आत्मनिर्भर भारत

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agri search with a human touch

वार्षिक प्रतिवेदन
Annual Report
2020





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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 is my proud privilege to present the consolidated Annual Report of IIPR highlighting the most significant achievements of the Institute for the year 2020. It is indeed a great pleasure for me to mention about record pulse production in the country, which exceeded 24 million tonnes during 2020-21 making the country self sufficient. This unprecedented success in pulse production could be possible due to strong network of pulses research in the country that includes IIPR and its regional stations/centres, the NARS system and AICRPs. Strong infrastructure was developed with implementation of cutting–edge technologies at Institute level. 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, two *desi* chickpea varieties, IPC 2011-112 and IPC 2004-01 and two lentil varieties IPL 225 and IPL329 along with high yielding, disease resistant urdbean variety, IPU 13-1 have been released in Uttar Pradesh. Two chickpea varieties, IPC 2007-28 (*desi*) and IPCK 2012-143 (*Kabuli*) were identified for Uttar Pradesh. Chickpea genotypes T 39-1, ICC 5912, and ICC 8397 were identified as stable high protein (~28%) germplasm accessions. CMS-based pigeonpea hybrid IPH 09-5 was released for NWPZ with 30.5% yield superiority over UPAS 120. Mungbean varieties IPM 512-1 (Soorya), IPM 409-4 (Heera) and IPM 312-20 (Vasudha) resistant to MYMV and *Anthracnose* have been released for NEPZ and Uttar Pradesh for cultivation during spring season. Three high yielding and disease resistant (powdery mildew and rust) fieldpea varieties IPF16-13 (*harit*) IPFD12-8 (*Aakash*) and IPFD 13-2 (*Anant*) have been released for NEPZ.

A total of 28 QTLs for salinity stress, yield and its related traits in chickpea were identified. 6177 SNPs markers were mapped in the cross K850 x IPC 2004-52 in eight different linkage groups for wilt resistant gene in chickpea. Improved MABC lines (*viz;* IPC L4-25, IPC L4-7 and IPC L 22-33-2) in genetic background of DCP 92-3 showed > 16% significant yield advantage over the recurrent parent. Waterlogging tolerant genotype IPAC 79 resistant to *Phythopthora* stem blight was registered with NBPGR. Association analysis with pigeonpea plant ideotype trait BLUP values following MLM Q+K model identified 22 MTAs for various traits like phenology, branches etc. Candidate genes related to flowering traits in pigeonpea such as Glycosyltransferase, cold-responsive protein kinase 1, NRT1/ PTR FAMILY 5.4 and root phototropism protein 2 were identified. Genome assembly of *Fusarium oxysporum* f. sp. *ciceris* was refined. Four diagnostic SSR markers could discriminate cowpea varieties (PL 3, 4 and 5) at molecular level. The *Bt* isolates F5.iipr exhibited highest chitinolytic activity and also the highest per cent mean mortality in root knot nematode. ODAP synthase gene structure was characterized in a set of grasspea genotypes. Genes for Raffinose Family Oligosaccharides (RFOs) biosynthesis pathway in pea genome was identified using Bioinformatics approaches. Stability of the multigene, marker free and pod specific *cry1Ac* and *cry2Aa* gene constructs in *Agrobacterium* have been assessed. In chickpea, three herbivore and pathogen inducible chitinase genes were identified. Genome wide Identification of 10, 6 and 18 Wound Induced Protein (WIP) genes were deciphered in chickpea, *Medicago* and *Arabidopsis*, respectively.

In Crop Production research, maximum system productivity and monetary returns were obtained under rice-wheat-mungbean system and inorganic fertilizers. The pulse-based rotation increased total

inorganic P in soil. Maize-wheat-mungbean (MWMb) and maize-wheat-maize-chickpea (MWMC) systems with integrated nutrient management (INM) increased soluble phosphorus (P) in soil. Available P increased with FYM addition in the rhizosphere. Soluble P increased in the rhizosphere of pigeonpea by 82% under INM. Productivity of fieldpea under zero tillage was observed to be lowered down crop water use and production cost and enhanced productivity and input use efficiency. Salicylic acid at 100 ppm was advantageous for increasing chickpea yield, water use efficiency and water productivity. Significantly higher yield was observed in chickpea under organic practice alone (FYM application combined with Biozinc and Biophos spray at flower & pod development). Integrated effect of R-W-Mb and INM had impact on P pool over R-W and RDF. About 32.5% higher grain yield of mungbean was recorded under Conservation Agriculture (CA). Early pigeonpea (UPAS 120) +urdbean-wheat (Unnat Halna) and early pigeonpea (UPAS 120)-wheat (Unnat Halna) could be recommended under CA for higher system productivity and sustainability. The system productivity in terms of mungbean equivalent yield was maximum in RWMb. Clodinafop-propargyl + Na-acifluorfen (IRIS) 122.5 ga.i/ha at 10-15 DAS in *kharif* mungbean and Topramezone 20.6 ml a.i./ha at 14 DAS in chickpea had minimum phyto-toxicity and higher weed control efficiency. Variable crop and genotypic tolerance to topramezone was also observed. *Sesbania* and halosulfuron methyl application in summer season reduced *Cyperus rotundus* and total weed density in *kharif* and subsequent seasons. Further, ammonium molybdate application also significantly influenced both soil- and seed-N content. Three grit roller upgraded the IIPR Mini Dal Mill for better pitting of pulses (64.3% dehusking).

In Crop Protection, promising pigeonpea lines were identified as resistant against Fusarium wilt and *phytophthora* stem blight (PSB).A talc based formulation of DALHANDERMA (IIPRTh-31) was developed for soil borne diseases. Chickpea accession IC 244324 was highly resistant under wilt sick plot. Eleven chickpea lines were identified as resistant against *Ascochyta* blight. Seven isolates of *Botrytis cinerea* infecting chickpea were characterized at different levels. Chickpea seed treated with *Bacillus subtilis* recorded minimum incidence of *Ascochyta* blight. Minimum BGM was observed in treatment, ST with *Trichoderma asperellum*. Using multiplex PCR, mating types of *A. rabiei* were identified. The first RAPD-SCAR marker designed as SCAR1F/SCAR1R for *Ascochyta rabiei* identification was developed. Several pigeonpea, mungbean and urdbean genotypes were identified as moderately resistant against *Meloidogyne javanica.* Five lines of pigeonpea *viz.* WD 2019-7, WD 2019-47, WDBCE 9-4-3-1, WDBCE 4-5-3-9 and WDBCE 6-3-5-1 and one line of urdbean GJU 1509 were observed highly resistant against cyst nematode, *Heterodera cajani.* GSL-2, Neelam and Sheetal varieties of *Brassica napus* and Karan Tara of *Eruca sativa* reduced nematode population. Emamectin benzoate was found to be the most suitable insecticide formulation for managing tobacco caterpillar, *S. litura*. The *Bt* isolates F5.iipr exhibited highest chitinolytic activity and also the highest per cent mean mortality in root knot nematode. The plant volatile/essential oils of plant species were identified for having contact toxicity against pulse beetle. The actinobacteria strains, *Streptomyces ginkgonis* IIPR:HD01:05 strain showed significant inhibition of *Rhyzoctonia bataticola* and *Fusarium oxysporum* f.sp. *cicieri*. The gamma irradiation dose 200 Gy found to be effective against bruchid infestation.

In the Basic Science Division, research activities involved foliar application of Jasmonic acid @ 5 µmole at the stage of flowering in chickpea variety, DCP 92-3 which significantly increased yield under drought stress. The highest percent pod retention under cold stress was observed in tolerant group (67.31%) such as MAL-13, NDA-2 and ICP 2275. Lentil genotypes IG 3522, IG 4112 and IG 2507, performed better under heat stress. The blackgram genotypes PU-19, IPU 99-179, IPU 99-213, PLU 65 and PGRU 95016 were identified as photo and thermo period insensitive. The esterase enzyme activity as a measure of stigma receptivity was found to be relatively more in the heat tolerant chickpea genotypes (ICCV 92944, ICC 1205 and Annigeri) as compared to the susceptible genotypes (ICC 10685 and Pant G 114). In fieldpea, phenolics like gallic acid, and catechin hydrate were detected. Free and bound phenolics of cowpea identified were gallic acid, protocatechuic acid, catechin hydrate, p-coumaric acid and ferulic acid in diverse genotypes while caffeic acid, ellagic acid and quercetin were detected only in few genotypes. Oligosaccharides such as verbascose, stachyose and raffinose were the major alpha galactosides in field pea while only stachyose and raffinose detected in cowpeas. The field pea and cowpea have enough alpha galactosides causing flatulence as humans lack the enzyme alpha galactosidase required for their breakdown. The concentration of alpha galactosides in both, field pea as well as cowpea, can be significantly reduced by indigenous processing treatments while *Rhizobium* IIPR-MR-127 for mungbean and *Rhizobium* stream IIPR-UR-32 for urdbean were identified as potential candidates for high nodulation. Pigeonpea genotypes IPAC 632,



IPAWD 1-2-1-2 and IPAWD 10-1 and urdbean genotypes IPU 99-141 and IPU 99-95 had up to 80% higher nodulation. The rajmash genotype IC 356018 and EC150250 were found positive for nitrogenase activity. Rajmash genotypes IC 417352, IC 338795, IC 356018, EC 150250, and IC 356072 were identified as high nodulating lines. Rhizobial isolates IIPR-RR11, IIPR-RR14, IIPR-RR17 and IIPR-RR40 were identified as most promising.

Sixty four putative CaNCR peptides from *Cicer arietinum* and 32 CrNCR peptides from *Cicer reticulatum* were identified, of which, 16 CaNCR peptides and 8 CrNCR peptides are unique and reported first time. Gene structure analysis revealed that NCR peptides of chickpea possess 0-2 introns. These introns were not observed in IIPR CaNCR56, IIPR CaNCR58 and IIPR CaNCR60, while coding region of 78% of IIPR CaNCR genes possess single introns.

In outreach programmes, 238 farmers having 59.46 ha area were covered for different interventions in crops including paddy, mango, guava, mustard, mungbean, maize, okra and chilli as well as fisheries and vermi-compost unit under Farmer FIRST project. Total 47 farmers adopted Virat variety of mungbean in 10 ha area for additional income and employment. Total 51 farmers on 16.66 ha area were covered for demonstration of rice variety Pusa Basmati-1509 with critical inputs which supported production and income in project area. Several farmers were also provided with improved variety of summer maize, chilli and Navya variety of okra for generation of additional income and employment during the COVID -19 pandemic in project villages. Ten vermi-compost units were established in project area for the purpose of organic vegetable cultivation and maintaining proper level of organic matter content in soil, improving the fertility status and increasing water holding capacity of soil. Mobile app services for farmers and web console services for experts have been designed and developed on mKRISHI platform. Several extension training programmes were organized for different stakeholders. MGMG and SCSP programme were implemented in Kanpur Dehat, Kanpur Nagar, Fatehpur, Kannauj, Unnao, and Hamirpur districts of Uttar Pradesh for benefiting Scheduled Caste farmers. Under FLD programme, 57 demonstrations on pigeonpea, mungbean, chickpea, field pea and lentil were conducted in different districts of Uttar Pradesh to increase the pulses production.

During the report period, major activities of Regional Station Bhopal, included release of one variety of urdbean (IPU 17-1) in Madhya Pradesh. Unique genotypes for anthocyanin rich, open flower (IC 349468) and earliy genotypes (IC 271435, IC 209236, IC 468644) were identified in *desi* chickpea. Genotype IPC 18-124 was identified for early maturity (96 days). Under ICARDA FLRP chickpea trials, three entries, FLIP 09-104C (54.20 gm), FLIP 07-6C-S1 (50.65 gm) and FLIP 09-191C (48.70 gm) were identified as extra-large seeded entries. Total 1036 pigeonpea germplasm lines were screened which led to the identification of determinate dwarf, early maturity, high yielding, and non-determinate type, medium early duration and for high yielding and early maturing (105 d) under ICRISAT trials. Shuttle breeding programme in pigeonpea was also executed. The germplasm screening of grasspea and mutagenesis were done for low ODAP content. Several mutants of grasspea were grown in M5 generation to select low ODAP lines. Total 237.4 q breeder seed was also produced for different pulses. 229 farmers were benefitted with the seed distribution of new pulse crop varieties under SC-sub-plan. At Regional Centre, Bikaner, 100 moth bean accessions were evaluated in arid ecosystem for selection of different plant types *e.g.* erect, semi-erect and spreading and few promising were identified on the basis of yield and plant morphological characteristics. Mungbean genotypes IPM 1103-1 and IPM 410-3 showed considerable resilience to drought.The pigeonpea accessions. SEDT08 and SEDT 06 showed better growth and performance under drought.

I am grateful to honorable Secretary DARE and DG ICAR, Dr Trilochan Mohapatra; DDG (CS) Dr TR Sharma and ADG (O&P) Dr Sanjeev Gupta for their constant support and guidance. I appreciate the efforts of the Project Coordinators, Drs. G.P. Dixit, Sanjeev Gupta, I.P. Singh, Shiv Sewak and the Heads of Divisions including, Drs. Farindra Singh, CS Praharaj, Bansa Singh, P.S. Basu, Rajesh Kumar and Meenal Rathore for research inputs from their respective divisions. I am thankful to the members of Publication Committee Drs. P.S. Basu, Aditya Pratap, Mohd. Akram, (Mrs.) Meenal Rathore and Member Secretary, Dr Rajesh Kumar Srivastava for their praiseworthy efforts towards editing and bringing out the Report. Last but not the least, I am thankful to all my 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



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Executive Summary

Crop Improvement

- Two *desi* chickpea varieties namely, IPC2011-112 and IPC2004-01 have been released and notified in 2020 for cultivation under timely sown condition in Uttar Pradesh. The average yield of 2004-01 was 1396 kg/ha which registered 9.0% yield superiority over best check KWR108 and matures in 135-140 days. It is moderately resistant to wilt. IPC2011-112 yielded 1296 kg/ha registering 12.1% yield superiority over the best check variety KWR108. It matures in 122 days and is resistant to wilt with medium seed size (22g/100 Seed wt.).
- Lentil variety IPL225 was released and notified for Uttar Pradesh state under timely sown condition with registered yield superiority of 8.86% over check variety KLS218 and matured in 124 days.
- Lentil variety IPL329 was released and notified for Uttar Pradesh state under timely sown condition with registered yield superiority of 9.03 % over check DPL62 and matured in 124 days.
- Mungbean variety IPM512-1 (Soorya) has been released and notified for cultivation in NEPZ during spring season. It recorded a yield advantage of 15.8%, 13.6% over Pusa Vishal and Pant Mung 5, respectively with high dgree of resistance to MYMV, anthracnose and moderate resistance to *Cercospora* leaf spot. Very less pod damage due to thrips has been observed in this variety.
- Two mungbean varieties IPM409-4 (Heera) and IPM312-20 (Vasudha) were released and notified for cultivation during Spring in Uttar Pradesh. IPM409-4 (Heera) performed consistently better over best check IPM99-125 in the UP SATs and yielded 10-12q/ha and it matured in 55-57 days with medium large seed (3.5g/100 seed). Another variety IPM312-20 (Vasudha) produced 10-11q/ha with shining, attractive, medium large seeds (3.9g/100 seed) and is resistant to yellow mosaic, Cercospora leaf spot and powdery mildew diseases.
- Urdbean variety IPU13-1 was released and notified for cultivation in UP during *Kharif season*. It mature in 72 days and has a potential yield of 10-12q/ha and is resistant to most of prevalent diseases like MYMV, ULCV, powdery mildew, anthracnose, and *Cercospora* leaf spot.
- Fieldpea variety IPF16-13 (*harit*) was released and notified for cultivation under NEPZ. It yielded 1752 kg/ha with 12.5% and 28.5% yield superiority over checks VL42 and HUDP15, respectively. It is resistant to powdery mildew and moderately tolerant to rust.
- 2 fieldpea varieties, IPFD12-8 (*Aakash*) and IPFD13-2 (*Anant*) were released and notified for cultivation in Uttar Pradesh and yielded 1158 kg/ha and 1409 kg/ha with 15 % and 24% yield superiority over the best check KPMR522, respectively.
- CMS-based hybrid IPH 09-5 was released and notified for cultivation in NWPZ. The mean yield of 1822 kg/ha was recorded under AICRP with registered yield superiority of 30.5% over UPAS120. This hybrid has shown the potential yield of 2293 kg/ha. It matures in 151 days, which is 7-10 days earlier than UPAS120. The average fertility restoration was 90.26% over 4 years. The 100-seed weight of 9.6g was recorded with better seed colour, shape and size than UPAS120.
- The long duration pigeonpea variety IPA15-2 (Sharada) has been notified for cultivation in NEPZ and it yielded 2281 kg/ha with a yield superiority of 25.2%, 30.0%, 20.7% and 20.3% over Bahar, IPA203, NDA-1 and MA 6, respectively. It matures in 245-255 days and shows resistance against wilt and SMD.
- Two chickpea varieties including one *desi* variety namely IPC2007-28 and another of *kabuli* type, IPCK2012-143 were identified for release in Uttar Pradesh. Genotype IPC2007-28 produced an average yield of 1683 kg/ha registering 11.9% yield superiority over the best check variety KPG59 under late sown condition. It matures in 128 days and is resistant to wilt. *Kabuli* line IPCK2012-143 yielded 1071kg/ha registering 35.4% yield superiority over the best check variety. It matures in 118-120 days and is resistant to wilt. It has large seed (34.5g of 100 seed wt.) with cream colour.
- A *kabuli* chickpea entry IPCK2013-163 was promoted to AVT-2 under NWPZ and WCZ. Beside, two *desi* chickpea entries namely, IPC2016-44 (NEPZ & ECZ) and IPC2015-123 (NEPZ) were found promising under AICRP trials and were promoted to AVT-1 in different zones (NEPZ and ECZ) under timely sown condition.



- Total 5879 SPS including **41** F_2: 518 SPS, **83** F_3: 2850 SPS, **63** F_4: 1492 SPS, **50** F_5: 607 SPS, **114** F_6: 396 SPS and **35** F_7: 16 SPS were harvested based on the targeted traits. Total 260 lines and 63 plot bulks were harvested from different generations for sharing with NARS partners.
- Germplasm accessions T39-1, ICC5912, ICC8397 of chickpea were identified as having high protein Content.
- Four hundred trait-specific germplasm accessions of chickpea were evaluated and maintained. Additional 113 wild accessions belonging to 7 *Cicer* species (42 *C.reticulatum*, 32 *C.judaicum*, 27 *C.pinnatifidum*, 6 *C.echinospermum*, 3 *C.cuneatum*, 2 *C.yamashitae* and 1 *C.bijugum*) were maintained in wide hybridization garden.
- Total 10 mapping populations (RILs) were developed through single seed descent method for heat including DCP92-3/ICC92944 (F_7 **232**); JG315/ICC 92944 (F_5 211), JG11/ICC1205 (F_5 **204**), DCP92-3/ICC96030 (F_5 **219**), DCP92-3/ICC1205 (F_5 **215**) and nutritional quality [IPC 2004-98/ T39-1 (F_6 **305**), JAKI 9218/T39-1 (F_5 **200**), JG 16/ T39-1 (F_5 **188**), DCP 92-3/ T39-1 (F_5 **189**), ICC4958/T39-1 (F_5 **192**)] to advanced next generations.
- A panel of 30 chickpea genotypes was evaluated for tolerance to post emergence systemic herbicide imazethapyr @ 120g/ha. The recommended dose of 75g/ha were applied for confirmation. Five entries, ICC12337, ICCIL04004, ICCV92504, ICC3575, ICC12316 performed better than check IPC18-186 sprayed with imazethapyr 1.5X. Two accessions, ICC11101 & IPC18-186 exhibited stable tolerance against targeted herbicide.
- Chickpea breeding line IPC10-121 showing resistance to *wilt* (race-2) has been identified for registration and the proposal has been submitted to NBPGR for registration as genetic stock. Two breeding lines (IPC10-78 and IPC07-28) were identified by Institute germplasm registration committee for registration.
- 110 breeding lines of chickpea with checks (JG14, JG16) were screened for tolerance. 19 lines (IPC15-48, IPC15-185, IPC17-54, IPC17-256, IPC17-351, IPC17-377, IPC17-53, IPC17-102, IPC12-211, IPC16-25, IPC18-154, IPC17-67, IPC15-12, IPC16-39, IPC17-308, IPC16-236, IPC17-373, IPC12-31, IPC15-165)were identified possessing heat tolerance with higher seed setting of top pods of plant and produce more yield than check JG14.
- Long duration pegionpea genotype IPA15-21 showed 12.5% yield superiority over IPA203 and was promoted to AVT-1 for NEPZ under AICRP. 4 entries IPA19-6, IPA19-29, IPA18-33, IPA19-55 were nominated for IVT for NEPZ under long duration category. In addition the long duration genotype at IPA15-6 is being evaluated in AVT-2 for CZ under AICRP.
- Three pigeonpea hybrids, IPH18-04, IPH18-09 (IHT) and IPH17-01 (AHT-1) showed 29%, 33% & 17%, superiority over best check ICPL88039 (1299 kg/ha) under AICRP.
- Two late maturing genotypes, IPA9-1, IPA13-1 have been promoted to SAT-2. Likewise, 7 entries, IPA2014-2, IPA2014-4a, IPA2015-2, IPA2015-19 and IPA16-18, IPA2014-6, IPA2014-7 are at SAT-1 stage in UP state adaptive trial.
- Total 30 sterile (A) lines, cognate maintainer (B) and 80 restorer (R) lines are being maintained in pigeonpea. The stable line GT288A was used a cytoplasm donor for new CMS conversion. The complete male sterility was observed in the BC_4F_1 (ICP88034, ICP20338, ICP11255, ICP20340, PAU 881) and BC_6F_1 lines (AL15, ICP7148, AL201, Pusa2002-2, MN 5).
- Total 21 accessions of wild pp. including *C. albicans*, *C. lineatus*, *C. sericeus*, *C. platycarpus*, *C. scarabaeoides* and *Rhynchosiaru fescens*, *R. bracteata* were maintained. 717 long duration and 315 early maturing lines were planted for rejuvenation. 7 wild spp. namely, *C. scarabaeoides*(22 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.
- Two cultivated genotypes namely, IPAC2 and IPA15-8 and 3, wild accessions viz. IPAW14-1 ©. *scarabaeoides*), IPAW14-2 (*C. scarabaeoides*), IPAW-14-5 (*C. platycarpus*) showed consistent resistance over the years to PSB under sick plot. IPAC2, IPA15-8, IPAW14-1, IPAW14-2 and IPAW-14-5 genotypes have been identified as donor for resistance to *Phythopthora* stem blight.
- Waterlogging tolerant genotype IPAC79 was registered with NBPGR which develops new roots above crown region and aerenchyma cells enhancing the survival rate under waterlogged condition and resistance to Phythopthora stem blight disease. Additionally, IPAV16-1 has been registered with NBPGR for high seed weight. This genotype exhibited high dried and green

weight of 23.04 and 52.00 g per 100 seeds, respectively.

