior Scale)
27. Mr. P.S. Shanmugavadivel	Biotechnology	Scientist

28. Mr. Arvind Kumar Konda	Biotechnology	Scientist
29. Dr. (Mrs.) Neetu Singh Kushwah	Biotechnology	Scientist
30. Mr. Sudhir Kumar	Biotechnology	Scientist
Crop Production		
31. Dr. C.S. Praharaj	Agronomy	Pr. Scientist & Head (In-charge)
32. Dr. Narendra Kumar	Agronomy	Principal Scientist
33. Dr. Prasoon Verma	ASPE	Scientist (SG)
34. Mr. Kali Krishna Hajara	Agronomy	Scientist
35. Mr. Chaitanya Prasad Nath	Agronomy	Scientist
36. Mr. Man Mohan Deo	FMP	Scientist
37. Mr. Asik Daffa	Soil Science	Scientist (on study leave)
Crop Protection		
38. Dr. Krishna Kumar	Plant Pathology	Head of the Division
39. Dr. Bansa Singh	Nematology	Principal Scientist, Medal (Zology)
40. Dr. Mohd. Akram	Plant Pathology	Principal Scientist
41. Dr. Naimuddin	Plant Pathology	Principal Scientist
42. Dr. R.K. Mishra	Plant Pathology	Principal Scientist
43. Dr. R. Jagdeeswaran	Nematology	Scientist
44. Dr. G.K. Sujayanand	Entomology	Scientist
45. Mr. Bandi Sanjay Maruti	Entomology	Scientist
46. Mr. Devindrappa	Nematology	Scientist
47. Dr. Manjunatha L.	Plant Pathology	Scientist
48. Mr. Kiran Gandhi Bapatla	Entomology	Scientist
49. Mr. Ravanasidda	Entomology	Scientist
Basic Science		
50. Dr. P.S. Basu	Plant Physiology	Pr. Scientist & Head (In-charge)
51. Dr. D.P. Patel	Plant Physiology	Principal Scientist
52. Dr. T.N. Tiwari	Plant Physiology	Principal Scientist
53. Dr. M. Senthilkumar	Microbiology	Principal Scientist
54. Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
55. Mr. S. Gurumurthi	Plant Physiology	Scientist
56. Mr. Surendra Kumar Meena	Plant Physiology	Scientist
57. Ms. (Mrs.) Kalpana Tiwari	Biochemistry	Scientist
58. Mr. Vaibhav Kumar	Biochemistry	Scientist
59. Mr. Krishnashis Das	Microbiology	Scientist
Social Science		
60. Dr. Rajesh Kumar	Agril. Extension	Pr. Scientist & Head (In-charge)
61. Dr. (Mrs.) Uma Sah	Agril. Extension	Principal Scientist
62. Dr. Devraj	Computer Application	Principal Scientist
63. Mr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)

64. Mr. Shripad Bhat	Agril. Economics	Scientist
65. Mr. K. Ravi Kumar	Agril. Extension	Scientist
G. Regional Centre-*cum* Off-season Nursery, Dharwad (Karnataka)		
66. Dr. M.S. Venkatesh	Soil Science	Pr. Scientist & Station In-charge
67. Dr. M.H. Kodandaram	Entomology	Principal Scientist
68. Mr. P.R. Saabale	Plant Pathology	Scientist
69. Dr. Revanappa	Plant Breeding	Scientist
70. Mr. Manu B.	Genetics & Plant Breeding	Scientist
H. Regional Station, Phanda, Bhopal (Madhya Pradesh)		
71. Dr. (Mrs.) Archana Singh	EB & Plant Genetic Resources	Pr. Scientist & Station In-charge
72. Dr. Ram Lal Jat	Agronomy	Scientist
73. Mr. Alok Kumar	Seed Science & Technology	Scientist
74. Shri S.K. Ghritlane	Scientist	Scientist (Study leave)
I. Technical Officers		
75. Dr. M.P. Singh	Chief Technical Officer (T-9)	
76. Mr. S.P.S. Chauhan	Chief Technical Officer (T-9)	
77. Dr. G.K. Srivastava	Chief Technical Officer (T-9)	
78. Mr. R.S. Mathur	Chief Technical Officer (T-9)	
79. Dr. Omkar Nath	Chief Technical Officer (T-9)	
80. Mr. Radha Krishan	Assistant Chief Technical Officer (T-7/8)	
81. Mr. S.K. Garg	Assistant Chief Technical Officer (T-7/8)	
82. Mr. Ramesh Chandra	Assistant Chief Technical Officer (T-7/8)	
83. Mr. A.P. Singh	Assistant Chief Technical Officer (T-7/8)	
83. Mrs. Rashmi Yadav	Senior Technical Officer (T-6)	
84. Mr. Rajendra Prasad	Senior Technical Officer (T-6)	
85. Dr. Rajesh Kumar Srivastava	Senior Technical Officer (T-6)	
86. Mr. Krishna Autar	Senior Technical Officer (T-6)	
87. Mr. R.K.S. Yadav	Senior Technical Officer (T-6)	
88. Mr. Rakesh	Senior Technical Officer (T-6)	
89. Mr Kanhaiya Lal	Technical Officer (T-5)	
90. Mr. Kailash Chandra	Technical Officer (T-5)	
91. Mr. Lakhan	Technical Officer (T-5)	
92. Mr. R.K. Singh	Technical Officer (T-5)	
93. Mr. Malkhan Singh	Technical Officer (T-5)	
94. Mr. Ashraf Khan	Technical Officer (T-5)	
95. Mr. Arvind Singh Yadav	Technical Officer (T-5)	
96. Mr. R.M. Pal	Technical Officer (T-5)	
97. Mr. H.N. Maurya	Technical Officer (T-5)	