- 13 lentil entries were evaluated under AICRP trials. IPL237 recorded 1189 kg/ha with yield superiority of 7.6% over best check VL126 and was promoted to AVT -1 for NHZ.
- Two small seeded lentil varieties IPLS231 and IPLS232 and a large seeded variety IPLB338 have been identified for release in Uttar Pradesh. In addition, 15 entries are being evaluated in SAT-2, SAT-1 and IET during *Rabi* 2019-20.
- During 2019-20, 2 station trials with 15 entries each were evaluated for yield performance. In ***ST-I,*** 2 entries IPL11702 and IPL171423 (22.2 q/ha each) with early maturity (116 days) have been identified promising over check variety DPL62. In ***ST-II,*** 5 small seeded entries, IPL10834, IPL151229, IPL161502, IPL161421, IPL131103 and IPL161426 were identified promising with mean yield (range) from 19.2q/ha to 20.9 q/ha over check variety IPL220 (18.3 q/ha).
- 33 crosses were developed in lentil. 27 F_1, 12 F_2 , 9 F_3, 21 F_4, 44 F_5 and 44 F_6 segregating populations were advanced.
- Trait specific RIL mapping populations for early seedling vigor (ILL7663/DPL15) having 160 RILs; root traits (IPL98/193/EC208362) having 200 RILs; earliness (L4603/ Precoz) having 160 RILs, wilt resistance (PL02/Precoz) having 160 RILs were maintained in lentil.
- 450 lentil accessions of active germplasm and 90 accessions of Mediterranean land races were grown for maintenance.Total 158 accessions of wild species were maintained and 834 accessions of lentil germplasm have been rejuvenated at Bhopal center.
- 13 mungbean entries were evaluated in AICRP during 2020. Geneotype IPM101-102 and IPM604-16-2 were promoted to AVT 2 and AVT 1, respectively in NEPZ during Spring season. IPM312-394-1 was promoted to AVT 1 in NHZ for cultivation during *Kharif* season.
- During *Kharif* 2020, 4 station trials were conducted. In ***ST1***, genotypes IPM1603-4, IPM101-102-1 and IPM9906-1-1 yielded better than the best check IPM410-3 (Shikha) and matured in 65-70 days. In ***ST2***, IPM101-102, IPM1603-3, IPM1604-1 and IPM1603-7 were better than best check (Shikha) and highly resistant to MYMV. In ***ST3***, IPM06-5, IPM409-4, IPM1620-5, IPM1205-2 and IPM 1604-4 yielded better than check IPM02-3. In ***ST4***, IPM1611-2, IPM701-704 and IPM312-18 were either better or on at par with best check IPM02-3. All these superior performing lines were also highly resistant to MYMV disease.
- During spring 2020, 2 station trials were conducted. In ***ST1***, genotypes IPM1610-1, IPM604-1-6, IPM1604-1 and IPM1603-3 yielded better than the best check IPM 2-3. In ***ST2***, IPM1205-2, IPM1604-4, IPM312-18-2 and IPM312-17-8 recorded better yield than check IPM205-7.
- 250 lines from 21 *Vigna* spp. were maintained in wild garden. There included *V. radiata (15), V. radiata* var. *setulosa (2),V mungo (12), V. sublobata (8), V. trilobata (108), V. umbellata (18), V. aconitifolia (8), V. sylvestris (8), V. stipulaceae (35), V. unguiculata*sp. *cylindrica* (4), *V. sinensis (8), V. hainiana* (4), *V. trinernia* var. *bournei* (3), *V. glabrescens* (1), *V. pilosa* (3), *V. trinernia* (1), *V. dalzelliana* (3), *V. unguiculata* (10), *V. vexillata* (2), *V. khandalensis* (1) V. *unguiculata* ssp. *unguiculata (4)*.
- 5mungbean accessions, VI004957AG, VI004934AG, VI004973B-BLM, VI004937AG and VI002190BG were found highly resistant to MYMV based on multi-season/multi-location data.
- Urdbean variety IPU19-10 was promoted to AVT-1 and yielded 1910 kg/ha and was better than best check in NWPZ zone under AICRP (MULLaRP). Besides the entry IPU10-30 was promoted for third year testing in UP State Adaptive Trials and showed superiority over best check
- 41 crosses were attempted for development of genetically improved breeding lines for abiotic stress tolerance (drought-heat tolerance and photo-thermo insensitivity) coupled with new plant type for new niches of different agro-ecological conditions during *Kharif* 2020.
- Based on F_2 phenotypic data in urdbean, shiny testa trait was dominant over Dull. MYMV resistance was dominant over susceptibility. Mottled green seed colour was dominant over black. In these cases single gene was found to be operative which was further confirmed in $F_{2:3}$
- One extra early fieldpea genotype IPFD18-14 has been recommended by Institute Germplasm and Genotype Identification Committee (GGIC) for registration with NBPGR, New Delhi.
- 2 tall type field pea entries, IPF19-18 and IPF19-



11, have been promoted in AVT-1 under NEPZ & CZ, respectively. Similarly, 2 dwarf entries, IPFD19-1 & IPFD19-3 were promoted in AVT-1 under NEPZ. 6 entries, IPF19-11, IPF19-15. IPF19-18, IPFD 19-9, IPFD19-1, IPFD19-3 were evaluated in IVT under tall and dwarf AICRP trials. 3 fieldpea entries, IPFD16-3, IPF14-16 and IPFD15-5 were found promising based on three years testing under UP SATs.

- Fieldpea variety IPFD14-2, an early maturing line with higher root length under rice fallow situation was recommended for cultivation under rice fallow area.
- 34 fresh crosses were attempted and 40 crosses were raised to advanced F_1 generation. Total 1506 SPS including 35 F_2: 400 SPS, 63 F_3: 556 SPS and 46 F_4: 550 SPS were harvested based on the targeted traits. In addition, 226, 154 and 47 SPS were harvested from F_5, F_6 and F_7 generation, respectively. A mapping population derived from HFP4(S)/FC1® (F_7 310) cross for rust resistance in fieldpea was advanced during *Rabi* 2019-20.
- Two station trials including dwarf and tall type fieldpea entries were conducted during 2019-20. In ***ST1*** (dwarf), IPFD2020-3 & IPFD2020-9 yielded more than best check IPFD12-2, while in ***ST2*** (tall), IPF2020-17 & IPF2020-21 were top yielder over the best check IPF16-13.
- 15 new cowpea crosses were attempted with trait specific donors during *kharif* 2020. The F_2, F_4 and F_4 generations from 11,10 and 2 crosses were evaluated.
- Total 670 cowpea germplasm accessions and released varieties were evaluated for rejuvenation, and maintained for their utilization in future breeding programme. In addition, 190 germplasm accessions were rejuvenated and evaluated for different morphological traits at RRS, Dharwad.
- Total 1934 rajmash germplasm accessions were procured and maintained at IIPR Kanpur. 600 accessions were evaluated for morphological and agronomic traits. In addition, 101 biofortified lines of rajmash received from CIAT were evaluated and characterized.
- 5 fresh rajmash crosses were attempted for desired traits *viz*., BCMV resistance, bush plant types, anthracnose disease resistance and cold tolerance.
- Rajmash accessions EC150250, GP203, IC340947, ET4515, EC540173. IC360831 and BLF101 showed high degree resistance and these were stable across the location and green house condition.
- A total of 13 entries with 4 checks (Uday, Arun, Utkarsh and HUR15) were evaluated in station trail for yield and yield attributing traits. Two entries IPR277-19 and IPR 205-19 yielded more over best checks (Uday & Utkarsh) with BCMV disease.

Plant Biotechnology

- Axiom®*CicerSNP* Array was deployed for construction of high-density linkage map in chickpea comprising of 1856 SNP markers and spanning a distance of 1106.3cM across eight chromosomes.
- 28 QTLs for salinity stress indices, yield and its related traits in chickpea were identified explaining up to 28.40% phenotypic variance. Two QTL clusters on CaLG03 and CaLG06 harbouring 7 major QTLs were also identified.
- 763 predicted genes were idntified from QTLs region (~3.3MB) from CaLG03 and 156 genes from ~0.1Mb QTL region in CaLG06.
- 6177 SNPs markers were mapped in the cross K850 x IPC 2004-52 in eight different linkage group (CaLG01- CaLG08) and were identifiyed putative QTLs in CaLG1, CaLG3, CaLG4, CaLG5 and CaLG7 for late wilting resistant gene in chickpea.
- Improved MABC lines (*viz;* IPC L4-25, IPC L4-7 and IPC L22-33-2) in genetic background of DCP92-3 showed >16% significant yield advantage over the recurrent parent in station trails. There lines have been submitted to AVT1 in AICRP chickpea during 2019-20.
- Association analysis with pigeonpea plant ideotype trait BLUP values following MLM Q+K model identified 22 MT. As for traits namely days to initial flowering days to fifty percent flowering, days to maturity, plant height, and number of primary branches and identified candidate genes related to flowering traits in pigeonpea such as Glycosyltransferase, cold-responsive protein kinase 1, NRT1/ PTR FAMILY 5.4 and root phototropism protein 2.
- Genome assembly of *Fusarium oxysporum* f.sp. *ciceri* and *Fusarium udum* with a size of 55.87 Mb and 62.23Mb, respectively was refined.
- Identified 46 such mimp (Miniature Impala) transposable elements in *Fusarium oxysporum* f.sp. *ciceri* 4 mimp TE and its associated virulence genes in *F. udum*.



- Decapitated embryonic axis of mungbean cv. ML 267 regenerates *in vitro* to reproducibly give multiple shoots per explant with BAP as choice phyto hormone and to achieve rhizogenesis on MS alone.
- Identified 4 diagnostic SSR markers that may aid in discrimination of cowpea varieties (PL 3, 4 and 5) at molecular level.
- The *Bt* isolates F8.IIPR was micro encapsulated and it ranged from 8.79 µm to 67.86µm. This micro encapsulated product was found to be stable for 120 days. Further the same isolate and F5.iipr exhibited highest chitinolytic activity and also highest percent mean mortality in root knot nematode.
- Characterized ODAP synthase gene in terms of gene structure, number of exons and introns, PCR amplification and size difference in agarose gel in a set of grasspea genotypes.
- Genes for Raffinose family oligosaccharides (RFOs) biosynthesis pathway in pea genome identified using Bioinformatics approaches.
- Stability of the multigene, marker free and pod specific cry1Ac and cry2Aa gene constructs in *Agrobacterium* has been assessed.
- In chickpea, three herbivore and pathogen inducible chitinase genes were identified: Car_Chi-1, Car_Chi-2 and Car _Chi-13. Car chi-1 was found to be the most effective at binding chitin oligomers than Car chi-2 and Car chi-13.
- Genome wide Identification of 10, 6 and 18 Wound Induced Protein (WIP) genes were deciphered in chickpea, Medicago and Arabidopsis, respectively. Conserved synteny and tandem duplication events drive the expansion of intronless Wound Induced Protein gene family.
- Draft genome sequencing of F6.IIPR revealed 391 contigs, 35% GC content, genome length of 6,342,611 bp and contig N50 value of 90602. The F6.IIPR genome has 6,887 protein coding sequences (CDS), 84 transfer RNA (tRNA) genes, and 6 ribosomal RNA (rRNA) genes.

Crop Production

- Maximum system productivity and monetary returns were observed under rice-wheat-mungbean and inorganic fertilizers (at par with INM). Yields of cereal crops (rice and wheat) were also higher under inorganic fertilizers followed by INM and the control.
- In a long-term experiment involving rice based cropping system, the study revealed that pulse inclusive cropping systems and INM led to higher weed emergence in surface soil over others (rice-wheat and inorganic fertilizer involving NPKSZnB). Maximum nodulation in chickpea was in INM. Rice-wheat-mungbean and INM also resulted in higher aggregated N & P content at 0-20 cm soil.In addition, rice-wheat-rice-chickpea (2-years rotation) and INM had higher K pools in this surface depth.
- Maize-wheat (MW) raised soil soluble P, while pulse based rotation increased total inorganic P in surface soil.Maize-wheat-mungbean (MWMb) and maize-wheat-maize chickpea (MWMC) with INM also increased soluble P at both soil depths.Integrated effect of MWMB and INM was distantly situated from that of M-W and RDF which highlighted the fact that cereal system (MW) with RDF had detrimental effect on soil nutrient status.
- In Maize/Bajra based cropping system the study revealed that pigeonpea-wheat (PW) and INM recorded higher weed emergence in surface and sub-surface soil.PW and INM had higher macro- and micro-aggregated N and P compared to others. MWMb and INM also resulted in significantly higher diversity indices compared with M-Wand RDF.
- Rhizospeheric studies showed that available P content increased with FYM addition as was prominently higher in soil in the rhizosphere than the bulk soluble P also increased in the rhizosphere of pigeonpea by 82% under INM plots over that in control.
- PSB was important for cereals rather than in pulses and its effect was more conspicuous following addition of organic sources like crop residues under INM. Incubation experiments showed following addition of organic residues in the soil, net P mineralisation increased (16% more P release in the soils amended with FYM compared to control).
- Productivity of fieldpea grown during *rabi* could be sustained with zero tillage as it lowered down crop water use, production cost while scaling productivity and input use efficiency. Therefore, practice of zero or minimum tillage for pulses during *rabi* season could be adopted.
- No difference in fieldpea crop responses (grain yield, biomass, yield attributes, water use efficiency and economics) to irrigation schedules (sprinkler or flood) was apparent due to frequent rainfall events (10 rainy days in 2019-20).
- No improvement in chickpea productivity or net



returns with hydrogel was observed. However, the least BCR was calculated at the highest hydrogel use (5 kg/ha) under rainfed condition. However, salicylic acid at 100 ppm at flower & pod development (at par under 2% urea and 0.5% NPK) was advantageous in respect of chickpea 'JG 16' grain yield (22.4%),WUE(20.1%), WP(15.3%), and net return (31.2%) over water spray under rainfed/deficit soil moisture condition.

- Organic farming in long duration pigeonpea (LDP) could enhance its performance (similar to inorganic NPK). In LDP, highest yield could be realized at 75 x 20 cm in low fertility/light soils under IGP. Significantly higher yield in chickpea can be realized with organic practice alone (FYM application combined with Biozinc and Biophos sprayat flower & pod development).
- Notable genotypic variations existed for lentil under relay cropping (surface seeding method). Also variations did exist for seed position on crop establishment with surface seeding in pulses.
- Wet-tillage (puddling) operation markedly increased rice productivity in alkaline sandy-loam soil of Kanpur by increasing water retention, suppressing weed growth, and increasing soil nutrients and root growth.
- Chickpea and lathyrus had higher rhizospheric acidification potential that subsequently increased the Olsen-P in the rhizosphere (being higher with chickpea and lathyrus over other pulses).
- Rice-wheat-mungbean and rice-chickpea increased labile organic P and fulvic acid in soil. Pulse inclusion in the existing cropping systems increased P pool in soil. INM practice increased organic P fraction at both soil depths.Association between crop rotation & nutrient management showed that integrated effect of R-W-Mb and INM had impact on P pool over R-W and RDF at both depths.
- On an average 32.5% higher grain yield of mungbean was recorded under conservation agriculture (CA) practices compared to conventional practice (CP). The increase in grain yield of summer mungbean under rice-wheat-mungbean was higher (24.4%)following ZT compared to CT (and 9.3% due to residue retention alone). Performance of mungbean in terms of grain yield under CA was in order: IPM 205-7 (1478 kg/ha) >Samrat (1387 kg/ha) > HUM 16 (1288 kg/ha) > IPM 2-3 (1277 kg/ha) > IPM 2-14 (1227 kg/ha).
- Early pigeonpea (UPAS 120) +urdbean-wheat (UnnatHalna) and early pigeonpea (UPAS 120) - wheat (UnnatHalna) could be recommended under CA for higher system productivity and sustainability.
- In a study on climatic resilient cropping systems under CA, the system productivity in terms of mungbean equivalent yield was maximum in RWMb (2972 kg/ha) followed by MWMb (2899 kg/ha), rice + *dhaincha* as green manuring –wheat - mungbean(2868 kg/ha) and the least in pearl millet - lentil+linseed (1286 kg/ha). Zero tilled direct seeded rice-chickpea hadthe highest total productivity, SYI, NR and BCR.
- Clodinafop-propargyl + Na-acifluorfen (IRIS) 122.5 ga.i/ha at 10-15 DAS in *kharif* mungbean and topramezone 20.6 ml a.i./ha at 14 DAS in chickpea had minimum phyto-toxicity and higher weed control efficiency under existing alluvial soil of IGP. Variable crop and genotypic tolerance to topramezone was also observed.
- Summer *Sesbania* and halosulfuron methyl application in summer reduced *Cyperus rotundus* and total weed density in *kharif* and subsequent season.
- Highest soybean equivalent yield was realized when soybean was fertilized with ammonium molybdat 1 kg/ha as soil application + 25 kg $ZnSO_4$/ha to soybean (at par with ammonium molybdate 1 g/kg as seed treatment+ 25 kg $ZnSO_4$/ha and ammonium molybdat 1 g/kg as seed treatment + Foliar spray of $ZnSO_4$at 0.5 %). Further, ammonium molybdate application (through both seed and soil) also significantly influenced both soil- and seed-N content compared to control.
- On enhancing efficiency of abrasive dehusking unit of IIPR Mini Dal Mill for different pulses, the study revealed that three grit combinations (18:24:30) roller performed better than two (24:30) or five (14:16:20:24:30) grit combination rollers; and thus, three grit roller could be used in IIPR Mini Dal Mill for better pitting of pulses (64.3% dehusking).
- Maximum dehusking to the tune of 77.47, 84.21, 81.53, 79.13, 91.53 and 86.33% were obtained with 24, 16, 20, 20, 30, 30 mesh grits, in pigeonpea, chickpea, lentil, mungbean, urdbean and fieldpea, respectively.
- An oil and water mixing unit was also developed for IIPR Mini Dal Mill. In addition, a cleaning-cum-grading unit was also developed/refined.
- Two pigeonpea genotypes viz., WDBCE5-4-2-1;

WD12-2-3 recorded ≤10 % pod infestation by pod fly. Six pigeonpea genotypes out of 41 pigeonpea genotypes screened were found to record lowest (3) mean percent pest susceptibility rating during *kharif* 2019.

Crop Protection

- Out of 600 advance breeding materials, some lines (IPA19-37, IPA 19-40, IPAE 15-06, IPA 15-02, IPA 18-8, IPA 19-68, IPAE 15-03, IPAE 17-03, IPA 18-04, IPA 15-21, IPH 09-05, IPA 16-18, IPA-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 identified as promising against *Fusarium* wilt.
- 601 early and medium duration pigeonpea lines were screened for *Phytophthora* stem blight (PSB) resistance in sick field during Kharif 2020-21. The lines *viz.*, IPA 15-08, IPAC-79, IPAPB 7-2-1-7, IPAPB-7-2-1, KPBR-80-2-1, IPAC-3, IPA 15-01, IPA 15-07, IPA 15-03, IPA 17-01, IPA 18-04, IPH 9-05, IPAP-19-08, IPH 18-02, IPH18-01, IPH 18-09, IPAE 15-05, IPAB-2019-1-6, IPAB 10-67, IPAC-2 and IPA 16E-7 were identified as promising.
- Developed talc based formulation of DALHANDERMA (IIPRTh-31) for soil borne diseases in pulses
- Identified seven stable resistant chickpea lines viz., IPC 2016-31, IPC 2013-209, IPC 2011-31, IPCK 2012-306, IPCK 2011-31, IPC 07-56, IPC 97-29 aginst Fusarium wilt of which one accession namely, IC244324 was highly resistant under wilt sick plot at Kanpur.
- Eleven chickpea lines viz., ILWC 21, ILWC 30, ILWC 50, ILWC 95, ILWC 182, ILWC 185, ILWC 188, ILWC 223, ICC 182, ICC 17151, ICC17164, were identified as resistant against *Ascochyta* blight.
- Seven isolates of *Botrytis cinerea* infecting chickpea were characterized at molecular level using ITS 1 and 4 primers and their genbank accession numbers are MT250958, MT250959, MT250960, MT250961, MT250962, MT250963, MT250940. The antagonistic phylloplane microbes such as *Chaetomium globosum* and *Trichoderma asperellum* were identified as effective against *A. rabiei* and *B. cinerea* and their ITS sequences genbank numbers are MT250938 and MK879406, respectively. The PPM which were effective under *in vitro* conditions were moderately effective against *A. rabiei* and *B. cinerea* as compared to fungicides under pot conditions.
- Chickpea seed treatment with *Bacillus subtilis* @10gm/Kg+ fungus inoculation @ 20DAS observed minimum *Ascochyta* blight disease rating scale of 4 followed by 5 in ST with *Bacillus subtilis* (PPM 15) + *Bacillus subtilis* (PPB 15) @10gm/Kg+ fungus inoculation @ 20DAS .
- Minimum Botrytis gray mold disease rating scale 5 was observed in treatment, ST with *Trichoderma asperellum* @ 10gm/Kg+ fungus inoculation @ 20 DAS followed by 5 in ST with *Bacillus subtilis* (PPM 15) + *Bacillus subtilis* (PPB 15) @10gm/Kg+ fungus inoculation @ 20DAS where disease rating was 5.2 when compared to control (9.0).
- Using multiplex PCR, mating types were identified and it was confirmed that, only single mating type (MAT-2) was present in Indian isolates of *A. rabiei*. Four pathotypes (I, II, III, IV) and six physiological races were delineated based on the differential reaction of the disease.
- RAPD-SCAR markers were designed for *Ascochyta rabiei* identification. The best set of SCAR marker pairs designated as SCAR1F/SCAR1R were developed with a detection sensitivity of 0.30 ng of genomic DNA. This is the first RAPD-SCAR marker having sensitive and species specific its for detection of *A. rabiei*.
- 15 representative isolates of *Ascochyta rabiei* from different geographical regions of Northern India were identified by molecular technique through sequencing of ITS region of the fungus with ITS primers (ITS1 and ITS4) through PCR amplification and sequencing. The obtained sequences were submitted to NCBI gene bank and their accession numbers are MT218392, MT252602, MT252603, MT252604, MT252605, MT252606, MT252607, MT252608, MT252609, MT252610, MT252611, MT252612, MT252613, MT252614, MT252615.
- In cluster analysis A. rabei isolates were categorized into six different clusters based on 72 % similarity. The cluster VI consists of AR-11 and AR-5. The isolate AR-5 found to be diverge from the rest of the isolates and clusters.
- Three pigeonpea genotypes WRGE 121, AKTE-12-04 and KPL 44 were moderately resistant against *Meloidogyne javanica*. Two lines of mungbean IPM 312-394-1 and NDML 17-07 were moderately resistant against *M. javanica*. Seven lines of urdbean namely, DKU 90, GJU 1509, IPU 17-1, IPU 2-43, KPU 514-75, KPU 52-87, KUG 479 were moderately resistant against *M.*



javanica.

- Five lines of pigeonpea namely, WD 2019-7, WD 2019-47, WDBCE 9-4-3-1, WDBCE 4-5-3-9 and WDBCE 6-3-5-1 were observed highly resistant against pigeonpea cyst nematode, *Heterodera cajani*. One line of urdbean GJU 1509 was observed as resistant and six lines namely, IPU 11-02, KPU 514-75, KUG 479, MU 52, SBC 50 and TU 94-2 were observed as moderately resistant against *Heterodera cajani*.
- GSL-2, Neelam, Sheetal 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.
- No significant reduction in blackgram (LBG 685) yield was found due to direct feeding by whiteflies, *B. tabaci*, up to the population level of 16.26 adult whiteflies per plant.
- Two population peaks of whitefly, *B. tabaci* were observed at 25-26 and 35 SMW in greengram and blackgram ecosystem during the year 2020.
- *B. tabaci* population varied from 3 to 75.67 in blackgram and 1 to 25.67 in greengram, out of 137 genotypes of blackgram and 111 genotypes of greengram screened for their extent of attractiveness to the pest.
- Emamectin benzoate 5 SG was found to be the most suitable insecticide formulation for managing tobacco caterpillar, *S. litura,* followed by Chlorantraniliprole 18.5 SC and Chlorpyrifos 20 EC.
- The *Bt* isolate F8.IIPR was micro encapsulated and it ranged from 8.79 µm to 67.86µm. This microencapsulated product was found to be stable for 120 days. Further the same isolate and F5.iipr exhibited highest chitinolytic activity and also highest percent mean mortality in root knot nematode.
- Two pigeonpea genotypes viz., WDBCE5-4-2-1 and WD12-2-3 recorded ≤10 % pod infestation by pod fly. Six pigeonpea genotypes out of 41 pigeonpea genotypes screened were found to record lowest (3) mean percent pest susceptibility rating during *kharif* 2019.
- The phylogenetic analysis of amino acid sequence of three conserved genes (*Polh, lef-8* and *pif-1*) revealed that the potential baculovirus isolate (HearNPV- IIPR05) is a member of the genus *alphabaculovirus* (family: *Baculoviridae*) and Group II NPVs. Partial nucleotide sequences of *Polh, lef-8 and pif-1* genes are available at GenBank under accession numbers MN603765, MN603764 and MN603763, respectively. The occlusion bodies (OBs) of HearNPV- IIPR05 isolate appeared irregular in shape which is a typical of baculovirus OBs and measured approximately 1.071 ± 0.068 µm (mean ± SE, n=20) in diameter.
- The plant volatile / essential oils of plant species; *Cymbopogon flexuosus, Mentha spicata, Curcuma longa, Ocimum basilicum, Coriandrum sativum, Eucalyptus citridora, Thuja occidentalis* and *Citrus limetta* were identified as having contact toxicity against pulse beetle, *Callosobruchus analis* (F.) and they were categorized as class II (*O. basilicum*), class-IV (*T. occidentalis, C. limetta, C. sativum*) and class-V repellents (*M. spicata*, C. *flexuosus*, *E. citridora, C. longa*) on the basis of RI (Repellency Index).
- Dual culture and food poison screening methods envisaged that amongst 48 actinobacteria strains, *Streptomyces ginkgonis* IIPR:HD01:05 strain had demonstrated significant and consistent inhibition of *Rhyzoctonia bataticola* and *Fusarium oxysporum* f.sp. *cicieri*.
- Bioassay of ethyl acetate extract from entire plant of *Cynodon dactylon* against *Spodoptera litura* larvae (3rd instar) resulted in 75% mortality with lower LC_{50} value (1.45µg/ml).
- Spatio-temporal dynamics of major insect pest of pigeonpea and chickpea in three successive cropping seasons (2015/16—2017/18) at western and eastern plateau hills agro-climatic zones showed leaf webber and plume moth mean counts never reached an economic threshold level (3 larvae/plant), but crossed the advisory level (1.5 larvae/plant). An incremental rise in pod borer mean counts and crossing economic threshold level over seasons in chickpea (1 larvae/meter row length), while it was not the case in pigeonpea (1 larvae/ plant).
- The bruchid field infestation on seeds/pods was observed to start from 3rd, 4th and 7th Weeks After Flowering Initiation in mungbean, cowpea and pigeonpea, respectively.
- Among the gamma irradiation doses tested on bruchid survivability and seed viability, 200 Gy found to adversely affect oviposition, hatching success and survivability into adults, however the same dosage did not affect the germination of cowpea seeds.
- The phosphine doses ranging 0.01–0.10 mg L^{-1} were observed to cause 10–95 percent mortality

on the bruchid adult beetles representing different locations.

- Among 158 mungbean genotypes screened for bruchid tolerance, 50 were found moderately susceptible, 38 were susceptible and 22 were highly susceptible against the three species.
- Among 50 urdbean genotypes, all the lines were immune to *C. chinensis* as this species did not complete life cycle in any of the genotypes. However against *C. analis* and *C. maculatus*, none of the lines were found highly resistant, 7 were resistant, 21 were moderately resistant, 7 were moderately susceptible, 10 were susceptible and 5 were highly susceptible.
- Among 24 cowpea genotypes, none was found either highly resistant or resistant, 1 was moderately resistant, 6 were moderately susceptible, 5 were susceptible and 12 were highly susceptible.

Basic Science

- Foliar application of Jasmonic acid @ 5 µmole at the stage of flowering in chickpea variety DCP 92-3 significantly contributed towards increased yield and yield attributes under drought as compared to the yield in crop without spray.
- Highest percent pod retention after exposure to cold stress in pigeonpea was observed in tolerant group (67.31%) which included varieties such as MAL-13, NDA-2 and ICP 2275. In cold susceptible group, the average percent pod retention was about 52% in varieties like Dholi–D, IPACT 22 and IPAD 1-17 having 29, 46 and 52% pod retention, respectively.
- Lentil genotypes IG 3522, IG 4112 and IG 2507, performed better and showed relatively higher tolerance towards heat stress.
- The blackgram genotypes PU-19, IPU 99-179, IPU 99-213, PLU 65 and PGRU 95016 were identified as photo thermo-insensitive genotypes at Kanpur as these genotypes take eight days to flower during different time of sowing / season in the year.
- Under the heat stress, the esterase enzyme activity as a measure of stigma receptivity was found to be relatively more in the tolerant chickpea genotypes (ICCV 92944, ICC 1205 and Annigeri) as compared to the heat susceptible genotypes (ICC 10685 and Pant G 114).
- Peroxidase activity was found to be higher in heat tolerant genotypes compared to the susceptible genotypes in both pollen as well as stigma. The superoxide dismutase (SOD) activity on stigma was found to be more under heat treated condition as compared to the normal condition.
- The chickpea genotypes which retain green colour after cooking have lower phenolic content as compared to the genotypes which do not retain green colour after cooking.
- In field peas, phenolics like gallic acid, and catechin hydrate were detected in several genotypes. However, protocatechuic acid, p-coumaric acid and ferulic acid were detected only in few fieldpea genotypes.
- Cowpeas were found to have a much diverse phenolic profile. Both free and bound phenolics of cowpea identified were gallic acid, protocatechuic acid, catechin hydrate, p-coumaric acid and ferulic acid in diverse cowpea genotypes while caffeic acid, ellagic acid and quercetin were detected only in few genotypes.
- Oligosaccharides such as verbascose, stachyose and raffinose were the major alpha galactosides in field pea while only stachyose and raffinose were detected in cowpeas. Verbascose was the predominant alpha galactoside in fieldpea while stachyose was predominant in cowpeas.
- The field pea and cowpea have enough alpha galactosides causing flatulence as humans lack the enzyme alpha galactosidase required for their breakdown. In order to reduce the alpha galactosides, four different domestic processing methods were adopted such as ; a) soaking in normal water (1:5 ratio) for 12 hrs., b) soaking in water containing 0.03% sodium bicarbonate (1:5 ratio) for 12 hrs., c) pressure cooking of overnight soaked seeds, d) germination of pre-soaked seeds for 15, 24. 48 and 72 hrs. at 25C with 8 hrs. of day light. The study revealed that the concentration of alpha galactosides in both field pea as well as cowpea can be significantly reduced by these indigenous processing treatments.
- *Rhizobium* IIPR-MR-127 for Mungbean and *Rhizobium* IIPR-UR-32 for urdbean were identified as potential candidates for high nodulation. Up to 22% increase in nodule specific weight was recorded in case of inoculated plants.
- Pigeonpea genotypes *viz*. IPAC 632, IPAWD 1-2-1-2 and IPAWD 10-1 and urdbean genotypes *viz*. IPU 99-141 and IPU99-95 were found to be most potential genotypes having up to 80% higher nodulation.



- Sixty four putative CaNCR peptides from *Cicer arietinum* and 32 CrNCR peptides from *Cicer reticulatum* were identified, of which, 16 CaNCR peptides and 8 CrNCR peptides are unique to this study and not yet reported by any other research group globally.
- Gene structure analysis revealed that NCR peptides of chickpea possess 0-2 introns. Introns were not observed in IIPR CaNCR56, IIPR CaNCR58 and IIPR CaNCR60, while coding region of 78% of IIPR CaNCR genes possess single introns.
- Among the ten rajmash genotypes tested, IC356018 and EC150250 were found positive for nitrogenase activity.
- Rajmash genotypes IC417352, IC338795, IC356018, EC150250, and IC356072 were identified as high nodulator lines. Nitrogenase activity of nodules were estimated through Acetylene Reduction Assay.
- 50 rhizobial isolates from different rajmash genotypes were isolated, purified and evaluated for their nodulation potential. Rhizobial isolates IIPR-RR11, IIPR-RR14, IIPR-RR17 and IIPR-RR40 were identified as most promising.

Social Science

- Total 238 farmers and 59.46 ha area were covered for different interventions such as paddy, mango, guava, fish, mustard, mungbean, maize, okra, chilli and vermi-compost unit under Farmer FIRST project.
- Total 47 farmers in 10.00 ha area raised Virat variety of mungbean for additional income and to generate additional employment during the season in village itself. The average yield of mungbean was recorded 13.88q/ha. The yield increase was 27.80 percent compared to local checks and additional income gain was Rs. 74766/ha which employment generation was 2-3 hours per day (60-90 hours/month).
- Total 51 farmers with 16.66 ha area were covered for demonstration of improved paddy variety (Pusa Basmati-1509) as a critical input for enhancing production and income in project area. The recorded average yield was 57.60 q/ha. The net return of Rs. 47610/ha was recorded. Total 16 farmers were provided with improved variety of summer maize.
- Total 43 farmers and migrant labours with 5.80 ha area were covered by Navya variety of okra for generation of income and employment during the COVID -19 pandemic in project villages. The average yield recorded was 72.42 q/ha and net return obtained by farmers was Rs. 55963.00 /ha. Total 43 farmers were also provided with improved variety of chilli.
- 10 vermi-compost unit were established in project area for the purpose of organic vegetable cultivation and maintaining proper level of organic matter content in soil, improving the fertility status and water holding capacity of soil.
- Considering wilt infestation along with genotypic stability and average yield, an index was developed and computed to rank the chickpea genotypes for the promotion of in next level of the trial in AICRP.
- Mobile app services for farmers and web console services for experts were designed and developed on mKRISHI platform. Contents related to the diseases and insect-pests 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 on the customized platform for the development of PulsExpert Mobile Service.
- Total 20 training programmes (07 offline and 12 online) were organized for different stakeholders from NIAM Jaipur, Madhya Pradesh and Uttar Pradesh. 45 exposure visits were conduced during the period, 1771 farmers visited the institute from different districts of Uttar Pradesh and Madhya Pradesh.
- MGMG and SCSP programme have been implemented in Kanpur Dehat, Kanpur Nagar, Fatehpur, Kannauj, Unnao, and Hamirpur district of Uttar Pradesh for covering 2865 Schedule caste farmers. Under FLD programme 57 demonstrations were conducted on pigeonpea, mungbean, chickpea, field Pea and lentil in different districts of Uttar Pradesh to increase the pulse production.

Regional Center, Phanda, Bhopal

(04) newly released varieties including (03) of urdbean and (01) of lentil were released and notified and one variety of urdbean (IPU17-1) was identified for release in Madhya Pradesh. Pigeonpea short duration entries (02), large seeded lentil entries (02) and lentil entries for abiotic tolerance (04) have been submitted to respective AICRPs for IVT. State trials for *rabi* / *kharif* 2020 were conducted for chickpea, pigeonpea and urdbean. 809 chickpea germplasm lines were evaluated and unique genotypes for

anthocyanin rich, open flower (IC 349468), earliness (IC 271435, IC 209236, IC 468644), mechanical harvesting (IC 408212, 100 cm plant height) and three seeds per pod (EC 55530) were identified in *desi* chickpea. Breeding line, IPC 18-124 was identified for early maturity (96 days) as comfared to check var. IPC 06-77 (106 days) in trial of chickpea comprised of 130 entries to assess genetic gain under BMGF project. ICARDA FLRP chickpea trials of three entries, FLIP 09-104C (54.20 gm), FLIP 07-6C-S1 (50.65 gm) and FLIP 09-191C (48.70 gm) were identified as extra-large seeded entries.

A set of 480 entries under shuttle breeding (genomic selection) are under field evaluation for central zone. Total 1036 pigeonpea germplasm lines were characterized and genotypes were identified for determinate type, dwarf, early maturity and high yield [IC 523649 (119 days and 1142.0 kg/ha) over PUSA Arhar-16 (125 days and 850 Kg/ha)], and indeterminate type, medium early duration [IC 468256 (134 days), IC 468259, IC 468251 (137 days), IC 468258 (138 days), IC 468260 (139 days), IC 468254 (140 days), IC 468255 (141 days), IC 468257 (142 days), IC 468253 (143 days), UPAS 120 (145 days)], for high yield (IC 468253 (1496.0 kg/ha), IC 468258 (1260.0 kg/ha), IC 468251 (1230.0 kg/ha), IC 468260 (1066.0 kg/ha), IC 468257 (1020.0 kg/ha), IC 468256 (1017.0 kg/ha), PUSA Arhar-16 (230.0 kg/ha), UPAS 120 (978.0 kg/ha) and for extra-large seed size [IC 634397 (21.0-25.8 gm/100 seed weight), IC 468496 (18.9-21.0 gm/100 seed weight), PUSA Arhar -16 (8.9 gm/100 seed weight), UPAS -120 (9.3 gm/100 seed weight), TJT 501 (8.9 gm/100 seed weight), Rajeshwari (9.5 gm/100 seed weight) ICPL 2, 0340, ICPL 11252, were identified as early maturing (105 days) entries in ICRISAT trials.

A set of 496 germplasm of grasspea was purified and evaluated for low ODAP content. 140 mutants of grasspea were grown in M5 generation to select low ODAP lines. FLRP & International ICARDA grasspea nursery comprising of 183 entries for low ODAP, earliness and high biomass were evaluated. 800 lentil germplasm were characterized and IC428472 having maximum pods (07 pods / peduncle).

Wilt sick plots for chickpea, pigeonpea and lentil are under development. 244 wild accessions of different pulses are being maintained. Total 237.4 q breeder seed was produced during *rabi* 2019-20 [chickpea (45.0 q), pea (141.2 q) and lentil (40.0 q)], summer mungbean (12.71 q), urdbean (27.10 q). It is expected that 2010 q breeder seed will be produced including pea (151.0 q), chickpea (10.0 q) and lentil (40.0 q) during rabi 2021. FLD on pigeonpea (5), chickpea (10 and15) and lentil (5 and10) were conducted during *kharif* 2020 and *rabi* 2021, respectively.

229 farmers were benefitted with the seed distribution of new pulse crop varieties under SC-sub-plan during October - November 2020. International and national dignitaries visited the station during celebration of World Pulses Day on 10th February and an exhibition (on pulses agro-technology) cum interaction with the farmers, FPOs, KVKs and scientists was organized.

Regional Station, Dharwad

Off-season generation advancement of chickpea breeding material from AICRP centres and chickpea and lentil breeding program from IIPR, Kanpur was carried out during *Kharif* season. Total 200 accessions of cowpea and 227 accessions of horsegram were maintained and evaluated for different agronomic traits. 296 accessions of mungbean-minicore received from World Vegetable Centre and 150 accessions of urdbean from IIPR were maintained and characterised for different traits. Wild *Vigna* species (*Vigna trilobalata, Vigna stipulacea, Vigna umbellata, Vigna vexillata and Vigna aconitifolia)* were maintained for their utilisation in pre-breeding programme. 104 germplasm lines of mungbean were characterized for drought and heat stress tolerance. 23 advanced lines of lentil were screened for drought stress. Chickpea (IPC-19-226, IPC-2017-53, IPC-2017-369, IPC-17-49 and IPC-18-166), and mungbean (IPM-14-35, IPM-14-9 and IPM-312-394-1) genotypes were found promising for cultivation in southern India. Two promising entries of mungbean (IPM-14-35, IPM-14-9) and desi chickpea were evaluated in state multi-location trial to assess their suitability for cultivation in Karnataka. During germplasm exploration, 22 wild/landraces of pulse crops were collected from Western Ghats of Kerala and Tamilnadu. Total 800 kg of breeder seeds of *kharif* pulses and 550 kg of truthful labelled seeds of different *rabi* pulse crops were produced.

Tebuconozole 50% + Trifloxystrobin 25% WP @ 0.5g/l and difenconozole 25% EC @ 0.75 ml/l were found effective aganist chickpea rust. Inheritance of resistance to two isolates of SMD in pigeonpea (Bahar) is governed by two genes which interact in non-allelic fashion (inhibitory gene interaction). Thirteen genotypes of mungbean viz., IPM99-125, IPM604-1-8, IPM2-14EC520034-1, IPM14-19-5, IPM312-394-1, IPM312-394-2, IPM410-3, IPM430-4, IPM9901-6-1, IPM207-7, VBN3, CO5, COGG912, BARIMUNG6, NR/18-85) are identified as donors for Yellow Mosaic disease. In mungbean, genotype



V1003490AG was identified as resistant donor and PDM54, COGG912 and VBN3 were identified as moderately resistant donor for Cercospora leaf spot. Genotypes, Vamban and V1003958-13-BLM were identified as moderately resistant against anthracnose disease in mungbean. The genotype, TM96-2 was identified as moderately resistant to powdery mildew disease in mungbean.

Pest outbreak of pod weevil, *Apion amplum* was recorded on blackgram and greengram during *kharif* season with 20-60 % pod damage and 17-59 % seed damage. Another emerging insect pest, pink pod borer, *Cydia ptychora* was recorded on greengram and cowpea, with 30.19 and 65.53 % pod damage, respectively and the seed damage by the pest was around 30 %. Cowpea intercropped (3:1) with okra was effective followed by cowpea + sorghum in reducing the incidence of pod borer *Maruca vitrata* with 18.0 and 21% pod damage, respectively. In cowpea, *Beauveria bassiana* @3gm/L was found most effective and recorded 61.15 % reductions in pod damage. Among, 19 cowpea lines screened against pod borer, one line CP 1 recorded per cent pod damage < 10%. In mungbean, out of 49 lines, 15 lines were found promising with pod borer damage <20%, whereas in urdbean, out of 61 lines, 26 lines were found promising with pod borer damage < 10%.

Regional Centre, Bikaner

- Segregating materials of cowpea (F_4 and F_5) received from main campus IIPR, Kanpur were evaluated and selections were made for different traits under arid ecosystem. Based on plant morphological and yield observations, crosses of F_4 generation (RC-101 X DCP-30 and RC-101 X GC-4) were showing earliness (46 and 48 days to flowering, respectively), semi erect growth habit, higher number of pods per plant with higher yield.
- Total 100 moth bean accessions were evaluated in arid ecosystem. Among those 4 erect (IC-36038, IC-415167, IC-258096, IC-120973), 8 semi-erect (IC-311396, IC-35975, IC-311423, IC-370533, IC-415150, IC-402283, IC-311425, IC-35681) and 4 (IC-39689, IC-36663, IC-121064, IC-39689) spreading type accessions were identified on the basis of yield and plant morphological characteristics. These accessions will be used for future breeding programme to improve moth bean.
- A trial was conducted with 20 mungbean genotypes in rainfed condition with optimum moisture and water deficit for identification of donors for drought stress. IPM 1103-1 and IPM 410-3 showed considerable resilience to drought and noticed less reduction in chlorophyll content and dry matter.
- Out of 39 pigeonpea accessions grown in rainfed conditions for identification of donors for drought tolerance, SEDT08 and SEDT 06 showed better growth and performance as compared to other ones.



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.

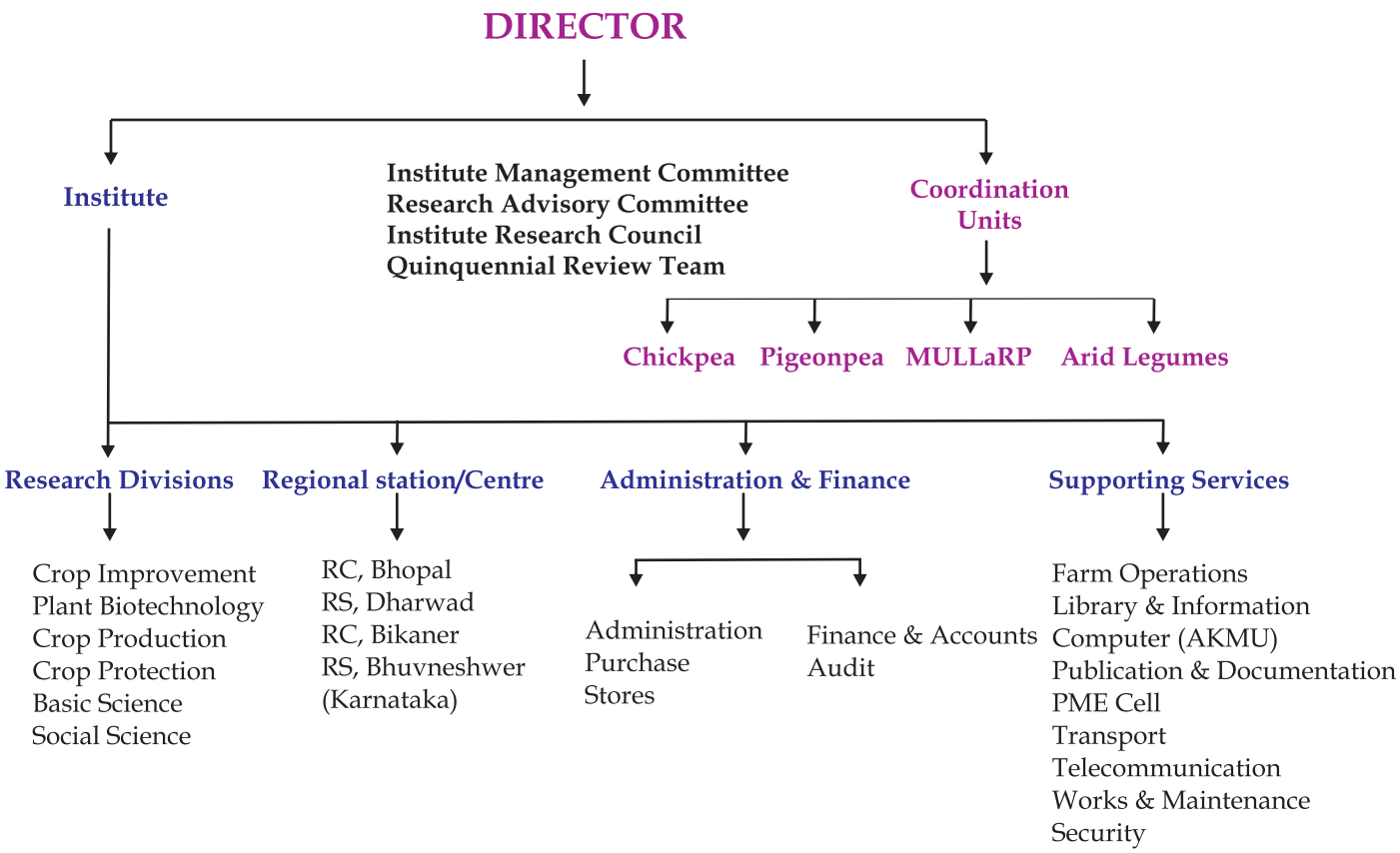
The overall climate varies from semi-arid to arid. The summers are very hot and winters are cool and dry. The monthly weather data for the year reveals that the mean monthly maximum temperature varied from 19.2°C to 41.7°C and the minimum temperature from 3.4^{0}C to 26.8°C. The relative humidity varied 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 station *cum* Off-Season Nursery at Dharwad in Karnataka and one Regional centre at Bhopal in Madhya Pradesh. Two more station/centre, 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



Staff Strength

As on 31.12.2020

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

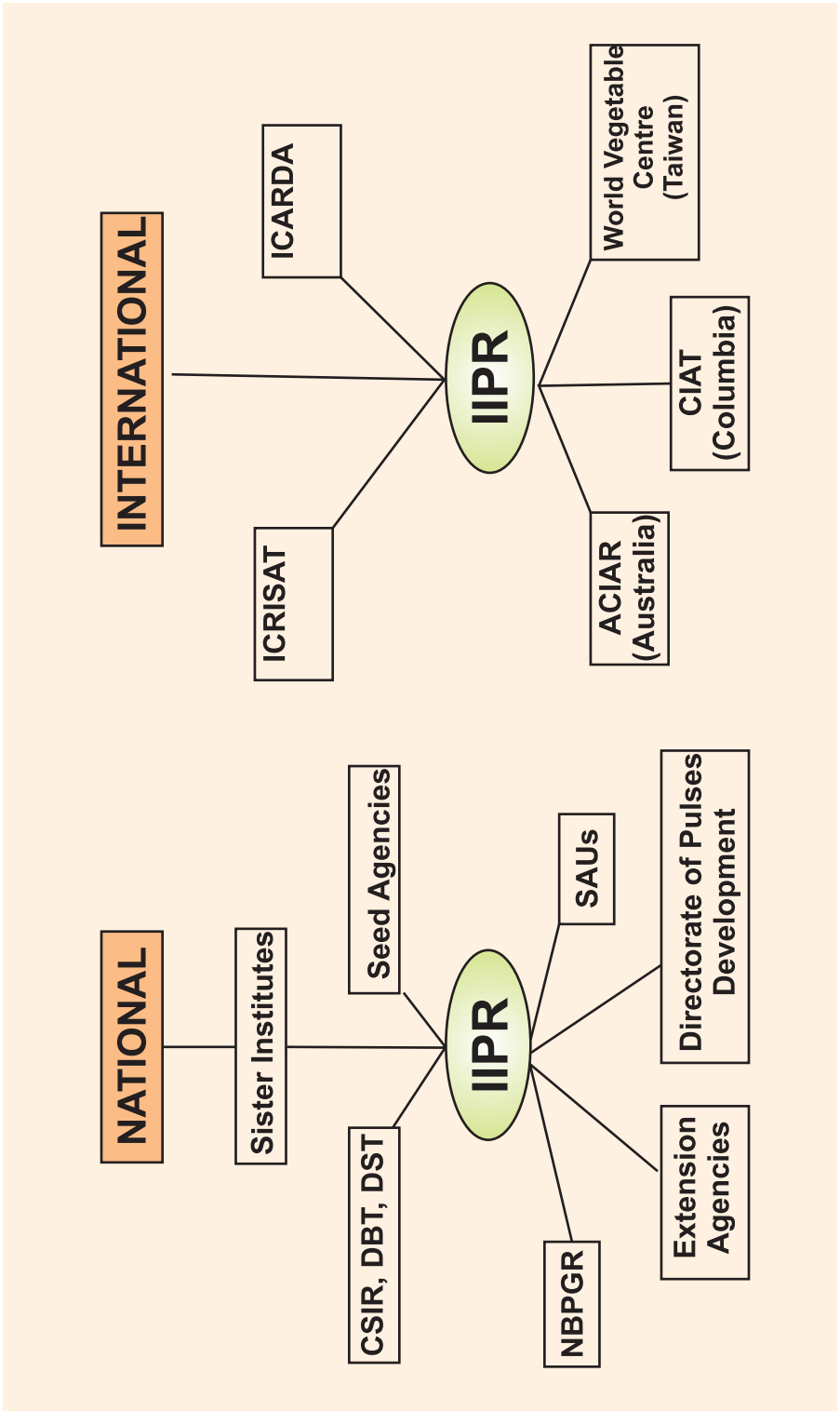
- Basic and strategic research on pulses to improve productivity and quality
- To provide equitable access to information, knowledge and genetic material to develop improved technology and enhance pulse production
- Planning, coordination and monitoring of applied research on national and regional issues 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 2020

(As on 31.12.2020)

		₹ in lakh
A.	**Receipt**	2944.56
B.	**Expenditure**	
	Plan	2560.37
C.	**Pension and other retirement benefits**	145.70
D.	**AICRP**	
	Chickpea	
	a. Coordination Unit	42.57
	b. Grant-in-aid	428.43
	Pigeonpea	
	a. Coordination Unit	74.96
	b Grant-in-aid	284.99
	MULLaRP	
	a. Coordination Unit	81.56
	b. Grant-in-aid	291.51
	AINPAL	
	a. Coordination Unit	27.13
	b. Grant-in-aid	73.44

Status of Implementation of SFC 2017-20 Three Year Plan (Upto 31.12.2020)

(₹ in lakh)

Head	**Approvd outlay (B.E.)**	**Expenditure (31.12.20)**
A. Recurring		
Pay & Allowances/Wages & Pension	2634.97	2154.05
TA	40.00	3.50
HRD	10.00	0.02
Contingency	890.00	425.76
Total	**3574.97**	**2583.33**
B. Non-Recurring		
Equipment, Information Technology & Furniture & Fixture	510.00	32.32
Works	300.00	7864
Library	0.00	0.00
Total	**810.00**	**110.96**
C. TSP	**35.00**	**11.78**
TOTAL (A+B+C)	**4419.97**	**2706.07**



Crop Improvement

Institute Funded Project

A. Chickpea

A01. Breeding for yield enhancement in desi chickpea

1. **Varieties developed:** Two *desi* chickpea varieties have been released and notified during 2020 for enhancing productivity of chickpea in Uttar Pradesh.