98.	Mr. S.N. Hatia	Technical Officer (Driver)
99.	Mr. K.S. Meena	Technical Officer (Driver)
100.	Mr. Satish Kumar Singh	Technical Officer (Driver)

J. Administrative

101.	Mr. Kumar Vivek	Senior Administrative Officer
102.	Mr. D.K. Agnihotri	Finance & Accounts Officer
103.	Mr. Shukdeo Mehto	Assistant Administrative Officer
104.	Mr. Rajendra Kumar Nigam	Assistant Administrative Officer
105.	Mr. B.K.Verma	P.S. to Director

Appointment, Transfer, Promotion, *etc.*

Transfers

Name	Designation	From	To	W.e.f.
Dr. Manu B.	Scientist	IIPR, Kanpur Dharwad	IIPR-RRC,	27.06.2019
Dr. Lalit Kumar	Pr. Scientist	IIPR-Kanpur	ICAR-IIFSR, Modipuram Meerut	30-11-2019 (A/N)
Ms. Poornima K.N.	Scientist	IIPR-Kanpur	ICAR-IIHR, Bangalore	30-11-2019 (A/N)
Sh. S.K. Ghritlahre	Scientist	ICAR-NRRI, Cuttak	IIPR, Kanpur	28-12-2019 (A/N)
Sh. Mayank Mishra	U.D.C.	IIPR R.S. Phanda, Bhopal	IIPR, Kanpur	07-10-2019 (A/N)

Promotions

Name	Promoted to	W.e.f.
Sh. Ravi Ranjan Singh	Sr. Technician	10.12.2017
Sh. Indra Bahadur	Sr. Technician	28.05.2017
Sh. Anand Kumar Yadav	Sr. Technical Assistant	20.10.2017
Sh. Babu Lal	Sr. Technician	17.06.2018
Sh. Amar Nath	Sr. Technician	10.06.2018
Sh. Devi Prasad	LDC	22.05.2019
Dr. A.K. Srivastava	Sr. Scientist	07-01-2017
Dr. Khela Ram Soren	Sr. Scientist	26-06-2017
Dr. Alok Das	Sr. Scientist	10-02-2018
Sh. Rajendra Kumar Nigam	Asstt. Administrative Officer	03-10-2019
Smt. Reeta Mishra	Assistant	03-10-2019
Sh. Mayank Mishra	Upper Division Clerk	03-10-2019

Retirement

Name	Post held	Date of retirement
Sh. Rajiv Nigam	AAO	31-08-2019
Sh. Rajendra Prasad	STO (Photographer)	31-08-2019

Obituary

- Sh. K.A. Chaturvedi, UDC left for Heavenly abode on May 21, 2019. May the departed soul rest in peace.

NOTE

NOTE

ISO 9001-2008

भाकृअनुप-भारतीय दलहन अनुसंधान संस्थान कानपुर 208 024

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