1.1. **IPC 2004-01:** This chickpea variety was derived from (RSG 533/BG 391)//(ICCC 42/ICC 106) double cross. It was released in 2014 while notified in 2020 for cultivation in Uttar Pradesh under timely sown condition. The average yield of 1396 kg/ha with 9.0% yield superiority to best check KWR108 over the state. It performs well in Central & Bundelkhand region and recorded 14% & 9.48% yield superiority over best checks, respectively. It matures in 135-140 days and is moderately resistant to wilt. It has medium seed size (20.2 g/100 seed wt.) with brown colour.

1.2. **IPC 2011-112:** This variety was derived from IPC 94-94/IPC 02-120 cross and released and notified in 2020 for cultivation in Uttar Pradesh under timely sown condition. The average yield of 1296 kg/ha line recorded with 11.0%, 11.8% & 12.1% yield superiority against the check varieties DCP 92-3, Avrodhi & KWR 108, respectively. It is performs well in Western region and recorded 34.6%, 56.6% & 28.6% yield superiority over check DCP 92-3, Avrodhi and KWR108, respectively. It matures in 122 days and showed resistant to wilt with medium seed (22 g/100 seed weight).

2.1. **IPC 2007-28:**It is a *desi* chickpea advanced breeding line derived from DCP 92-3/SAK I9516 cross. This entry was found promising based on yield performance in SATs conducted in Uttar Pradesh under late sown during 2017-18 to 2019-20 at nine locations representing all zones. The proposal has been invited for identification by *Rajya Beej Vimochan Samiti* of Uttar Pradesh. It produced an average grain yield of 1683 kg/ha over the state with 11.96% yield superiority over the best check KPG 59. It matures in 128 days and showed resistant against *Fusarium* wilt disease. It has large seed (18.2 g per 100 seed weight) with brown seed coat colour and semi-erect growth habit

3. **Performance of breeding lines in AICRP trials:** Two entries namely, IPC 16-44 (NEPZ & ECZ) and IPC 15-123 (NEPZ) were promoted to AVT-1. A total of 12 IPC elite breeding lines namely, IPC 15-48, IPC 14-133, IPCB 16-25 (Timely sown); IPC 15-185, IPC 17-10, IPCB 17-245 (Late sown); IPC 17-303, IPC 17-292, IPCD 2019-226 (Rainfed) and IPC17-253, IPC17-141, IPCB15-132 (Mechanical Harvesting) are being evaluated in IVT under AICRP during 2020-21.

4. **Performance of breeding lines in State Adaptive trials:** A total of 16 chickpea superior lines including IPC 13-74, IPC 14-28, IPC 14-120, IPC 14-51, IPC 16-107, IPC 15-12, IPC 14-10, IPC 15-17 (**Timely sown**:); IPC 15-116, IPC 15-267, IPC 15-165, IPC 11-247, IPC 11-28, IPC 11-30, IPC 07-100 (***Late sown***:) are being evaluated in Uttar Pradesh State Adaptation Trials during *Rabi* 2020-21. Apart from this, IPC 10-72, IPC 15-12, IPC 16-107, IPC 16-69, IPC 16-222, IPC 15-133, IPC 15-17, IPC 13-70, IPC 08-11, IPC 11-30, IPC 11-141, IPC 12-108, IPC 09-21, IPC 07-28, IPC 10-134 are being evaluated in Madhya Pradesh, Chhattisgarh and Jharkhand during 2020-21.

5. **Generation of breeding material:** Prominent donors for heat tolerance (JG 14), mechanical harvesting (HC 5, IPC 06-11), post-emergence herbicide (ICC 1205, ICC 11101, IPC 18-186), drought (ICC 4958), salinity (CSG 8962), *Fusarium* wilt resistance (JSC 37, IPC 07-28, IPC 07-56, IPC 18-37, IPC 18-52, IPC 18-79, IPC 18-131, IPC 18-145, IPC 18-41), Dry root rot (JG 03-14-16, IPC 10-134, IPC 05-28), collar rot (RSG 888), stunt virus (IPC 04-52). Four wild accessions (ILWC 121, ILWC 142, 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, IPC 05-62). Total 43 crosses including 23 & 20 (39 single & 4 three way crosses) were made during *Kharif* 2019 & *Rabi* 2019-20 at Off-season Nursery, Dharwad and Kanpur, respectively for developing improved lines (yield, biotic/abiotic stress resistance, herbicides, tollrance earliness, tall/erect).

6. **Segregating material and generation advancement:** The generation were advanced during *Kharif* 2019 and *Rabi* 2019-20 at Dharwad and Kanpur, respectively. Total 161 F_1 plants from 43 crosses were harvested separately. Total 932 SPS, 224 Line Bulks (LB) and 43 Plot Bulks (PB) from 20, 35, 17, 26, 31 & 28 crosses from F_2, F_3,F_4,F_5, F_6 &F_7, respectively were harvested. These includes **20 F_2:** 76 SPS + 14 LB + 8 PB, **35 F_3:** 573 SPS+ 57 LB + 7 PB, **17F_4:** 147 SPS + 36 LB, **26F_5:** 104 SPS + 72 LB + 2 PB, **31F_6:** 25 SPS + 30 LB +12 PB, **28F_7:** 7 SPS + 15 LB + 17 PB. LB and PB of breeding material to be shared with AICRP Center.

7. **Evaluation of elite breeding lines:** Total 310 breeding lines including 138 and 172 entries as station trials (ST) and preliminary yield trials (PYTs), respectively were evaluated under timely sown (TS), late sown (LS), rainfed, pre-breeding (PB) and mechanical harvesting (MHT) at Kanpur, Bhopal, Dharwad. The trials-wise details is given below:

7.1. ***Station Trial-1 (Mechanical harvesting):*** A total of 23 entries including 3 checks were tested

during 2019-20. Entry IPC 16-53 (2667 kg/ha, 72.0 cm) was found superior followed by IPC 17-351 (2639 kg/ha, 72.5 cm), IPC15-132 (2578 kg/ha, 67.1 cm), IPC 15-95 (2539 kg/ha, 68.9 cm) check JG 16 (2483 kg/ha, 44.4 cm), HC 5 (1856 kg/ha, 67.7 cm), NBeG 47 (1806 kg/ha, 68.5 cm) with 7.4%, 43.7%, 47.7% yield superiority, respectively with lodging resistant.

7.2. ***Station Trial-2 (Pre-breeding):*** Altogether, 20 entries developed from pre-breeding lines and three checks were evaluated during 2019-20. Entry IPC17-37 (2944 kg/ha) was found top yielder followed by IPC 17-88 & IPC 17-249 (2933 kg/ha), IPC 17-10 (2817 kg/ha), IPC 17-358 (2789 kg/ha), IPC 18-103 (2750 kg/ha) and checks IPC 06-77 (2694 kg/ha), BG 3043 (2317 kg/ha) & GNG 1581(1783 kg/ha) with 9.3%, 27.1% & 65.1% yield superiority over checks, respectively.

7.3. ***Station Trial-3A (Timely Sown):*** Altogether, 22 breeding lines with 3 checks were evaluated during *Rabi* 2019-20. Entry IPC 16-25 (3544 kg/ha) was found top yielder followed by IPC 18-31 (3511 kg/ha), IPC 18-38 (3389 kg/ha), IPC 15-126 (3222 kg/ha), IPC 18-117 (3133 kg/ha), IPC 18-59 (3111 kg/ha) and checks IPC 06-77(2917 kg/ha), KPG 59 (2722 kg/ha), GNG 2207 (2017 kg/ha) with registered 21.5%, 30.2% & 75.7% yield superiority, respectively.

7.4. ***Station Trial-3B (Timely Sown):*** Total of 21 entries with 3 checks were tested during 2019-20. Entry IPC 17-78 (3361 kg/ha) was found top yielder followed by IPC 16-26 (3289 kg/ha), IPC 17-361 (2967 kg/ha), IPC 18-129 (2739 kg/ha), IPC 16-06 (2833 kg/ha) and checks IPC 06-77 (2694 kg/ha), KPG 59 (2667 kg/ha) & GNG 2207 (1844 kg/ha) with 24.8%, 26.0% & 82.3% yield superiority over checks, respectively.

7.5. ***Station Trial-4 (Rainfed):*** Thirty one entries with 3 checks were evaluated in Kanpur, Bhopal and Dharwad locations under rainfed condition. Based on mean yield over 3 locations, entry IPC 17-78 (1946 kg/ha) was found top yielder followed by IPC17-369 (1931 kg/ha), IPC17-53 (1923 kg/ha) and check JG16 (1822 kg/ha), JAKI 9218 (1705 kg/ha) and RSG 888 (1487 kg/ha) with 6.8%, 14.1% & 30.9% yield superiority over checks, respectively.

7.6. ***Station Trial-5 (Late sown):*** Total 27 entries with 3 checks were evaluated during *Rabi* 2019-2019 under late sown condition. Entry IPC 17-373 (3489 kg/ha) was found top yielder followed by IPC17-16 (3450kg/ha), IPC17-139 (3211kg/ha), IPC14-133 (3200kg/ha), IPC15-185 (3189kg/ha)and check IPC06-77 (3061kg/ha), KPG 59 (2906 kg/ha) & BG 372 (2761 kg/ha) with 14.0%, 20.1% & 26.4% yield superiority over checks, respectively.

7.7. ***PYT-1 (MHT):*** Entry IPC 19-29 (2140 kg/ha & 80.2 cm) was found top yielder followed by IPC 18-27 (1937 kg/ha & 91.5 cm), IPC 18-149 (1927 kg/ha & 73.2 cm) and best check HC 5 (1736 kg/ha & 81.2 cm) with 23.3% yield superiority.

7.8. ***PYT-2 (PB):*** Entry IPC19-42 (2465 kg/ha) was found top yielder followed by IPC 19-48 (2461 kg/ha), IPC 19-173 (2325 kg/ha), IPC 19-34 (2306 kg/ha) and best check GNG 1581 (2083 kg/ha) with 18.3%, yield superiority.

7.9. ***PYT-3A (TS):*** Entry IPC 19-62 (2134 kg/ha) was found top yielder followed by IPC 19-73 (2100 kg/ha) and the best check KPG 59 (1964 kg/ha) with 8.7% yield superiority.

7.10. ***PYT-3B (TS):*** Entry IPC 19-19 (2153 kg/ha) trial was superior followed by IPC 19-113 (1975 kg/ha) and best check IPC 06-77 (1728 kg/ha) with 24.6% yield superiority.

7.11. ***PYT-4 (RF):*** Entry IPC 19-139 (2523 kg/ha) was superior followed by IPC 19-37 (2069 kg/ ha), IPC 17-315 (2050 kg/ha), IPC 19-46 (1933 kg/ha) and best check JAKI 9218(1669 kg/ha) with 51.2% yield superiority.

7.12. ***PYT-5 (LS):*** Entry IPC19-28 (3135 kg/ha) was found top yielder followed by IPC 19-153 (3256 kg/ha), IPC 19-74 (2983 kg/ha), IPC 19-58 (2954 kg/ha), IPC 19-142 (2896 kg/ha) and best check IPC 06-77 (2513 kg/ha) with 24.8% yield superiority.

8. Phenotyping against biotic stresses

8.1. ***Fusarium wilt:*** Total 274 lines were evaluated in wilt sick plot at Kanpur for screening against *Fusarium* wilt. Five entries (IPC 16-31, IPC 07-56, IPC 97-29, IPC 13-209, IPC 11-31) were exhibited stable resistance to wilt over 5 years screening under AICRP. Eleven lines (IPC 18-118, IPC 18-152, IPC 19-163, IPC 19-171, IPC 19-185, IPC 18-130, IPC 18-29, IPC 07-56, IPC 97-29, IPC 10-72, IPC 07-04) were observed moderately resistant

8.2. ***Ascochyta blight:*** Ten lines (ICC 17164, ICC 17151, ICC 182, ILWC 30, ILWC 95, ILWC 50, ILWC 182, ILWC 188, ILWC 223, ILWC 185) were showed resistance, 6 line (ICC 17155, ICC 17116, ICC 17150, ILWC 238, EC 600099, EC 6000100) exhibited moderate resistant.

8.3. ***Dry root rot:*** Four breeding lines (IPC 12-98, IPC 13-33, IPC 11-85, IPC 10-219) exhibited moderate resistance against DRR under AICRP.

9. Screening against post-emergence herbicide: A panel of thirty chickpea genotypes varying for tolerance to post emergence systemic herbicide imazethapyr (@ 120g/ha. *w.r.t* recommended 75 g/ha.) were evaluated during *rabi* 2019-20 for confirmation. All the entries had 100% plant survival following the treatment. Five entries performed better than the check IPC2018-186, namely, ICC 12337, ICCIL 04004, ICCV 92504, ICC 3575 and ICC 12316. The panel comprised of released varieties like JG 16, JG 14, JSC 37, JG 11 which showed resilience with lower seed yield.

10. Development of chickpea genotypes tolerant to heat stress: Total 112 lines were sown (07.01.2020) for screening to heat (>35°C). 19 lines were found tolerant to heat with regards of seed setting and yield (IPC 15-48, IPC 15-185, IPC 17-54, IPC 17-256, IPC 17-351, IPC 17-377, IPC 17-53,

IPC 17-102, IPC 12-211, IPC 16-25, IPC 18-154, IPC 17-67, IPC 15-12, IPC 16-39, IPC 17-308, IPC 16-236, IPC 17-373, IPC 12-31, IPC 15-165).

11. **Maintenance breeding:** Two hundred SPS each were harvested from eight variety for maintaining genetic purity. Total 1037 kg nucleus seed including DCP 92-3 (62.4 kg), IPCK 02-29 (49.9 kg), IPCK 04-29 (63 kg), IPC 06-77 (297 kg), IPC 04-98 (177 kg), IPC 05-62 (149 kg), IPC 04-01 (40 kg), IPC 11-112 (223.9 kg) was produced based on single plant progenies for enhancing breeder seed.

12. **International *desi* chickpea nurseries/trials evaluated for productivity:** Two ICVTs (desi & MHT) were evaluated. Entry ICCV 191112 (2270 kg/ha) was found top yielder followed by rest entries in *desi* ICVT. Similarly, entry ICCV191604 produced more yield (2276 kg/ha) followed by others including checks (HC5, NBeG47) in ICVT (MHT).

A02. Genetic enhancement of *Kabuli* chickpea for grain yield and seed size

1. **Proposals invited for identification and release:** Aproposal of *Kabuli* variety IPCK 2012-143 has been invited by *Rajya Beej Vimochan Samiti* of Uttar Pradesh for identification/ release based on yield performance in the SAT conducted during 2017-18 to 2019-20 at nine locations.

1.1. **IPCK 2012-143 (*Kabuli*):** This line derived from the cross between JGK 1 and IPCK 96-1. This entry was found promising based on yield performance in SAT conducted in Uttar Pradesh under timely sown during 2017-18 to 2019-20 at 9 locations of the State. The proposal has been invited for identification by *Rajya Beej Vimochan Samiti* of Uttar Pradesh. It produced mean yield of 1071 kg/ha with 35.38% yield superiority to the best check K 3256. It matures in 118-120 days with resistant to wilt. It has large seed (34.5 g of 100 seed wt) with creamy colour seed wat.

2. **Promising entries in AICRP trials:** A *Kabuli* chickpea entry IPCK 13-163 was promoted to AVT-2 under North Western Plain Zone and Western Central Zone during 2019-20. Besides of this, three entries of *Kabuli* chickpea namely, IPCK 18-187, IPCK 18-189, IPCKB 18-188 (*Kabuli*) are being evaluated in IVTs under AICRP during 2020-21.

3. **Generation of breeding material:** Total 12 kabuli crosses including 10 and 2 were made during *Rabi* 2019-20 and *Kharif* 2019 at Kanpur and RC Dharwad, respectively for developing improved lines (yield, biotic/abiotic stress resistance, large seed size) and their wide adaptability.

4. **Segregating material and generation advancement:** Generation were advanced during *Kharif* 2019 & *Rabi* 2019-20 at Dharwad and Kanpur, respectively. Total 44F_1 seeds from 4 crosses were raised and 28 F_1 plants harvested. Total 138SPS, 14 Line Bulks (LB) and 17 Plot Bulks from 6, 8, 3, 5, 7 & 7 crosses from F_2, F_3,F_4,F_5, F_6&F_7, respectively were harvested. It includes 6F_2: 27SPS + 5 PB, 8F_3: 57SPS + 3PB, 3F_4: 13SPS + 2LB, 5F_5: 25SPS + 12LB, 7F_6: 7SPS + 5PB &7F_7: 9SPS + 4PB.

5. **Evaluation of advance breeding lines:** Total 34 breeding lines of *kabuli* chickpea were evaluated in Station Trial (ST) and Preliminary Yield Trial (PYT) at Kanpur and Bhopal during 2019-20 for their yield and yield attributing traits.

1. ***Station trial-1 (Kabuli):*** Total 20 lines with checks were evaluated at Kanpur and Bhopal. Entry IPCK 10-124 (2075kg/ha, 38.3 g HSW) was found superior followed by IPCK14-125 (1981 kg/ha, 32.9 g HSW) and check Shubhra (1969 kg/ha, 34.6 g HSW) with 5.4% yield superiority.

2. ***PYT–1 (Kabuli):*** Total 14 breeding lines and 3 checks (PG 0517, KAK 2, Shubhra) were evaluated during 2019-20 at Kanpur. Entry IPCK 19-44 (2799 kg/ha, 36.0 g HSW) was found top yielder followed by IPCK 19-141 (1869 kg/ha, 32.5 g HSW) and best check KAK 2 (1342 kg/ha, 38.5 g HSW)with 108% yield superiority.

6. **Phenotyping against biotic stresses:** Total of 220 IPC lines were evaluated in wilt sick plot at Kanpur for screening aganist wilt. Entry IPCK 13-209 showed moderately resistance, while IPCK 12-306 and IPCK 11-31 exhibited stable resistance to wilt over five years in AICRP.

7. **Evaluation of ICVT (*Kabuli*):** Total 18 fixed lines were evaluated for yield and other traits. Entry ICCV 191312 (1772 kg/ha, 40.1 g HSW) was found top yielding followed by ICCV 191302 (1670 kg/ha, 42.4 g HSW), ICCV 191315 (1542 kg/ha, 40.5 g HSW), ICCV 191310 (1503 kg/ha, 43.1 g HSW), ICCV 191314 (1476 kg/ha, 41.1 g HSW) and best check Shubhra (1341 kg/ha, 33.7 g HSW) with registered 32.1% yield superiority.

A03. Breeding for higher yield and enhanced resistance against abiotic stress tolerance (heat and drought) in chickpea

1. **Generation of breeding material:** Total 20 crosses including 17 single (JG 16/ICC 96029, ICC 1356/ICC 96029, GG 2/ GNG 2144, ICC 07110/ICC 15614, DCP 92-3/RSG 888, ICC 1205/JG 11,ICC 96030/ILWC 181, ICC 4567/JG 14, KWR 108/ILWC 116, IPC 06-77/RVG 203, JG 315/IPC 06-77, JG 315/ICC 15925, IPC 06-77/ILWC 181, ICC 4958/IPC 06-77,ICC 7110/JG14,DCP92-3/ILWC 81, ICC 92944/ICC 15925), a double (GG 2/ICC 4958)//(JG 11/RVG203) and 2 multiparent crosses for MAGIC population [JG 11/ICC 96029)//(JG1 30/ICC 92944)]//[ICC 7110/ RVG 203], [(JG 130/ICC 92944)// (JG 11/ICC 96029)]//(ICC 07110/RVG 203) were made.

2. **Generation advancement of heat tolerance:** Total F_1s' were advanced to F_2 and SPS from each cross harvested separately. Total 2080 SPS including 30**F_2**: 140 SPS, 25**F_3**: 850 SPS, 12**F_4**: 350 SPS, 8**F_5**: 200 SPS, 6**F_6**: 250 SPS, 13**F_7**: 290 SPS and 8 line bulks were harvested.



3. **Evaluation of elite breeding lines tolerant against drought and heat:** Total 25 lines including three checks were evaluated under both normal and late sown condition for heat. Entry IPC14-09 (2159 kg/ha) was found top yielder followed by IPC 15-66 (2149 kg/ha), IPC 14-55 (2124 kg/ha), IPC 13-44 (2079 kg/ha) and checks ICC 92944 (1811 kg/ha) and KWR 108 (1745 kg/ha) under normal sown. While, IPC 14-55 (1721 kg/ha) found superior to IPC 15-66 (1728 kg/ha), IPC 14-09 (1638 kg/ha) and check ICC 92944 (1479 kg/ha), KWR 108 (1423 kg/ha) under late sown.
4. **Development of mapping populations for heat tolerance:** Six mapping populations including DCP 92-3/ICC 92944 (***F_7* 225***), JG 315/ICC 92944 (***F_5* 232***), JG 11/ICC 1205 (***F_5* 211***), DCP 92-3/ICC 96030 (***F_5* 219***), DCP 92-3/ICC 1205 (***F_5* 215***) for heat tolerant were advanced. The mapping population of DCP 92-3/ICCV 92944, RIL cross for heat tolerant has already been characterized for various phenological and yield related traits under normal and late sown.

A04. Breeding for higher yield and enhanced resistance against biotic stresses

1. **Breeding material generated:** Total 12 crosses with contrasting parents for DRR/wilt, IPC 12-100/IPC 12-98, PG 0405/GJG 0904, IPC 12-100/JG 37, IPC 12-100/GNG 2144, IPC 12-100/IPC 2000-25, IPC 12-100/T 39-1, JAKI 9218/SGPWR 30, IPC 12-100/RSG 931, IPC 12-100/IPC 05-64, JAKI 9218/GJG 0921, PG 0405/SGPWR 28, JG16/IPC 08-69 were made.
2. **Generation advancement:** Total 12 F_1s' were advanced to F_2 and SPS from each cross harvested separately. Total 2300 SPS including 11**F_2**: 400 SPS, 19**F_3**: 900 SPS, 26**F_4**: 700 SPS, 15**F_5**: 300 SPS harvested separately during *Rabi* 2019-20.
3. **Evaluation of elite breeding lines:** Total 57 advance breeding lines composed from IIPR, Kanpur and ICRISAT were evaluated as Preliminary yield trial (PYT). The lines DR 1506, IAPC 18-2, DR 1501, DR 1502, DR 1527 were found promising
4. **Mapping population development for fusarium wil/dry root rot:** Two crosses viz, IPC 05-28/BG 212 and JSC 37/BG 212 utilizing IPC 05-28 & JSC 37 as resistant and BG 212 as susceptible parent were advanced to F_4 for developing mapping populations for dry root rot resistance.
5. **Association mapping studies:** Association mapping for FW (race 2) was done in 75 elite breeding lines based on two year phenotypic data and several marker trait associations were elucidated. These MTA could be useful for MAS for FW (race 2).

A05. Improving quality traits in chickpea

1. **Identification of high protein genotypes:** Variability for seed protein content was studied in advanced breeding lines of chickpea. Four advanced lines namely, IPC 06-77 (~26%), IPC 08-103 (~26%), IPC 10-72 (~26%) & IPC 06-11 (~26%) were identified with high protein. Seed protein content which normally ranges from 17-22% in chickpea.
2. **Promising breeding lines with greenness retained after boiling:** Families retaining the greenness in seed after boiling have been identified in F_5 segregating population (IPC 2008-103/ICC 15614) of desi chickpea.
3. **Development of breeding materials for grain quality enhancement:** Breeding materials has been developed for grain quality parameters. $3F_1$, $4F_2$ & $4F_3$ populations have been developed with IPC 08-103, ILWC 257, ILC 5498, ILWC 21, IPC 06-11, IPC 10-72 donors.

A06. Improving seed protein content

Significant achievements in seed protein enhancement

- Stable donor lines for high protein content (≥28%) were confirmed through multilocation testing at Kanpur, Bhopal and Dharwad. Landraces T 39-1 and T 1-A had high protein content.
- Considerable genetic diversity for protein content in seed was observed (17-29%) in a diverse panel of chickpea genotypes (comprising of germplasm accessions, landraces and trait specific donors). Genotypes contrasting for protein content in seeds were confirmed.
- F_2 population distribution of NEC755/T39-1 cross from reported contrasting lines for protein content was normal, showing polygenic inheritance, no definite ratios could be worked out
- Five QTLs for seed protein content have been identified in the F5 population of IPC 2004-98/T39-1. Linked markers (SSRs) have been identified for seed protein content trait in F_5 population of IPC 2004-98/T39-1 at LG 3, LG 5 and LG 6, respectively.
- Breeding materials segregating for high protein content were developed. Four mapping populations have been developed for seed protein content trait ($F_{4:5}$). Three F_1, 5 F_2, 12 F_3, 13 F_4 & F_3 F_5 breeding populations have been developed. High protein families identified.

B. Pigeonpea

B01. Genetic enhancement in Long duration pigoenpea

1. **Varieties notified**

1.1. **IPA 15-2 (Sharada):** The long duration pigeonpea variety IPA 15-2 (Sharada), derived from NDA 1/MAL 13 has been notified for cultivation in North-Eastern Plain Zone (NEPZ). IPA 15-2 yields about 2281 kg/ha in 245-255 days, which was 25.19% over Bahar (National check), 30% over IPA 203 higher (Zonal check), 20.68% over NDA 1 and 20.30% over MA 6 (Local

checks). The variety IPA 15-2 showed 15.11% susceptibility to wilt and 15.62% susceptibility to SMD whereas the susceptible check recorded 77.24% wilt (ICP 2736) and 66% SMD (ICP 8863). The variety IPA 15-2 had recorded 6% pod damage by *H. armigera* and 28.31% damage by *Maruca obtusa* whereas the Bahar (National check) recorded 6.73% and 43.56% pod borer damage, IPA 203 (Zonal check) 7.25% and 36.44% pod borer damage and MA 6 (Local check) 6.25% and 22.38% pod damage by *H. armigera* and *M. obtuse,* respectively.



Fig. 1: Vivid presentation of pigeonpea variety IPA 15-2 (Sharada)

2. **Performance of breeding lines in AICRP trials:** IPA 15-21 showed 12.5 % superiority over national check IPA 203 and promoted to AVT-1 for NEPZ. Four entries namely, **IPA 19-6** (IPAC 79 X ICOPL 87194), **IPA 19-29** (NA-1 x IPA 8F), **IPA 18-33** (IPA 203 x BRG-2), **IPA 19-55** (NA-1 x IPA 8F) were nominated for IVT for NEPZ.
3. **Performance of breeding lines in UP state pigoenpea adaptive trial:** Two late maturing genotypes viz. IPA 9-1, IPA 13-1 have been promoted to third year testing. Likewise, seven entries namely, IPA 2014-2 (Pusa 9/Kudrat), IPA 2014-4a (MAL 13/Kudrat), IPA 2015-2 (MAL 13/NA1), IPA 2015-19 (Ranchi local/UPAS 120) and IPA 16-18 (IPA 203/ICP 287 Sel), IPA 2014-6 (Ranchi local/PUSA 9), IPA 2014-7 (PUSA 9/KUDRAT 3) are at AVT-1 stage in UP state adoptive trial.
4. **Evaluation of promising lines in station trials:** The first station trial comprised 20 entries 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, along with 4 checks viz. IPA 203, IPA 206, NDA-1 and Bahar. IPA 19-6 significantly outperformed the best check by 17%. The second trial also comprised of 20 test entries viz. IPA 19-1, IPA 19-1, IPA 19-21, IPA 19-22, IPA 19-23, IPA19-24, IPA19-25, IPA19-26, IPA19-27, IPA19-28, IPA19-29, 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 39 and IPA 40 along with 4 checks as mentioned earlier. IPA 19-29 out-yielded best check by 15%.
5. **Characterization of cleistogamous lines:** A set of 14 advanced cliestogamous breeding lines (IPAcliesto 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 & 14) was characterized along with their male and female parents' *viz.*, IPA203 and ICPL87154 respectively (Fig. 1). The study revealed that, all breeding lines were indeterminate in growth habit having the plant height range from 158-218 cm with an average of 19 primary

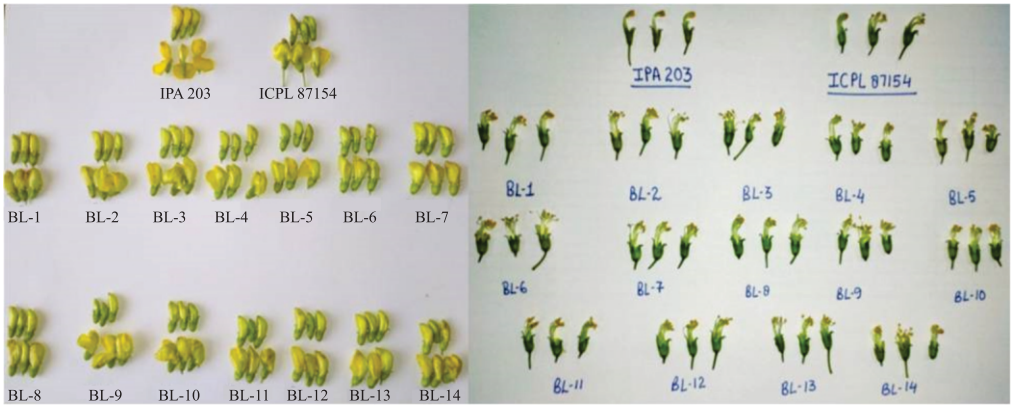


Fig. 2: Flower traits characterization of cleistogamous advanced lines and parents

branches/plants. The genotype ICPL 87154 had 13 flowers/cluster whereas; the advanced line IPAcliesto 1 had 10 flowers per cluster. IPAcliesto 14 recorded the longest flower bearing raceme of 29.33 cm. The absolute selfing was recorded in 9 advanced lines, IPAcliesto 3, 5, 6, 7, 8, 10, 12, 13 and 14. These lines were having good yield attributing with high selfing trait holds immense scope to breeders during the course of varietal development.

6. **Breeding materials generated:** Total 13 F_2 populations, 500 SPS from 23 F_3 generation crosses, 2500 SPS from 49 F_4 generation crosses, 100 SPS from 9 F_5 generation crosses, 49 SPS from 7 F_6 generation crosses and 41 SPS from 6 F_7 generation were advanced during *Kharif* 2020
7. **Sharing of breeding materials:** A total of 550 advance breeding lines were shared with division of crop protection for screening against wilt at ICAR-IIPR, Kanpur and SMD at RC, Dharwad
8. **Production of nucleus seed:** A total of 400 kg nucleus seed was produced during *Khairf* 2019 for varieties namely IPA 203 (220 kg) and IPA 206 (180 kg). For *Kharif* 2020 a target was set to produce 250 kg, 300 kg and 50 kg nucleus seed of IPA 203, IPA 206 and IPA 15-2, respectively.
9. **Maintenance of donors genetic stocks:** A total of 95 trait specific donors and parents are being maintained for use in pigeonpea breeding programme.

B02. Genetic enhancement in short duration pigoenpea

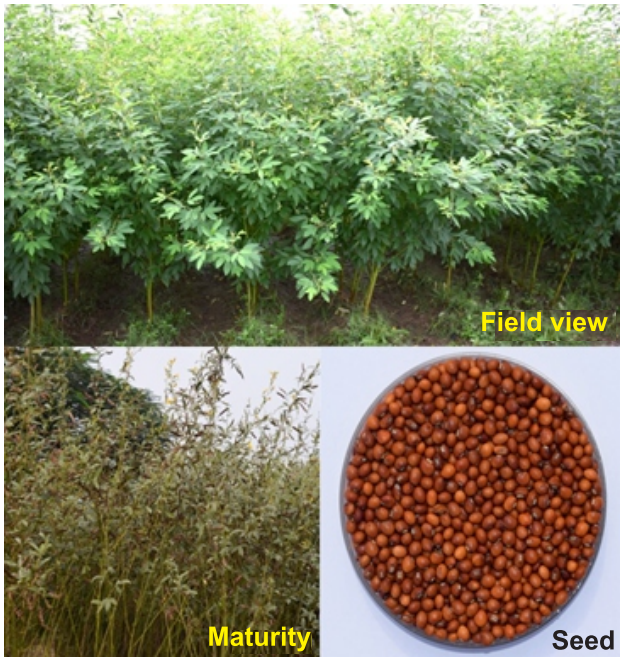
1. **Performance of breeding lines in AICRP trials**: Two extra early genotypes *viz.* IPAE 19-23 and IPAE 19-24 and three early elite genotypes namely, IPA 17-01, IPA 17-03 and IPA 15-08 are being tested in AICRP-IVT whereas, IPA 15-6 is being evaluated in AICRP-AVT-2 for CZ.
2. **Evaluation of promising lines in station trials:** One station trial comprising 10 extra early genotypes namely, IPAE 19-01, IPAE 19-02, IPAE 19-03, IPAE 19-04, IPAE 19-05, IPAE 19-06, IPAE 19-07, IPAE 19-12, IPAE 19-1 and IPAE 19-14 were evaluated against three checks *viz.* PAU 881, ICPL 88039 and Pusa 992 for yield parameters. Likewise, one station trial comprising 10 early genotypes namely, IPAE 19-15, IPAE 19-16, IPAE 19-17, IPAE 19-18, IPAE 19-19, IPAE 19-20, IPAE 19-21, IPAE 19-22, IPAE 19-23 and IPAE 19-24 were evaluated against two checks viz. ICPL 88039 and Pusa 992 for yield and phonological traits.
3. **Breeding materials generated:** Twelve crosses were generated namely, PA 291//Paras/ICPL 20338, PA 406/20340, UPAS 120/CORG 9701//Manak, UPAS 120/ICPL 87154//Manak, CORG 9701/ICPL 88039//Paras, UPAS 120/ICPL 87154//Manak, PA 421/PAU 881, PA 421/ICPL 20338, PA 421/ICPL 20340, PA 421//AL 201/PAU 881, UPAS 120/DSLR 129//PAU 881, IPAC 79/Manak. F_2 population from 10 early lines, ICPL 11298/ICP 6992, ICPL 11298/ICP 7130, ICPL 11285/ICP 14459, ICPL 11285/ICP7 148, 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 and SPSs made for generation advancement. The selections from the crosses namely, AL 15/ICPL 84023, AL 15/D20, 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, 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) have reached F_4 stage. SPSs were made from 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) crosses to generate F_5 progenies. Progeny selections were made from the crosses, CORG 9701/Pusa 992, CORG 9701/ICPL 88039, CORG9701/AL201, UPAS120/Pusa992, Pusa2002-2/UPAS120, Pusa 2002-2/MN5, 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 for deriving F_6 progenies. Selection from ICPL 87154/ICPL 88039, ICPL 88039/UPAS 120, ICPL 20335/ICPL 87154, 67B/UPAS 120, ICPL 87154/Pusa 992, ICPL 20330/Pusa 992, CORG 9701/Pusa 992, Pusa 992/CORG 9701 crosses have reached F_7 stage and these were evaluated for constitution

of station trial. The entries originating from UPAS 120/ICPL 87154, ICPL 87154/CORG 9701, CORG 9701/UPAS 12, UPAS 120/CORG 9701 crosses were evaluated in replicated trial and screened for wilt and PSB resistance.

4. **Maintenance breeding:** The elite patents of extra early and early genotypes were maintained through selfing. The seed of elite advance breeding lines and entries of AICRP trials were produced under selfing net.

B03. Hybrid pigeonpea

1. **Hybrid released and notified:** The cytoplasmic male sterility (CMS)-based hybrid IPH 09-5 was released and notified for cultivation in the north-western plain zone (NWPZ). In AICRP trials, average yield of IPH 09-05 was recorded to be 1822 kg/ha, which was 30.5% more over UPAS 120 (National check). The hybrid has shown the potential yield of 2293 kg/ha. The hybrid is having indeterminate growth habit and matures in 151 days, nearly 7-10 days earlier in maturity as compared to UPAS 120. The hybrid shows 90.26% fertility restoration averaged over four years of evluation. The 100-seed weight of the hybrid has been recorded as 9.6 g, and its seed has better colour, shape and size as compared to UPAS 120. The hybrid seed has 20.8% protein content.
2. **Evaluation of hybrids in station and multi-location trials:** Three pigeonpea hybrids, IPH18-04, IPH 18-09 (IHT) and IPH 17-01 (AHT-1) have shown 29%, 33% and 17% yield superiority over the best check ICPL 88039 under AICRP trials The days to maturity varied from 137 days (PAU 881) to 192 days (BDNPH 12-05 and BDNPH 13-04). Two hybrids PAH13 (2010.4 kg/ha) and IPH 19-01 (1960.4 kg/ha) showed 48% and 44% yield superiority, respectively over the best check BDN 711 (1358.33 kg/ha). In station trial, six hybrids were evaluated with three checks ICPL 88039, PAU 881 and Pusa 992 and two hybrids IPH 19-05 and IPH 19-06 produced more yield than the best check Pusa 992 (2057.3 kg/ha) and their yield superiority ranged from 27-38%. A total of 46 AXR combinations were evaluated in augmented design with check Pusa 992 and UPAS 120. Days to maturity and fertility restoration ranged from 126-181 days and 7.7-100%, respectively. Superior cross combinations such as AL 116A/AK 250189R were identified.



3. **Development of new CMS lines:** In CMS conversion program, backcross was performed of the current BC_3F_1s with their respective recurrent parents (ICPL11244, ICPL11301, ICPL11326, ICPL20325, ICPL20326, ICPL20327, ICPL20329). The stable line GT 288A was used a cytoplasm donor for new CMS conversion for new pigeonpea genotypes. Complete male sterility was observed in the BC_4F_1 (ICP 88034, ICP 20338, ICP 11255, ICP 20340, PAU 881) and BC_6F_1 lines (AL 15, ICP 7148, AL 201, Pusa 2002-2, MN 5).
4. **Maintenance of A, B and R lines:** A total of 30 sterile (A) lines, cognate maintainer (B) lines and 80 restorer (R) lines are being maintained.

C. Genetic enhancement in lentil

1. Varieties Developed

1.1. IPL 225: The lentil variety (IPL 225) has been released and notified for cultivation in Uttar Pradesh. It has been developed through hybridization from three way crosses [(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 which are another advantages with this variety.

1.2. IPL 329: This lentil variety has been notified and released for cultivation in Uttar Pradesh. This variety developed through hybridization from a single cross (KL 178/DPL 62). IPL 329 has yield superiority of 9.03% over check variety DPL 62 in

Uttar Pradesh under the normal sown conditions. It has average yield 1012 kg/ha and matures 124 days. This 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.



IPL 225



IPL 329

1.3. Performance of breeding lines in AICRP trials: Total 13 entries were evaluated in AICRP trials during 2019-20. One entry IPL 237 having average yield 1189 kg/ha and 7.6% yield superiority over best check VL 126 has been promoted to AVT-1 for NHZ. Six new entries including IPL 239 & IPL 240 (small seeded), IPL 345 & IPL 346 (large seeded) and IPL603 & IPL 604 (Rice fallow) are being evaluated in AICRP during current *Rabi* season 2019-20.

1.4. Performance of genotypes in UP State Adaptive Trials: IPLS 231 and IPLS 232 (small seeded) and IPLB 338 (large seeded) performed well and recommended for releasing in Uttar Pradesh. In addition to this, 15 entries are being evaluated in AVT-2, AVT-1 and IVT during *Rabi* 2019-20.

1.5. Evaluation of promising breeding lines: During 2019-20, two station trials with 15 entries each and aPYT with 60 entries were evaluated at main and new research farm for yield performance. At main farm, in ST-I, 2 entries IPL 11702 and IPL 171423 (22.2 q/ha each) have been identified promising over the check variety DPL 62. The later entry IPL 171423 has highest yield along with early maturity (116 days). In ST-II, five small seeded entries including IPL 10834, IPL 151229, IPL 161502, IPL 161421, IPL 131103 and IPL 161426 were identified promising having average yield from 19.2 q/ha to 20.9 q/ha over check variety IPL 220 (18.3 q/ha). Among these, entry IPL 151229 had early maturity (116 days). In PYT, 11 entries (IPL 171392, IPL 141550, IPL 171398, IPL 1936201, IPL 141563, IPL 151134, IPL 131225, IPL 141159, IPL 1946104, IPL 191520, IPL 11718) were found promising. Five entries (IPL 181662, IPL 14977, IPL 131210, IPL 181618, IPL 121802) have been identified promising at RS-Bhopal. These large seeded entries (>3.0 g/100 seeds) had average yield 29.2 to 31.8 q/ha and matured 104 to 109 days.

1.6. Generation of breeding material: During *Rabi* 2019-20, 33 crosses including multi-parent crosses (SLLOPFL/IG 54, DPL 62/IG 54, EC 520204/IG 54, IPL 181662/IG 54, IPL 316/IG 54, IPL 316/L 4710, IPL 316/L 4603, DPL 62/JL 3, IPL 316/JL 3, IPL 316/ILL 7663, IPL 316/L 4717, IPL 316/ PL 02, IPL 316/PL7, IPL 220/SLLOPFL, IPL 316/IPL 321, Kota Masoor 2/ILWL 146, IPL 316/DPL 58, IPL 316/LL1114, ICARDA 1946133/IPL 406, IPL 406/LIENMH 36119, LIENMH 36119/IPL 406, IPL 316/LL 699, [(IPL 539/IPL 534)//(IPL 321/IPL 220)], [(IPL 316/IPL 534)//(IPL 316/L 4710], [(IP 225/IPL 220)//(IPL534/IPL 321)], [(IPL 534/IPL 321)//(IP 225/IPL 220)], [(IPL 321/IPL 220)//(IPL 539/IPL 534)], [(IPL 316/l-4710)//(IPL 316/IPL 534)], [(IPL 11702/IPL 10820)//(IPL 316/IPL 10820)] were attempted among the EBLs having earliness, high biomass and wider adaptability.

F_1 seeds were grown from 27 crosses (IPL 534/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/SLLOPFL, IPL 232/SLLOPFL, IPL 321/Kalamasara, IPL 220/Tal-9, JL 3/EC520204, IPL 316/L 4714, DPL 62/IPL 406, IPL 220/IG 4686, JL 1/Kalamasara, 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). Total 179 F_1 plants were generated from these crosses. The single plants were selected from 12 F_2 (87 + 4 bulks), 9F_3 (140 SPS), 21F_4 (259 SPS), 44F_5 (345 SPS) and 300 progenies of 34F_6 bulked for yield. These lines have been advanced to next generation and 60 improved breeding lines having higher yield, selected from F_5 bulk progenies are being evaluated in PYT during current Rabi-season (2020-21).

1.7. 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) has been advanced to next generation (F_5) for developing NILs. While AB QTL mapping populations for early vigour from a cross ILL 6002/IPL 220 has been advanced to BC_2F_4. These mapping populations have been grown for generation advancement. In addition to this, trait specific RIL mapping populations for early seedling vigor (ILL 7663/DPL 15) having 160 RILs; root traits (IPL 98/193/EC 208362) having

200 RILs; earliness (L 4603/Precoz) having 160 RILs, wilt resistance (PL 02/Precoz) having 160 RILs have also been maintained.

1.8. Nucleus seed production: Total 739 kg nucleus seeds of 12 released varieties (IPL-81, IPL-406, DPL 15, DPL 62, IPL 316, IPL 526, IPL 220, IPL 321, IPL 315, IPL 534, IPL 225 and IPL 329) were produced and 6800 SPSs of above varieties were selected for next year nucleus seed production.

1.9. ICARDA nurseries: Three ICARDA nursery of large seeded (LIEN-L-2020), mechanical harvesting (LIENMH-20) and earliness (LIEN-E-2020) comprising 25 entries were evaluated. Among these, SPSs were made from 13 and 6 entries from LIENMH-20 and LIEN-E-2020, respectively.

D. Urdbean

D01. Genetic enhancement in Urdbean

1. Variety Developed

1.1. IPU13-1: In addition to Madhya Pradesh, this variety was recommended for cultivation in Uttar Pradesh state (Notification no. 99(E) 06.01.20.). This variety was developed by hybridization (DPU 88-31/UG27) followed by pedigree selection The variety has been tested in different agro-climatic zones of Uttar Pradesh including Bundelkhand zone during the year 2015, 2016 and 2017 and performed well over the check varieties. Thoroughly tested in AICRP across all the zones in the country in IVT and AVT 1 during *kharif* 2015 and *kharif* 2016 and yield varied from 588 kg/ha to 1703 kg/ha. In Southern zone, IPU13-1 outperformed all the checks and showed yield superiority of 17.20 % to 19.98%. This is multiple disease resistant variety. Highly 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. Also resistant to white fly and Jassids insects under field conditions. Early maturing (72 days) slightly better than check variety. Attractive black seed colour, medium large seeds (4.14 g/100 seeds) with high protein content (26.12 %).

1.2. Generation of breeding material and Generations advancement: Fourteen fresh crosses were obtained involving diverse breeding lines or parents. The crossed pods were harvested. The crosses were as following: IPU 94-1/Jalpaiguri local, PU 19/IPU 99-95, IPU 02-43/LBG 17, T9/LBG 17, IPU 94-1/Lalitpur local, PKGU-1/IPU 99-95, IPU 94-1/PLU-272, IPU 19-27/IPU 19-53, IPU 11-02/PM-6, IPU 11-02/Jalpaiguri local, IPU 11-02/Lalitpur Local, KUG-489/Barabanki local, DPU 88-31/MukundraUrd 2, PU19/IPM 2-3.

1.3. Advancement of segregating generations: Twenty advanced breeding lines, and segregating generation (F_2-F_8) were advanced as follows:

Generation	Families	Crosses	SPS made
F_2	-	46	46 bulks
F_3	-	23	150+23 bulks
F_4	209	45	200+ 178 bulks
F_5	19	19	140+19 bulks
F_6	20	20	20 bulks

Table 1 : Advancement of grafting generations

1.4. Promotion of entries in AICRP trials: IPU 19-10 (mean yield 1910 kg/ha) was promoted to AVT1 trial in NWPZ zone of AICRP-MULLaRP trials.

1.5. Promotion of entries in state varietal trials: The urdbean entry IPU 10-30 was promoted for third year of testing in Uttar Pradesh State Adaptive Trials. Over the last two years, it showed superiority over the best check.

D02. Genetic enhancement of urdbean for new niches of different agro-ecological zons

1. Hybridization and generation advancement: For development of genetically improved breeding lines of urdbean for abiotic stress tolerance (drought-heat tolerance and photo-thermo insensitivity) coupled with new plant type for new niches of different agro-ecological conditions, a new set of 40 crosses were attempted involving diverse breeding lines during Kharif 2020. However, seeds could be obtained from 27 crosses. The list of seeds obtained from new crosses are as follows;

SL	Crosses	SL	Crosses
A	**Photo-thermo insensitivity**	**B**	***Drought & Heat tolerance***
1	LBG 17/PGRU 95016	**17**	PU 19/IC 369817
2	LBG 17/IC 261180	**18**	PU 19/STY 2289
3	PDU-1/PKGU 3	**19**	PU 19/PKGU 3
4	PDU-1/PGRU 95016	**20**	IPU 10-26/IC 369817
5	PDU-1/LBG 752	**21**	IPU 10-26/KNP Sel.-1
6	PU 19/PKGU 3	**22**	PU 19/KNP Sel.-1
7	PU 19/PGRU 95016	**23**	PU 19/LBG 685
8	IPU 10-26/PKGU 3	**24**	PDU 1/SPS 5
9	IPU 10-26/PGRU 95016	**25**	IPU 10-26/STY 2289



SL	Crosses	SL	Crosses
10	LBG 17/IPU 02-43	C	*Wide Hybridization*
11	PDU-1/IPU 02-43	26	LBG 17/*V. sylvestris*
12	PDU-1/SPS 5	27	IPU 94-1/*V. sylvestris*
13	PU 19/LBG 752		
14	PU 19/IPU 02-43		
15	IPU 10-26/LBG 752		
16	IPU 10-26/IPU 02-43		

Table 2: New crosses developed in urdbean

2. **Evaluation and advancement of segregating generations for abiotic stresses:** The segregating generations (F_1's and F_2's) was advanced during *Rabi* 2020 and *kharif* 2020 at ICAR-IIPR, RC Dharwad and ICAR-IIPR, Kanpur, respectively. A total of 36 F_1's (6F_1's for heat tolerance,13F_1's for drought tolerance and 12F_1's for photo-thermo insensitivity are being raised at ICAR-IIPR Main campus, Kanpur during spring/ summer 2020 for generation advancement to F_2 generation. During *Kharif* 2020, a total of 31 F_1's (6F_1's for heat tolerance, 15F_1's for drought tolerance and 10F_1's for photo-thermo insensitivity), while, a total of 28 F_2's (6F_2's for heat tolerance,14F_2's for drought made tolerance and 8F_2's for photo-thermo insensitivity). A total of 570 single plant selections were from different segregating generations. All segregating generations were advanced through single plant selections. The breeding lines and segregating generation (F_1-F_4) were advanced as following.

Generation	Crosses	SPS made
F_4	31	1250 + 31 bulks
F_3	28	570 + 28 bulks
F_2	28	28 bulks
F_1	36	36 bulks
G_2	09 Multiline cross	40 bulks

E. Mungbean

1. Varieties Developed:

1.1. **IPM 512-1 (Soorya):** This variety has been developed from the cross IPM 99-125/Co 5 and released and notified for cultivation in NEPZ (Eastern U.P., Bihar, Jharkhand, Assam and W.B) during spring season. IPM 512-1, exhibited an average yield potential of 1255kg/ha under AICRP Trials with a very high yield potential (upto 2.0 tons/ha). The yield advantage of 15.83% over Pusa Vishal and 13.57% over Pant Mung 5. This variety is highly resistant to MYM was recorded 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 (3.9g/100 seed) with 21.53% protein content and will be a suitable choice to farmers for cultivation in during Spring. This variety will provide a superior alternative to IPM 99-125 (Meha).



Fig. 3: Mungbean variety IPM 512-1 (Soorya)

1.2. **IPM 312-20 (Vasudha):** This variety was developed from the cross IPM 03-1/SPS 5. It exhibited >18% yield superiority over the best check IPM 99-125 in U.P. State Adaptive Trials over a period of 3 years. With a yield potential of 10-11 q/ha, this variety is highly resistant to yellow mosaic diseases and resistant to Cercospora leaf spot and powdery mildew diseases and has green, shining, attractive and medium large (3.9 g/100 seed) seeds. This variety has been released and recommended for cultivation during Spring season in Uttar Pradesh.

1.3. **IPM 409-4 (Heera):** The variety IPM 409-4 (Heera)has been developed from the cross PDM 288/IPM 03-1 and it performed consistently better over the best check IPM 99-125 in U.P. State Adaptive Trials during Spring season. This variety has a yield potential of 10-12 q/ha and matures in 55-57 days. It has green, medium large (3.5g/100 seed) and shining seeds. This variety has been released and recommended for cultivation during Spring in Uttar Pradesh.

2. **Identification of unique material:** While most of the consumers prefer shiny green grains of mungbean, yellow grains are preferred in parts of West Bengal, Assam and also a few pockets in Bangladesh and Sri Lanka. Yellow seeded traditional mungbean cultivars are known to be associated with a peculiar aroma after boiling and owing to their organoleptic properties fetch a premium price. However, cultivation area of



IPM 312-20 (Vasudha)



IPM 409-4 (Heera)

yellow mung could not expand much due to the associated limitations *viz.*, indeterminate growth, asynchronous flowering, high susceptibility to yellow mosaic disease and long crop duration in contrast to the modern high yielding, synchronous and stress resistant mungbean cultivars. To improve the yellow mungbean cultivars and increase their adaptation, an initiative was taken to improve the local cultivars of Sona Mung through breeding. Three elite cultivars viz., IPM 99-125, IPM 02-3, PDM 139 were crossed with a local landrace of Sona Mung collected from Malda District of West Bengal. All the crosses were advanced till F_7 between 2009-16 following pedigree method of breeding and single plant selections were done in each generation F_2 onwards for golden yellow seed coat colour besides other desired traits viz., erect plant type, resistance to yellow mosaic disease, early and synchronous maturity (<70 days) and a wider adaptability to different cropping systems. Finally, the superior fixed lines were evaluated in preliminary yield and station trials and 5 outstanding golden yellow seeded lines viz.,



IPM 604-1-1, IPM 604-1-2, IPM 604-1-6, IPM 604-1-7 and IPM 604-01-8 were identified from the cross IPM 99-125 x Sona Mung. Among these, the genotype IPM 604-1-7 performed significantly better than the best check and therefore, was nominated for multilocation evaluation in AICRP on MULLaRP in 2019. Currently, this genotype is in advanced stage of evaluation and is expected to be identified and released as superior golden yellow cultivar of mungbean.

3. **Multilocation evaluation of promising genotypes in AICRP/Adaptive trials:** During 2020, thirteen mungbean genotypes were evaluated in multilocation trials under the umbrella of AICRP (MULLaRP). Genotype IPM 101-102 was evaluated in AVT-2 in NEPZ during Spring 2020 and it recorded a yield superiority of 4.66% over the best check, SML 832 although it could not be identified for release. The genotype IPM 312-394-1 was promoted to AVT-I during *kharif* in NHZ with a yield superiority of >15 % over the best check. Likewise, two genotypes viz., IPM 1604-1 (20.49%) and IPM 604-16-2 (10.5%) were promoted to AVT-I in NEPZ during Spring season with a yield superiority of 20.49% and 10.5%, respectively over the best check IPM 99-125.

In addition, nine new genotypes were entered in AICRP trials for their multilocation evaluation in different seasons. These included three genotypes *viz.*, IPM 1103-1, IPM 1610-1 and IPM 1603-1 for Spring and Summer seasons as well as during *rabi* rice fallow; 2 genotypes *viz.*, IPM 604-1-2 and IPM 1604-1 for *kharif* season and another 2 new genotypes *viz.*, IIPM 20-1 and IIPM 20-2 developed in partnership with World Vegetable Centre for *kharif* and *rabi* respectively seasons. Two genotypes viz., IPMD 1604 and IPMD 101-2 were also entered for multilocation evaluation in collaboration with IIPR-RS, Dharwad. Earlier, the genotypes *viz.*, IPM 14-49-5 and IPM 1604-1 were included in AICRP trials for their multilocation evaluation in Spring and Summer seasons.

4. **National crossing programme:** Three genotypes, IPM 409-4 (early and synchronous maturity), IPM 4 10-3 (high no. of clusters, high no. of pods and resistance to yellow mosaic disease) and EC 398889 (heat and drought tolerance) were included in National Crossing Programme during *kharif* season across different centres in the country and were involved in hybridization programme to generate fresh breeding materials.

5. **Evaluation of elite breeding lines:** Two demonstrations, four station trials and four PYTs were conducted at IIPR Kanpur and two station trials (ST) at RS, Dharwad during *Kharif* 2020. The demonstrations were conducted with 13 entries including nine mungbean varieties developed by IIPR and four advanced lines currently under multilocation evaluation through AICRP, one each at main farm and New Research Campus, ICAR-IIPR, Kanpur.

All four station trials were conducted at the main research farm, IIPR Kanpur each with a total of 14 entries including four check varieties in three replications. In ***ST1***, three genotypes, IPM 1603-4 (1490 kg/ha), IPM 101-102-1 (1350 kg/ha) and IPM

9906-1-1 (1337 kg/ha) yielded better than the best check Shikha (1256 kg/ha). All these genotypes were also highly resistant to MYMV and matured in 65-70 days. In ***ST2***, 4 genotypes, IPM 101-102 (1450 kg/ha), IPM 1603-3 (1340 kg/ha), IPM 1604-1 (1244 kg/ha) and IPM 1603-7 (1220 kg/ha) produced more yield than the best check IPM 410-3 (Shikha) (1186 kg/ha) and also recorded very high resistance to MYM disease. In ***ST3***, four genotypes were either on a par or yielded better than best check IPM 02-3 (1120 kg/ha). These included IPM 06-5/IPM 409-4 (1446 kg/ha), IPM 1202-1 (1168 kg/ha), IPM 1620-5 (1158 kg/ha), IPM 1205-2 (1120 kg/ha) and IPM 1604-4 (1112 kg/ha). In ***ST4***, total 3 genotypes, IPM 1611-2 (1128.23 kg/ha), IPM 701-704 (1097 kg/ha), and IPM 312-18 (1058 kg/ha) were either better or on a par with best check IPM 02-3 (1054 kg/ha). All these superior performing lines were also highly resistant to MYM disease.

Four preliminary yield trials were also conducted during *Kharif* 2020, each with 28 entries and two replications. The materials included 23 advanced lines and five checks in each trial. In ***PYT-I***, the genotypes IPM 732-2 (50 kg/ha) and IPM 1718-3 (1160.60) yielded better than the best check IPM 205-7 (1110 kg/ha). In ***PYT-2***, the genotype IPM 1704-18 (1118 kg/ha) was found yielding better than the best check IPM 205-7 (1000 kg/ha). In ***PYT-3***, the genotype IPM 312-18 (1104 kg/ha) was the best yielder and performed better than the check IPM 2-14 (1035 kg/ha). In PYT-4, the check cultivar IPM 410-3 (Shikha) was observed to be the highest yielder (1230 kg/ha).

During Spring 2020, two station trials were conducted at ICAR-IIPR, Kanpur main campus with 25 entries each including four checks in each trials. In ***ST1***, the genotypes IPM1610-1 (1840 kg/ha), IPM 604-1-6 (1688 kg/ha), IPM 1604-1 (1540 kg/ha), and IPM 1603-3 (1540 kg/ha) yielded better than the best check IPM 2-3 (1499 kg/ha). In ***ST2***, the genotypes IPM 1205-2 (2302 kg/ha), IPM 1604-4 (2088 kg/ha), IPM 312-18-2 (1797 kg/ha) and IPM 312-17-8 (1701 kg/ha) recorded better yield in comparison to the best check IPM 205-7 (1659 kg/ha).

At IIPR Regional Station, Dharwad, two station trials each with 25 elite breeding lines of mungbean along with two checks (IPM2-14 and DGGV-2) were conducted during *kharif* 2020. In ***ST1***, the entries, IPM 14-10 (1245 kg/ha) and IPM 1620-1 (1121 kg/ha) were significantly better than the best checks (IPM2-14 (1005 kg/ha), DGGV-2 (900 kg/ha). In ***ST2***, the entries IPM 312-18 (1395 kg/ha) and IPM 539-10-2 (1074 kg/ha) produced higher seed yield compared to best checks IPM2-14 (1050 kg/ha) and DGGV-2 (950 Kg/ha). Likewise a station trial was conducted during summer 2020 at RS, Dharwad with a total of 25 entries including 4 checks. 5 entries, *viz.*, IPM 14-35 (1364 kg/ha), IPM 14-9 (1295 kg/ha), IPM 312-394-1 (1254 kg/ha), IPM 1603-4 (1175 kg/ha), IPM 9901-6-1 (1147 kg/ha) were found to be performing better than the best check IPM 2-14 (1087 kg/ha). All the above high yielding lines were found to be highly resistant to yellow mosaic and other prevalent diseases of mungbean.

6. **Generation and advancement of breeding materials**: During *kharif* 2020, 14 intra-specific crosses were attempted between 6 elite mungbean cultivars (IPM 99-125, IPM 410-3, IPM 02-3, IPM409-4, IPM 2-14, IPM 205-7) and 5 donors (EC 398889, IC 251433, WGG 42, BMWCD 31, RMG 1028). Likewise 14 inter-specific crosses were also generated using 6 elite mugbean cultivars (IPM 99-125, IPM 410-3, IPM 02-3, IPM 409-4, IPM 2-14, and IPM 205-7) and 4 donors viz., PGRU 95016, VBG 04-008, SPS 5 of urdbean and *V. umbellata* (different accessions). Simultaneously 6 new crosses were also generated under the umbrella of international Mungbean Improvement Network using the elite mungbean cultivars IPM 409-4, PDM 139 and IPM 205-7 as the recipients and genotypes VI 00496AG, VI004969AG, VI 003355 AG and VI 002190BG. These crosses were exclusively developed for early maturity and bruchid resistance.

   Besides development of new crosses, the breeding materials in different segregating generations were also advanced. Single plant selection were done for superior plant types *w.r.t.* various morphological and agronomic traits, disease resistance and maturity duration accordingly, 24 SPS were isolated from eight crosses in F_8, 40 from six crosses in F_7, 40 from four crosses in F_6, 74 from 16 crosses in F_5, 58 SPS from 14 crosses in F_4, 192 from 26 crosses in F_3 and >200 SPS from 12 crosses in F_2 generation. Simultaneously 37 outstanding lines were bulked from the above breeding materials which will be evaluated in preliminary yield trials during next year. 12 superior bulks were also isolated for their sharing with AICRP centre.

7. **Maintenance breeding:** During 2020, total 470 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, Heera was produced >3200 SPS for IIPR released varieties were also taken during kharif 2020 for growing single

plant progeny rows for producing nucleus seed.

8. **Establishing International Mungbean Improvement Network (IMIN):** A replicated trial of mungbean minicore collection (MCC) comprising 296 was conducted to evaluate the MCC during *kharif* 2019 at ICAR-IIPR, Main campus. Another trial to evaluate MCC was conducted at ICAR-RS, Dharwad (Karnataka) during *Kharif* 2020. On the basis of observations at both the locations during this as well last years, five accessions *viz.*, VI004957AG, VI004934AG, VI004973B-BLM, VI004937AG and VI002190BG were found highly resistant to yellow mosaic disease while 32 accessions were found resistant at both the locations. Another set of 90 superior lines comprising advance breeding line as well as released varieties of Australia, Bangladesh and Myanmar was also raised at both the locations and evaluated for morho-physiological characters as well as disease resistant supplied by World Vegetable Centre was evaluated for morpho-physiological traits and 16 promising lines *w.r.t* yield and quality parameters were identified. These will be subjected to further validation next year and will be used in hybridization programme.

F. Fieldpea

1. Varieties Developed:

1.1. IPF 16-13(Harit): This variety is tall, green seeded and leafy type. This variety is a derivative of cross between fieldpea and vegetable type genotypes 'IPF 99-25 and 'VRP 22, respectively. It has portrayed more than 12.45% yield superiority over the best check VL-42 with average grain yield of 1752 kg/ha across different locations of NEPZ and the highest was observed 3146 kg/ha. Moreover, it is resistant to powdery mildew and moderately tolerant to rust disease. Hence, it has been notified for NEPZ on January 6, 2020.

1.2. IPFD 12-8: This variety is white, dwarf and leafy type developed from by crossing IPFD 1-10/DDR27 as parents. It has average grain yield potential of 1158 kg/ha across different locations of Uttar Pradesh and the highest yield was recorded 2568 kg/ha. In addition, 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 and notified for whole Uttar Pradesh during 2020.





1.3. IPFD 13-2: This is a dwarf and leafy type variety of fieldpea developed from the cross between IPFD 1-10/DDR 23. It has portrayed more than 24% yield superiority over the best check KPMR 522 and gave average yield 1409 kg/ha over Uttar Pradesh State. It is resistant to powdery, downey mildew and rust disease. It has medium seed size with round, smooth and white colour with yellow cotyledon. Hence it has been released and notified in 2020 for whole Uttar Pradesh



2. **Genetic stock:** One extra early genotype IPFD 18-14 of fieldpea has been recommended by the Institute germplasm and Genotype Identification Committee for registration with ICAR-NBPGR.

3. **Generation of breeding material:** Total 34 crosses were successfully synthesized involving different donors having specific traits (large seed size, seed nos./pod, pod length, pod nos., earliness, powdery mildew resistant and rust tolerant) during *Rabi* 2019-20. In addition, fifteen more crosses were developed to different genetics related studies. Similarly, during *Rabi* 2020-21 crosses are being attempted using trait specific donors.

4. **Evaluation of advanced breeding lines:** In station trial-1 (dwarf), 10 genotypes were evaluated with three checks. Entry IPFD 2020-3 (4116 kg/ha) and IPFD 2020-9 (3200 kg/ha)

produced more yield than the best check IPFD 12-2 (3042 kg/ha). In station trial-2 (tall), 12 genotypes were evaluated with three checks. Entry IPF 2020-17 (2845 kg/ha) and IPF 2020-21 (2918 kg/ha) gave more over best check IPF16-13 (2628 kg/ha). In case of PYT (tall), 36 lines with three checks were tested. 16 entries showed yield superiority over best check IPF5-19 (2806). In dwarf category, total 22 entries were tested and 12 entries registered yield advantage over best check IPFD 1-10 (3472 kg/ha). In PYT for early category, total 35 entries were evaluated and 21 entries portrayed yield superiority over the best check DDR 23 (2850 kg/ha). In station trial (dwarf), 10 genotypes with 3 checks and in tall 12 genotypes with three checks are being evaluated. In PYTs (dwarf, tall and extra early), total 30, 37, 32 genotypes, respectively are being evaluated with three checks.

5. **Selections of promising genotypes from segregating population:** Thirty four fresh crosses were attempted and 40 crosses were raised to advanced F_1 generation. Total1506 SPS including 35 F_2: 400 SPS, 63 F_3: 556 SPS and 46 F_4: 550 SPS were harvested based on the targeted traits. In addition, 226, 154 and 47 SPS were harvested from F_5, F_6 and F_7 generation, respectively. Similarly, 49 F_1 including eight crosses of MAGIC population have been raised during *Rabi* 2020-21.

6. **Development of mapping population**: A mapping population derived from HFP 4(S)/FC 1(R) (F_7 310) cross for rust resistance in fieldpea was advanced during *Rabi* 2019-20.

7. **Nucleus seed production:** As per the DAC indent, the nucleus seed of IIPR fieldpea varieties like Adarsh (20.0 kg), Aman (80.0 kg), Vikas (20.0 kg), Prakash (20.0 kg), IPFD 10-12 (67.0 kg), IPF 4-9 (80.0 kg), IPFD 6-3 (106.0 kg), IPFD 11-5 (89.0 kg) and IPFD 12-2 (220.0 kg). IPFD 9-2(129.0kg), IPFD 2014-2 (91.0 kg), IPF 16-13 (148.0 kg), IPFD 12-8 (104.0 kg), IPFD 13-2 (141.0 kg) were produced during *Rabi* 2019-20.

8. **Promising entries in AICRP trials:** Three tall type entries IPF 18-17, IPF 18-14 and IPF 18-20 were tested in AVT-1 for NEPZ during *rabi* 2019-10 under AICRP. Similarly, a entry IPFD 18-2 (dwarf) was evaluated in AVT-1 under NHZ. However, none of the entry could surpass the best check in respective zone. Beside this, 6 entries, IPF 19-11, IPF 19-15. IPF 19-18, IPFD 19-9, IPFD 19-1, IPFD 19-3 were evaluated in IVT for tall and dwarf trials under AICRP. Based on results, two tall entries, IPF 19-18 and IPF 19-11 have been promoted in AVT for NEPZ and CZ, respectively. Likewise, two dwarf entries, IPFD 19-1 and IPFD 19-3 have been promoted in NEPZ. In Uttar Pradesh state adaptive trials three entries, IPFD 16-3, IPF 14-16 and IPFD 15-5 found promising based on three years testing. Presently total eleven entries are being tested in UP state adaptive trials.

9. **Evaluation of field pea in rice fallow:** Nine advanced lines and varieties (IPFD 14-11, IPFD 16-4, IPF 12-20, IPF 12-7, IPFD 14-2, IPFD 10-13, IPF 13-14, IPFD 11-10 & IPFD 12-2) were tested under rice fallow condition to understand fieldpea performance. Observations had been recorded for root length, RWC (%), Nodule No, Nodule weight (mg/plant), NBI, leaf chlorophyll, Flavonoids, crop health (Green Seeker), days to flowering, days to maturity and yield. Based on two year results, IPFD 14-2, IPFD 10-13 and IPF 13-14 were found promising with higher nitrogen balance index, chlorophyll content, greenness and yield. Most interestingly, CZ released variety IPFD 14-2 was having lowest maturity days with higher root length in rice fallow situation.

G. Biofortification in mungbean and urdbean

- Eighty three urdbean genotypes of diverse origin were evaluated for iron and zinc concentrations over two locations. Analysis of variance showed that genotype effects were significant for both traits over both the locations. Iron concentration ranged from 19−235 mg/kg and 16−255 mg/kg among tested genotypes at Main Farm and NRF, respectively. For zinc concentration, it ranged from 5−134 mg/kg at Main Farm, while at NRF, it ranged between 12 and 59 mg/kg. Analysis of variance showed the 'genotype (G)', 'location (L)' and 'genotype' (G) x location (L) interaction effects significant for both micronutrient concentrations. For high iron concentration, most promising urdbean genotypes (PU 31 & IPU 99−43) were identified. Similarly, highly stable genotypes for high zinc concentration were BGP 28 & HPU 120. These donors could be used in urdbean biofortification.
- Twenty urdbean genotypes were phenotyped for iron and zinc concentration using ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy) over three locations, were also analyzed for protein, moisture, total carbohydrate, fat, fibre, and phytic acid content.
- Two field trials of 150 urdbean genotypes and 150 mungbean genotypes were conducted at the biofortification trial site in NRF, IIPR during *Kharif*, 2020. All the seed materials were harvested and will be analyzed for iron and zinc concentration.
- Two field trials comprising 20 genotypes each of mungbean and urdbean were conducted during *Kharif* 2020 in randomized complete block design. Seed materials will be tested for iron and zinc
- Total 21 crosses were made under



biofortification programme as following: LBG 17/IPU 02-43, LBG 685/LBG 17, IPU 19-51/Mukundra Urd 2, KUG 479/GP 20, GP 20/IPU 19-53, IPU 19-53/ *Vigna sylvestris*, IPU 19-53/IPU 19-27, LBG 787/LBG 17, IPU 19-53/Mukundra Urd 2, DPU 88-31/GP20, IPU 02-43/ *Vigna sylvestris*, IPU 11-02/ *Vigna sylvestris*, GP 20/IPU 94-1, IPU 94-1/IPU 19-53, IPU 94-1/ *Vigna sylvestris*, IPU 94-1/IPU 19-27, IPU 19-27/Mukundra Urd 2, IPU 94-1/IPU 19-27, IPU 94-1//IPU 19-53, IPU 94-1/GP 20, IPU 94-1/ *Vigna umbellata*.

- Mapping populations available in were also biofortification programme for iron and zinc concentration are: HPU 120/IC 560408 (F_3 stage), WBU 108/Shekhar-2 (F_3 stage), Azad 3/T-9 (F_3 stage).

Plant genetic resource management and its utilization through pre-breeding

A. Chickpea

1. **Maintenance of wild *Cicer* species:** Total 113 wild germplasm accessions belonging to seven *Cicer* spp. 42 (C. *reticulatum),* 27 *(C. pinnatifidum),* 6 (*C. echinospermum),* 3 (*C. cuneatum),* 2 (*C. yamashitae),* 32 (*C. judaicum),* 1 (*C. bijugum)* are maintained in Wide Hybridization Garden. 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 donor 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 during *Rabi* 2019-20.

2. **Breeding material generated:** Eleven F_1, $8F_2$, $25F_3$, $14F_4$, $17F_5$, $20F_6$ and $15F_7$ populations have been developed out of pre-breeding. Donors for plant architecture & high podding (ILWC 256, ILWC 245, ILWC 179, ILWC 21, ICC 4958-root traits, ICC 16696, ICC 11276); Nutrition & grain quality (T 39-1, T 1-A, ILWC 257, P 3318, ICC 5912), heat tolerance and source-sink relation (ILWC 292, ILWC 81, ILWC 238, ILWC 142, ILWC 252, ILWC 243, ILWC 49, ILWC 21, ICC 1205, ICC 3525, ICC 14778, ICC 1164); Generation of variability (ILWC 179, ILWC 115, ILWC 141, EC 54154, EC 583268, EC 600098, EC 6000100) and Phosphorus use efficiency (ICC 7272, IPC 2008-34) were identified and used for developing breeding materials.

3. **Identification of distinct genotypes:** Advanced lines with up to 50% pods having 3-4 seeds/pod have been developed. Evaluated distinct landrace isolated from T 39-1. Germplasm accessions/breeding lines tolerant to post emergence herbicide Imazethapyr (1.5X @ 120 g/ha.) have been identified. Germplasm accessions with high podding and yield has been identified.

4. **Broadening genetic base:** Panel of 78 desirable accession with yield potential ≥ 22 q/ha has been constituted and evaluated under adoptive trial (Pre-breeding) for their utilization in breeding. Promising accessions: ICC 1903, ICC 6336 and ICC 4243 were identified. Ascochyta resistant lines identified ICC 17164 & ILWC 21 (CR); ILWC 188 (CP) & 8-CJ.

5. **Field evaluation:**Breeding lines with high yield has been developed for PYTs and station trials. Potential entries IPC17-37, IPC17-88 and IPC17-249 were identified with yield up to 29 q/ha

B. Pigeonpea

1. **Germplasm rejuvenation:** The germplasm holding are being rejuvenated on regular interval. A set of about 1,000 genotypes are sown each year for seed revival and multiplication. 717 long duration genotypes and 315 early maturing genotypes were planted for rejuvenation.

2. **Maintenance of wild relatives:** Twelve wild pigeonpea spp. evaluated in garden with appropriate of were photoperiod and temperature. *C. albicans* do not produce seed and was maintained as a perennial. *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, ICP 15775, 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) and *Rhynchosiaaurea* (ICP 15809, ICP 15810) were maintained. In addition, 10 genotypes are being maintained under net house for crossing with cultivated.

3. **Pre-breeding:** Wild relatives of pigeonpea harbour useful alleles against biotic and abiotic stresses. Few accessions of *C. scarabaeoides* and *C. platycarpus* have shown consistent resistance to Fusarium wilt and Phythopthora stem blight. In addition, some accessions of *C. scarabaeoides* have exhibited tolerance to pod borer. Two accessions of *C. cajanifolius* have been found to bear large number of primary branches. Wide range of variations was observed in the segregating generations derived from wild crosses. Pre-



breeding in pigeonpea is targeted for incorporating trait specific alleles with minimal aberration in the background of advance derived lines. This is being achieved through rigorous selection and intermating among early segragants. Crosses were attempted between *C. cajan* and *C. scarabaeoides*, *C. cajanifolius*, *C. sericious*, *C. lineatus*and *C. platycarpus*. Segregating materials of crosses, *C.scarabaeoides*, *C.sericious*, *C.lineatus* generated from extramural project were also included in pre-breeding programme. Intermating was also followed among rigorously selected trait specific early generation segregants. Trait specific lines of *C. cajan* were also utilized for the incorporation of *Fusarium* wilt and *Phythopthora* trait specific alleles into improved lines. Early maturing segregants were identified from the F_2, F_3 and F_4 and progenies of C. *cajan* /*C. scarabaeoides* are being advanced to next generation. Beside this, the advance generation emanating from the wide crosses, early three (determinate, early and pod bearing in cluster) x *C. scarabaeoides* (ICP 15685), UPAS 120/*Cscarabaeoides* (ICP 15731), IPAC 64/*C cajanifolius* (ICP 15629) are being screened for pod borer tolerance. Large number of progenies from UPAS 120/ICPL 11263, UPAS 120/ICP 15685-2, UPAS 120/ICP 15763, UPAS 120//ICPL 20340/ICP 15739 and Pusa 992/ICP 15642 are also being advanced to F_5. 100 SPS were selected from each crosses for constituting next generation

4. **Generation advancement of pre-bred materials:** Single plant selections are continued for late filial generations to ensure fixation of alleles in the wild derivatives. The BC_1F_9 and F_{10} populations derived from crosses, namely Early 3 (determinate, early and pod bearing in cluster) x *Cscarabaeoides* (ICP 15685), UPAS 120/*Cscarabaeoides* (ICP 15731), IPAC 64/*C. cajanifolius* (ICP 15629) being generated. The derivatives of wild crosses were advanced to F_{10} generation. The selfed progenies of cross derivatives among selected F_4's plants between the adapted lines and F_5 derivatives of *C. scarabaeoides* namely, NDA 1/WDN 100, Pusa 2001/Bennur local, IPAC 79/WD 5, Maruti/WD 5-1, Maruti/WDN 100, WDBCU-5-2/WDBCU-5-1 were advanced to the F_5 generation. Selections were made from the F_8 derivatives of *C. scarabaeoides* (IPAC 8/WDN 2-258, ICP 88039/IPAC 3, ICP 88039/WD 3, WDN 1-95/IPAC 3, IPAC 79/WD 4, IPAC 79/WD 5, IPAC 79/WD 3, IPAC 70-1/WDN 2-288) for advancing them to F_9.

5. **Screening of genotypes for *Fusarium* wilt and *Phythopthora* stem blight resistance:** The pre-breeding lines and newly acquired genotypes are raised in the *Fusarium* wilt and *Phythopthora* stem blight sick. SPSs are made from the segregating generations for fixing genotypes for resistance. Fixed lines are also screened for confirmation of stability of resistance. One hundred and fifty two lines including germplasm accessions were sown in wilt sick plot for screening against *Fusarium* wilt. A population derived from intermating of wilt resistant genotypes followed by open pollination for two generations in wilt sick plot is also being screened for selection of resistant genotypes for reconstituting the population with maximum favourable alleles for wilt resistance. Likewise, 22 advance lines of pre-breeding material were screened for *Phythopthora* stem blight in sick plot.

6. **Validation of *Phythopthora* stem blight resistance genotypes:** Two cultivated (IPAC 2 & IPA15-8) and 2 wild accessions of *C.scarabaeoides* namely, SPD/DD-2 (IPAW14-2) and SPD/DD-3 (IPAW14-3) showed consistent resistance over 2 years (2019 & 2020) to PSB in sick plot. The average disease incidence over the years was 16.8 %, 20.2 %, 19.8% and 11.8%, respectively for IPAC 2, IPA15-8, SPD/DD-3 and SPD/DD-3,which are considered as resistant reaction, whereas the susceptible check showed 84 % infection. The genotypes, IPAC 2, IPA15-8, SPD/DD2 (IPAW14-2) and SPD/DD-3 (IPAW14-3) have been identified as donor for resistance to *PSB*. IPA 15-8 has high worth in development of short duration varieties whereas, IPAC 2 is valuable source of PSB resistance in medium duration variety for central and southern zones. The *Cajanus scarabaeoides* wild accessions viz. SPD/DD-2 and SPD/DD-3, collected from two distinct locations have high value in pre-breeding programme as these accessions are also resistant to *Fusarium* wilt and tolerant to heat and drought in addition to PSB resistance.

7. **Evaluation of wild derivatives for pod borer tolerance:** A trial in second year comprising 40 advance lines derived from *C. scarabaeoides* is being screened for tolerance against *Helicoverpa armigera* and *Maruca vitrata*. This trial is being conducted by entomologist using standard procedure for evaluation of tolerance against insect damage.

8. **Registration of trait specific genotypes:** Waterlogging tolerant genotype IPAC 79 was registered with ICAR-NBPGR. It exhibited waterlogging tolerance (survival 53.8%) for 96 hrs under randomized artificial waterlogging condition at two farms for three years, whereas



check genotype ICPL 7035 showed less than 1% survival. Potted waterlogged plants of IPAC 79 developed new roots above crown region and aerenchyma cells which enhanced survival rate under waterlogged condition. It did not develop anthocyanin pigment in the leaves after waterlogging, which is another indicator of waterlogging stress tolerance. This genotype is resistant to *Phythopthora* stem blight. IPAV16-1 have been registered with ICAR-NBPGR for high seed weight. This genotype exhibited high dried and green seed weight of 23.04 and 52.00 g per 100 seeds, respectively.

C. Mungbean

1. **Germplasm resources and wild accessions**: During *kharif* 2020, 961 germplasm accessions were rejuvenated. This included 290 active germplasm collections, 35 accessions including landraces and farmers' materials, one IMIN minicore set comprising 296 accessions and 90 AVMU advanced breeding lines supplied by the World Vegetable Centre (advanced breeding materials as well released cultivars of Australia, Myanmar and Bangladesh). The 296 minicore accessions were raised in two replications during *Kharif* season at ICAR-IIPR, Kanpur and during Summer at IIPR, RS, Dharwad. Data were recorded on 24 morpho-physiological parameters besides disease incidence at IIPR Main Campus. 7 superior entries w.r.t.Among wild genetic resources, 250 *Vigna* accessions of 21 spp as described in the table below were rejuvenated during *Kharif* 2020. These were also evaluated for morpho-physiological traits following IBPGR descriptor.

Candidate entries with check	pedigree	Days to matu-rity	% PSB incidence (average of 2019 & 2020)	Remarks
IPAC-2 *Cajanus cajan*	UPAS 120 / Banda Palera	190	16.8	Moderately resistant to wilt. Serves as important donor for PSB in medium maturity group
IPAE 15-08 *Cajanus cajan*	Pusa 992 /UPAS 120	155	20.2	Valuable candidate for PSB resistance genes in early maturity because all other known sources of PSB resistance are in medium or late maturity group
SPD/DD-2 *Cajanus scarabaeoides*	Germplasm accession collected from Tripura (23.928 E 91.289N)	160	19.8	This is a new accession reported for PSB resistance in *C. scarabaeoides*, no other accession of this species is registered for PSB resistance
SPD/DD-3 *Cajanus scarabaeoides*	Germplasm accession collected from Tripura (23.518 E 91.671N)	160	11.8	This is a new accession reported for PSB resistance in *C. scarabaeoides*, no other accession of this species is registered for PSB resistance
UPAS-120 (Check)		165	84.0	

Table 3: Germplasm maintenance during 2019 at ICAR-IIPR in mungbean

SL	Germplasm Set	No. of accessions
1.	Active germplasm collection	290
2.	Landraces and Farmers' materials	35
3.	Miniore set	296
4.	AVMU advanced lines	90
6.	Wild accessions	250
	Total	**961**



Vigna wide hybridization garden at ICAR-IIPR, Main Campus

D. Lentil

Total 450 accessions of active germplasm and 90 accessions of Mediterranean land races were maintained. Total 601 single plant progenies from 41 wild x cultivated crosses were advanced and maintained. A fresh cross between Kota Masoor2/ILWL146 was attempted and F_2 seeds were harvested from 3 F_1 plants of 2 wide crosses (IPL220/ILWL63 and IPL321/ILWL63) for generating new variability. Total 56 pre-breeding lines have been evaluated for yield in F_6. Among these,15 were selected for further evaluation for yield in PYT during 2020-21. LIEN-MH18-36119, LIENE19-46130, LIENE19-46133, LIENE19-46136 have been identified donors for tolerance to lodging and IG54 has been identified donor for wilt resistance under wilt sick plot. Total 158 accessions of wild species were maintained and 834 accessions of lentil germplasm have been rejuvenated at Bhopal center.

E. Urdbean

1. **Maintenance and management of urdbean germplasm:** Total 558 germplasm lines including 408 and 150 lines were evaluated during kharif 2020 and summer 2020 at IIPR Kanpur and RRC Dharwad, respectivelyfor maintainance and further utilization in future breeding program
2. **Screening of urdbean germplasm lines for abiotic stresses:**310 urdbean germplasm lines were raised during kharif 2020 for screening of biotic/abiotic stress resistantce coupled with yield attributing traits. Observations were recorded on reproductive phenology, seeds/pod, pods/plant, 100-seed weight and yield/plant under field conditions. Five plants were randomly selected from each line. 18 genotypes, IC 369817, IC 274608, IPU 94-1, IPU 13-1, IPU 99-98, IPU 90-32, IPU 99-168, LBG 17, LBG 20, LBG 752, LBG 787, KNPSel-01, SPS 32, SPS 38, UH 8241, UH 864, PLU 4815, PLU 832 were identified as the promising germplasm lines under field and controlled conditions, indicating the existence of significant genetic variability for yield and yield attributing traits among genotypes and identified as promising lines for both stresses

Table 4: Maintenance and evaluation of wild *Vigna* accessions during 2020

SL	Name of species	Accession no.	SL	Name of species	Accession no.
1.	*Vigna radiata*	15	12.	*V. hainiana*	04
2.	*V. trilobata*	108	13.	*V. trinerniavar. bournei*	03
3.	*Vigna mungo*	12	14.	*V. glabrescens*	01
4.	*V. umbellata*	18	15.	*V. pilosa*	03
5.	*V. sublobata*	08	16.	*V. trinernia*	01
6.	*V. aconitifolia*	08	17.	*V. dalzelliana*	03
7.	*V. sylvestris*	08	18.	*V. unguiculata*	10
8.	*V. stipulaceae*	35	19.	*V. vexillata*	02
9.	*V. radiata* var. *setulosa*	02	20.	*V. khandalensis*	01
10.	V. *unguiculata* ssp. *cylindrica*	04	21.	V. *unguiculata* ssp. *unguiculata*	04
11.	*V. sinensis*	08		**Total**	**250**

F. Fieldpea

1. **Germplasm rejuvenation and evaluation:** 400 accessions of field pea were rejuvenated and evaluated for different traits like days to 50% flowering, anthocynin, leaf size, foliage colour, leaf axil colour, plant height, petal colour, pod length, seed colour, 100-seed weight, days to maturity, powdery mildew and rust. Ample amount of variability was noticed for all the studied traits. Some of the traits like pods/plants, pod length and seeds/pod could not be recorded during lockdown. Similarly, during winter season of 2020, more than 300 accessions are being evaluated for different qualitative and quantitative traits.
2. **Variability for qualitative traits:** Frequency distribution for different quantitative traits like Anthocynin, foliage color, leaf axil color, petal colour, pod no./axil, pod curvature, pod beak, pod colour and seed shape is also calculated and portrayed below through different pie chart.
3. **Identification of trait specific donors:** Based on the evaluation of 400 germplasm accessions, the following trait specific donors have been



identified which are mentioned.

4. **Sharing of materials:** Total 40 genotypes were

Characters	Accessions
Days to flowering (<60)	EC 341987, P 1531, P 91-4, P 107-2-1, EC 324131
Days to maturity (<110)	EC 341987, EC 324131, EC 329550, P 107-2-1, P 118-1, EC 324133, P 122-8, EC 292162-1
100-seed weight (>22.0 g)	EC 328758, P 346-2, P 1422-2, P 868-2, P 62

shared with Lovely Professional University, Jalandhar, Punjab.

5. **Herbicide tolerance:** During winter season 2019-20, 20 genotypes were screened to topramezone at @ 25.7 ml a.i./ha (1.25X). Based on visual phytoxicity, the genotypes IPFD 10-12, IPF 5-19, EC 499761, IPFD 2-5 and P 2016 were found promising with minimal phytotoxicity .

Genotype	35 DAS	45 DAS	65 DAS	Mean	Yield (t/ha)
IPFD 10-12	**3.0**	**2.7**	**0.0**	**1.9**	**1.16**
IPF 99-25	4.3	4.3	0.3	3.0	1.13
IPFD 12-2	3.3	3.3	0.0	2.2	1.39
IPF 5-19	**2.3**	**1.7**	**0.3**	**1.4**	**1.45**
EC 595961	2.3	3.0	0.3	1.9	0.99
EC 499761	**2.3**	**1.3**	**0.3**	**1.3**	**1.19**
IP2K 57	3.3	4.3	0.3	2.7	1.36
IPFD 16-4	2.7	4.0	0.0	2.2	1.01
IPFD 17-6	5.3	5.3	0.3	3.7	1.09
IPF 2018-18	3.7	5.3	0.7	3.2	1.27
IPFD 2-5	**2.3**	**1.3**	**0.3**	**1.3**	**1.34**
IPF 27	3.7	4.3	1.0	3.0	0.80
IPF 12-17	3.3	4.7	0.0	2.7	1.30
IPF 14-13	4.0	4.0	0.3	2.8	1.03
P 158	4.3	4.7	0.0	3.0	1.08
P 2016	**3.7**	**2.0**	**0.0**	**1.9**	**1.12**
P 10-62	4.0	2.3	0.3	2.2	1.15
ET 9120	4.7	4.3	0.0	3.0	1.11
P 1579	5.0	5.0	0.0	3.3	1.05
P 1075	4.7	5.3	0.0	3.3	1.17

Table 5: Phytotoxicity and grain yield in tested genotypes of fieldpea against topramezone

6. **Screening for powdery mildew and rust resistance:** Total 400 accessions screened for powdery mildew and rust severity under field conditions. During this season, sufficient disease incidence was noticed for both disease due to congenial conditions (Fig.1).0-5 scale and 1-9 scale were used to assess diseases severity of powdery mildew and rust, respectively. In case of rust, 45 genotypes showed resistance and 58 showed highly susceptible reaction. For powdery mildew, 51 genotypes showed resistance and 65 genotypes demonstrated highly susceptible, while the remaining showed moderate resistance and susceptible reaction for both diseases. The identified genotypes for further confirmation will be screened for both diseases in next season.

G. Cowpea

1. **Generation of breeding materials:** During *kharif* 2020, 15 crosses were atempted involving different traits specific donors like determinate plant type, Yellow mosaic disease, powdery mildew, bruchid tolerance, pod length, number of pods, grain size and colour.

2. **Selection of promising genotypes from segregating populations generation advancement:** 15 crosses were raised. In the segregating generations, single plants were selected based on the desirable traits *i.e.* earliness, seed colour, pod length, resistant to YMV and plant type. In total, 11 crosses in F_2, 10 crosses in F_4 and 2 crosses in F_5 were evaluated.

3. **Germplasm evaluation and rejuvenation:** Total 670 germplasm accessions including 200 accessions belong to IITA core set received this year through ICAR-NBPGR were maintained. All 670, were planted for seed multiplication. Out accessions that, 100 accessions were evaluated during *kharif* 2020 for 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. Abundant variability was noticed for studied traits such as days to maturity, seed size, pod length, seed coat color etc. In addition, 29 released varieties were maintained and evaluated for different yield contributing traits.

4. **Sharing of materials**: Advanced breeding material was supplied at ICAR-IIPR Regional Center, Bikaner for evaluation in arid





conditions.

Fig. 5: Field view at ICAR-IIPR Kanpur

H. *Rajmash*

1. **Germplasm conservation:** A total of 1934 germplasm accessions were maintained in medium term cold storage module of IIPR pulses gene bank. In addition to this, during 2019-2020, imported 101 lines of biofortified Common Bean (*Rajmash*) from CIAT (International Centre for Tropical Agriculture), and evaluation and characterization these biofortified lines is underway in *Rabi* 2020-21 Evaluation, rejuvenation and characterization of 600 accessions of common bean accessions has been carried out.

Year	Germplasm collection	Botanical name	Source of collection
2015	52	*Phaseolus vulgaris*	IIPR, Kanpur
2016	270	*Phaseolus vulgaris*	NBPGR-RS, Bhowali
2017	9	*Phaseolus vulgaris*	SeKU, Jammu
2017	21	Varieties Rajmash	NBPGR, SAU, AICRP
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	20	Wild accession	NBPGR-RS, Shimla
Total	**1934**		

Table 6: Common bean genetic resource maintained at ICAR-IIPR, Kanpur

2. **Germplasm characterization:** A total of 600 germplasm accessions were evaluated for morphological and agronomic traits in augmented design by utilizing Uday, Utkarsh, Arun as the check varieties. Based on the absolute analysis, it is revealed that wide range of viability for flowering to maturity duration, plant growth habit, plant height, leaf colour, leaf shape, pod colour, pod shape, seed yield and resistant/tolerant to biotic and abiotic stress resistance. From this study, few promising trait specific accessions were identified and these



accessions could be utilized in common bean breeding.

Fig. 6: Pattern of variation for seed traits *viz.*, colour, shape, & size in common bean germplasm

3. **Generation of breeding material and generation advancement:** Five F_1 hybrids (EC 931194/Kanchan, Uday/Amber, Amber/Uday, EC 931194/Uday, Amber/Kanchan) were raised and successfully produced for desired traits like, BCMV resistance, bush plant types, anthracnose disease resistance cold tolerance. F_2 generation derived from four crosses (Uday/Amber, Arka Bold/Uday, Amber/HUR 15, Utkarsh/HUR 137) were raised for evaluation during *rabi* 2019-20 and individual plant selection was followed based on maturity, growth habit, pods/plant, seeds/pod, seed yield/plot and seed quality. Similarly, eighty-five single plant selection of two F_3 progeny of HUR 137/Arun and Amber/Kailash cross were advanced to next generation. Further, as a part of shuttle breeding programme during *Kharif* 2020, the *rabi* season harvested breeding materials of different stages were advanced and evaluated for wider adaptability and biotic abiotic stress resistance/tolerance at ICAR-NBPGR, Regional Station, Shimla.

4. **Evaluation of promising entries in station trial:** Total 13 entries with four checks (Uday, Arun, Utkarsh and HUR 15) were evaluated in replicated station trial for agronomic performance and yield traits. Two entries IPR 277-19 (2985 kg/ha) & IPR 205-19 (3025 kg/ha) noticed superiority over the best check varieties

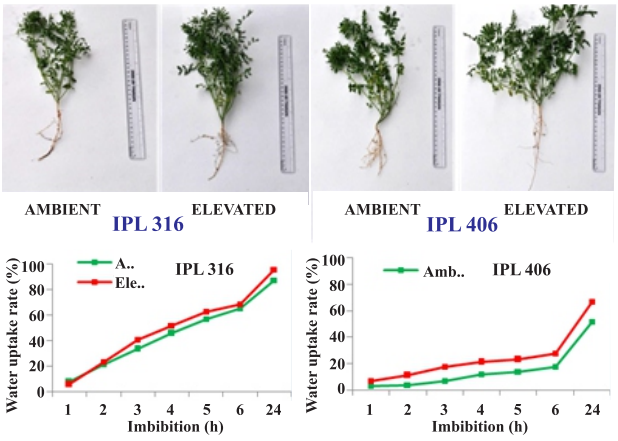
viz., Uday (2556 kg/ha) & Utkarsh (2636 kg/ha) in terms of high grain yield, pods/plant, plant type and BCMV disease resistance and the same are being evaluated in IVT trial under AICRP on MULLaRP.

5. **Identification of resistant donor against BCMV disease:** During *rabi* 2020, a total of 160 germplasm accessions were screened against BCMV disease under natural field condition by using two susceptible (Jawala & Uday) and two resistant (Amber and Arun) checks varieties. The genotypes were classified based on per cent of disease incidence reaction (PDI). The results exhibited that genotypes *viz.*, EC 150250, GP 203, IC 340947, ET 4515, EC 540173. IC 360831 and BLF 101 showed highly resistant and stable reaction across the locations and greenhouse condition. These genotypes will be utilized as a donor parents for BCMV disease resistance breeding programme.

Seed Technological Studies in Pulses

1. **Variation of hardseededness in *kharif* and summer grown mungbean and urdbean:** Hardseededness (physical dormancy) refers to the development of water impermeable seed coat that does not allow the seed to imbibe water. To understand the effect of growing season, occurrence of hardseededness was assessed through germination test in freshly harvested seeds of *kharif* and summer grown mungbean and urdbean genotypes. The hard seeds in *kharif* grown urdbean genotypes (131) ranged between 2 and 76% with a mean of 30%, while in summer grown urdbean, the value ranged from 0-52% with a mean of 12%. Likewise, the hard seeds in *kharif* grown mungbean genotypes (67) ranged between 0 and 66% with a mean of 20%, while in summer grown mungbean genotypes, the value ranged from 0-24%, with a mean of 6%. The occurrence of hardseededness in freshly harvested seeds of mungbean and urdbean was more in *kharif* season as compared to summer season.

2. **Effect of elevated CO_2 on seed yield and quality of lentil:** Lentil *cv.* IPL 316 and IPL 406 were grown at Open Top Chamber with varying CO_2 concentration [400 ppm (ambient) and 550 ppm (elevated)] and seed yield and quality was assessed. Elevated CO_2 resulted into increase plant height, biomass, number of pods/plant, number of seeds/plant and seed yield/plant in both the cultivars. The seed yield/plant increased by 13% in IPL 316 and by 7% in IPL 406. There was no effect of exposing lentil crop to e[CO_2] on germination as the seeds harvested from both the environment recorded similar germination value in both the cultivars. However, seeds harvested from e[CO_2] recorded

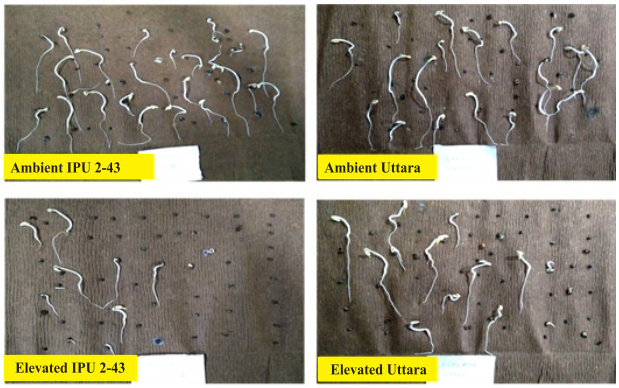


higher water uptake rate as compared to seeds harvested from a[CO_2].

Fig. 7: Crop growth at a[CO_2] and e[CO_2] and water uptake rates of seeds of IPL 316 and IPL 406 harvested from a[CO_2] and e[CO_2] environments.

3. **Effect of elevated CO_2 on seed yield and quality of urdbean:** Effect of carbon dioxide [400 ppm (ambient) and 550 ppm (elevated)] on crop growth, biomass accumulation, yield and quality of urdbean *cv.* IPU 2-43 and Uttara was studied. Elevated [CO_2] was maintained throughout the crop growth stages for 8-10 h a day. Elevated [CO_2] resulted into higher plant height and biomass (especially during flowering and podding stages), number of pods/plant (14 and 18% in IPU 2-43, Uttara), number of seeds/plant (15 and 11% in IPU 2-43 and Uttara) and seed yield/plant (11 and 7% in IPU 2-43 & Uttara). The seeds of IPU 2-43 and Uttara harvested from a[CO_2] environment recorded the mean germination of 32 and 21%, while seeds from e[CO_2] recorded the germination of 7 and 14%, respectively. The decrease in germination value of seeds harvested from e[CO_2] was due to increase in hard seeds from 62-91% and 76-80% in IPU 2-43 and Uttara, respectively. Increase in hard seeds also resulted into low water uptake rate. Total seed protein content was comparable in IPU 2-43, while in

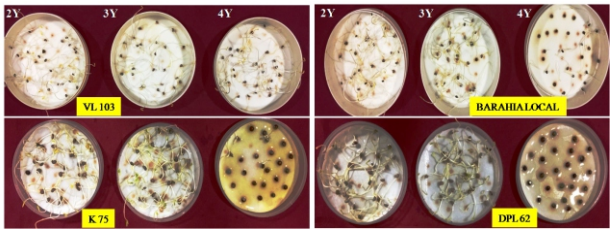




Uttara, it was reduced by 11% due to [CO_2] exposure.

Fig. 8: Germination of seeds of IPU 2-43 and Uttara harvested from ambient and elevated [CO_2] environments.

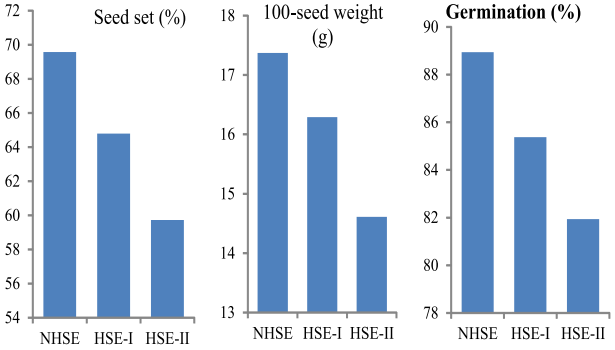
4. **Seed longevity of lentil cultivars:** An experiment was conducted to study the longevity of 36 cultivars of lentil stored in ambient room temperature for four years. In all the tested varieties, the mean viability was 85, 94, 94, 93 and 50% when stored for 0, 1, 2, 3 and 4 years, respectively. After four years of storage, there was a complete loss of viability in DPL 15, DPL 62; while varieties like IPL 406, PL 639, ASHA, PL 77-12, RANJAN, NDL 1, VL 103, WBL 77 and KLS 218 recorded ≥75% viability which is the minimum germination requirement as per the Indian Minimum Seed Certification



Standard and therefore, could be stored for four years at least.

Fig. 9: Lentil Cultivar VL 103 showing profuse germination even after four years of storage while K 75 and DPL 62 demonstrating complete loss of germination after 4 years of storage.

5. **Effect of exposing fieldpea plant on quality of harvested seeds:** Total 150 fieldpea genotypes were grown in three environments [normal sowing time or no heat-stress environment (NHSE); moderately-late and late sowing time [15 days (HSE-I) and 30 days (HSE-II) after normal sowing time] to expose the crop reproductive phase to high temperature stress. The average maximum temperature during flowering was about 22, 26 and 31°C for NHSE, HSE-I and HSE-II, respectively. High temperature stress resulted into reduction in seed set by 7-14% and in 100-seed weight by 6-16%. Likewise, the seeds harvested from NHSE, HSE-I and HSE-II environments had the average seed germination of 89, 85 and 82%, respectively,



showing the reduction of 4 and 8% at HSE-I and HSE-II compared to NHSE.

6. **Identification of intact funiculus accessions in fieldpea:** A seed is attached to the pod through funiculus which is the only means of nutrient supply to developing seeds. Generally, the seed detaches itself from funiculus during harvesting and threshing, and the resultant seed is devoid of funiculus. However, out of about 950 fieldpea accessions available at IIPR, Kanpur, eight accessions (EC 414478, EC 328778, EC 414486, ET 5115, EC 564816, EC 564814, EC 414479 and EC 564803)were found in which the funiculus remained attached to seed even after harvesting and threshing. The seeds of all accessions with funiculus recorded low rate of water uptake as compared to without funiculus (funiculus manually removed). Such intact funiculus accessions with slow rate of water uptake could be ideal for growing in rice fallow where the

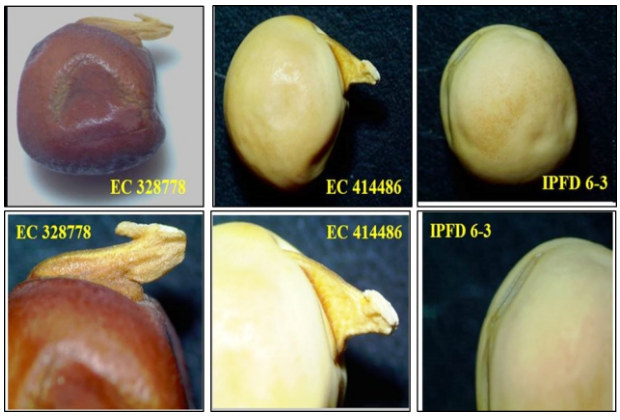


Fig. 10: Whole seed (upper half), closer view (lower half) of presence (EC 328778, EC 414486) or absence (IPFD 6-3)of funiculus in harvested seed of fieldpea.

germination and seedling establishment is a real challenge due to high initial moisture content.

7. **Breeder Seed Production:** A total of 758.31 q of breeder seed was produced for different pulse

Crop	Breeder seed production (q)	Enhancing breeder seed production (q)	Total (q)
Mungbean	124.39	248.55	372.94
Urdbean	52.85	331.55	384.40
Pigeonpea	27.61	449.00	476.61
Chickpea	104.31	611.00	715.31
Lentil	90.19	325.00	415.19
Fieldpea	358.96	470.00	828.96
Total	**758.31**	**2435.10**	**3193.41**

crop during 2019-2020. Additionally, 2435.10 q of breeder seed was produced in the project enhancing breeder seed production.

8. **Quality seed production:** During 2019-20, total of 109614.77 q of quality seed of different pulse

Crop	Production (q)
Mungbean	13561.41
Urdbean	12840.46
Pigeonpea	24848.52
Chickpea	42336.01
Lentil	8717.44
Fieldpea	4662.64
Rajmash	86.86
Mothbean	190.19
Cowpea	192.00
Horsegram	2002.74
Lathyrus	176.50
Total	**109614.77**

crops were produced in the project Creation of seed hubs for increasing indigenous production of pulses in India.

Externally Funded Projects

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

1.1. **QTL mapping for protein content:** Five QTLs were mapped for total protein content trait in seeds in Linkage groups 3 (QTL.pro.1, LoD 3.14); 4 (QTL.pro.2,LoD 2.89); 6 (QTL.pro.3,LoD 2.94 & QTL.pro.4, LoD 4.12) and 8 (QTL.pro.5, LoD 2.63) utilizing the F4 seeds of mapping population JAKI 9218/T39-1 (n=200).

1.2. **Mapping populations for protein content:** Four populations including IPC 04-98/T 39-1 (F_6 200), JAKI 9218/T39-1 (F_5 200), JG 16/T39-1 (F_5 180), DCP 92-3/T39-1 (F_5 160) and IC C4958/T39-1 (F_5 190) for protein content were advanced to F_6 & F_5 during 2019-20

2. **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. 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. 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 program has been submitted from ICAR-IIPR, Kanpur and RS, Bhopal, respectively. Field trials for evaluation of advanced breeding lines under the project has been sown during the ongoing *Rabi* 2020-21

Significant Achievements

- Interactive training for Product Profile development, Product replacement and optimization of breeding pipeline attended: 3
- Five product profiles of chickpea was finalized from IIPR and submitted.
- Trial inventory and breeding programme status of chickpea in IIPR was reviewed by Excellence in Breeding Platform (EiB) and Breeding Pipeline Assessment Tools (BPAT) teams.
- Historical data migration and on farm data recording of trials. Total 84 nurseries from 2005-19 are being migrated to BMS. Crosses of 2017-18 & 2018-19 have been uploaded
- Nomenclature document finalized for data migration of chickpea to BMS and shared with AICRP.

✓ Four field trials were conducted during *Rabi*



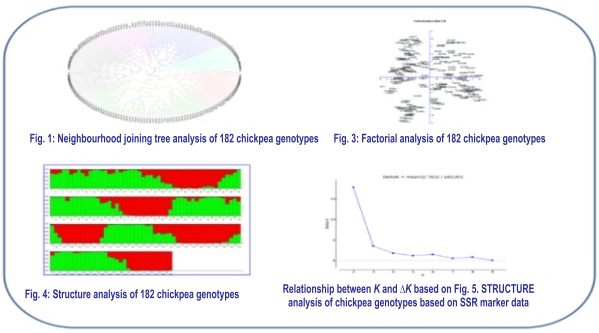
2019-20 (2 in Kanpur and 1 each in Bhopal and Dharwad) for evaluation of breeding lines and digital data recording.

3. National Innovations on Climate Resilient Agriculture project: Chickpea

3.1. Screening of germplasm for heat stress tolerance: Screening of 182 chickpea germplasm for heat tolerance was done. The following lines for heat and drought tolerant lines were identified ICC 15925, ICC 10255, ICC 15852, ICC 15182, ICC 15925 based on three years performance and these could be used as donor for transferring heat tolerance related traits to elite line.

3.2. GWAS for identifying marker trait association for heat stress relevant traits for molecular breeding for heat tolerance in chickpea: Based on the GWAS analysis in a panel of 182 chickpea germplasm with the help of 120 SSR, the following markers ICCM0297, CESSR159, GA11, NCPGR199 showed significant MTAs under both normal and late sown conditions for both years. Thus, these could be used for MAS for heat tolerance in chickpea.

3.3. Development of mapping population for heat stress tolerance: Mapping population JG 315 x ICC 92944 (F5 RILs) for heat stress tolerance has been developed and it was evaluated under normal and heat stress condition.



4. Delivering more produce and income to farmers through enhancing genetic gains for chickpea component

4.1. Generation of breeding material: Six crosses (JSC 37/SA1, GNG 1581/SA1, BG 212/SA 1, JSC 37/GNG 1581, ICC 4958/JG 14, GNG1581/RSG888) were made during 2019-20 for developing breeding lines resistance for biotic/abiotic stresses.

4.2. Generation advancement: F_1's and F_2 derived from 6 and 5 crosses were advanced to F_2 and F_3 population and SPS from each crosses harvested.

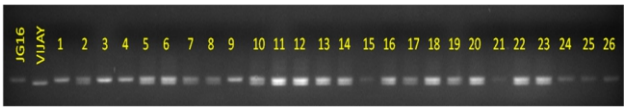
4.3. Development of mapping population: Three mapping population for drought and heat (DCP 92-3/ICC 4958, JAK I9218/JG 14, JG 14/ICC 4958) were advanced to (F_4) and harvested SPS during *Rabi* 2019-20

4.4. Evaluation of elite breeding lines of desi chickpea: Seventy lines with two checks were evaluated. Entry IPC 14-120 (3115 kg/ha) was found superior followed by ICCX -090044-F4-P18-BP-BP-BP (2781 kg/ha), IPC 13-25 (2726 kg/ha), PG 0805-17-5 (2656 kg/ha), IPC 15-85 (2638 kg/ha), IPC 15-105 (2577 kg/ha), IPC 12-98 (2562 kg/ha), IPC 14-112 (2530 kg/ha) and best check DCP 92-3 (2326 kg/ha) with registered of 33.9% yield superiority, respectively.

4.5. Farmers participatory varietal trials (FPVS): Altogether, three chickpea varieties (JG 14, RVG 202, RVG 203) were demonstrated in 19 targeted villages and covered of 40.7 ha area in Fatehpur (16.7 ha), Mahoba (12.2 ha) and Jalaun districts (12.1 ha) of Uttar Pradesh. Total 30.0 qtls quality seed including 13.6, 8.20 & 8.20 qtls of JG 14 (1360 kg), RVG 202 (820 kg) and RVG 203 (820 kg) were supplied among farmers including 10 villages (Pilkhini, Goonjhi, Dalakheda, Godhrauli, Shipuri, Karchalpur, Khadra, Mirai Shahpur, Baithaka) of Fatehpur; six villages (Jaitpur, Atarpatha, Belatal, Charkhari, Panwadi, Lidhora Khurd) of Mahoba and 3 villages (Birhara, Garhguvan, Sujanpur Kothi) of Jalaun. Total 106 FPVS trials including 59, 30 & 17 were conducted as cluster form in each village of Fatehpur, Mahoba & Jalaun districts, respectively. Based on yield performance, the highest mean yield was recorded of variety JG 14 (9.90 qtls/ha), followed by RVG 202 (9.29 qtls/ha) and RVG 203 (8.69 qtls/ha) in targeted districts. The yield of chickpea ranged from 6.29 to 6.50 qtls/ha, 12.08 to 15.48 qtls/ha & 6.10 to 8.69 qtls/ha in Fatehpur, Mahoba, Jalaun districts, respectively.

5. CRP-Molecular Breeding for Improvement of Tolerance to Biotic and Abiotic Stresses, Yield and Quality Traits in Crops: Chickpea

This project has been undertaken with an objective to introgress multiple race resistance against *Fusarium* wilt caused by races 1, 2 3 and 4 of *Fusarium oxysporum* f.sp. *ciceri* in elite chickpea cultivar JG 16. Two elite chickpea genotypes viz., Vijay and WR3 15 are being used as the donors for introgressing the genes of interest in JG 16. The backcross progenies are subjected to marker analysis using foreground markers viz., TAA 60, TA 194, GA 16, TA 59 for race 1, TR 19, TA 110, TS 47, TA 37 for race 2, TR 19, TAA 60, TA 194, GA 16



for race 3, TR 19, GA 16, TA 59 for race 4. The true heterozygotes are further backcrossed to pyramid multiple race resistance against *Fusarium* wilt.

Fig. 11: Identification of true F_1 hybrids using GA 16 marker linked to Fusarium wilt resistance, Lanes 1–26 denote the JG16 x Vijay Fresh F_1 plants.

At the start of programme, JG 16, an elite cultivar of chickpea was used as a recipient parent and it was crossed with Vijay as well WR315 to generate F_1 seeds in both the cross combinations during 2014-15 and 2015-16. Vijay is resistant to race 2 of *Fusarium oxysporum* f.sp. *ciceri* (foc) while WR 315 is resistant to several *foc* races (race 1, 3, 4 and 5). Both these donors were chosen to introgress multiple race resistance in a single elite cultivar of chickpea, JG 16.

During *rabi* 2019-20, third round of backcrossing was initiated in the crosses JG 16/WR 315 and JG 16/Vijay in those BC_2F_1 plants which were identified as true heterozygotes on the basis of foreground selection using identified markers as described above. Simultaneously, second round of backcrossing was also done in the cross [(JG 16/WR 315)//(JG 16/Vijay)] in order to pyramid multiple race resistance against *Fusarium* wilt.

In the cross JG 16/WR 315, 24 BC_3F_1 and 9 BC_2F_1 seeds were obtained. Likewise, in the cross JG16/Vijay, a total of 11 BC_3F_1 seeds were harvested. In the cross [(JG 16/WR 315)//(JG 16/Vijay)] a total of 38 BC_3F_1 and 128 BC_2F_1 seeds were harvested. These are being subjected to foreground and background selection during *rabi* 2020-21 and those which will be identified on the basis of FG and BG will be multiplied and subjected to phenotypic evaluation in wilt sick plot. Fresh F_1s were also generated during *Rabi* 2019-20 in order to maintain continuity in the programme. Accordingly, 42 F_1 seeds in the cross JG 16/Vijay and 47 F_1 seeds in the cross JG 16/WR315 were obtained.

6. Genetic enhancement in pigeonpea through pre-breeding efforts for developing *Phytophthora* stem blight tolerant/resistant and photo-thermal insensitive early genotypes (DST-SERB funded)

6.1. Evaluation of promising genotypes: Under this project, screened 258 early genotypes and have identificed of set of 27 cultivated and 15 wild accessions belonging to 5 different species which could be classified as less-responsive to photo-thermal regimes. The 27 cultivated genotypes are ICPL 2287, PDAT 16, ICPL 11326-2, ICPL 11326-1, DSLR 43, ICP 3800B, ICPL 85010, ICPL 20325-1, ICPL 11318-1, ICPL 11273 A-D, ICPL 11261, ICPL 11318B, ICPL 11299, ICPL 20327, ICPL 11273A, AL 201-2, AL 201-1, AL 2091, AL 1992, ICPL 11270A-A, ICPL 11279-1, ICPL 1134, ICPL 113529, WDN 2-47-1-1A, ICPL 11335, ICPL 11263, ICPL 20325-2. 15 wild accessions belonging to *C. scarabaeoides* (Acc. No. ICP15683, ICP15690, ICP15699, ICP15710) *C. platycarpus* (ICP 15921, ICP 15661, ICP 15662, ICP 15663, ICP 15664, ICP 15666 and ICP 15668), *C. albicans* Acc. No. ICP 15616 *R. minima* Acc. No ICP 15838 and *R. aurea* Acc, No. ICP 15819 and ICP 15809. During *Kharif* 2020, Validation trial for photo-thermal insensitivity was conducted using a set of 54 genotypes which comprises previously identified cultivated and wild entries along with checks were planted at three different dates.

6.2. Generation advancement: Advanced about 1200 pre-breeding F_3 lines developed involving *C. scarabaeoides, C. sericeus* and *C. lineatus* wild species for widening the genetic base in pigeonpea. Most of these lines are in early maturing group (< 130 days). During the course of screening against *Phytophthora* stem blight resistance under sick field we have identified promising donors namely ICPL 11258-1, IPAC 2, ICPBN 19-8 & 9, IPAHS31 for use in pigoenpea PSB resistance breeding prorammes.The controlled PSB screening technique developed under this project is highly promising to scale up the screening of pigeonpea germplasm and breeding lines.

6.3. Generation of fresh crosses for incorporating PSB resistance and earliness in pigeonpea: New crosses namely, IPAC 2/UPAS 120, IPAHS 31/ICPBN 19-9, ICPBN 19-8/UPAS 120, ICPBN 19-9/IPAE 19-21 were made for combining earliness, high biomass, Phytophthora blight resistance and yield attributes.

7. Transcriptome analysis of genotypes grown under heat stress in lentil:

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 35ºC 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 76 transcripts were up-regulated and 47 transcripts were down-regulated at late reproductive stage. The validation of 12 up- or down transcripts through RT-PCR corresponded well with expression analysis data of RNAseq with a correlation of R^2=0.89. Among these transcripts, DN364_c1_g1_i9 and DN2218_c0_g1_i5 transcripts encoded enzymes involved in tryptophan pathway indicating role of tryptophan biosynthesis under heat stress in lentil. Moreover, KEGG pathways enrichment analysis identified transcripts associated with genes encoding proteins/regulating factors related to different metabolic pathways including signal transduction, fatty acid biosynthesis, rRNA processing, ribosome biogenesis, gibberellin (GA) biosynthesis and riboflavin biosynthesis. This analysis also identified 6852 genic-SSRs leading development of 4968 SSR primers that are potential genomic resources for using in molecular mapping of heat tolerant genes in lentil.

8. Genetic enhancement of minor pulses: Cowpea (DBT project)

8.1. Generation of breeding material: During *kharif* 2020, total 20 crosses were made using different trait specific donors like determinate plant type, Yellow mosaic, powdery mildew resistance bruchid tolerance, pod length, number of pods, grain size and colour.

8.2. Generation advancement: Total 30 F_1 were raised along with parents during *kharif* 2020 for generation advancement. Similarly, 10 F_2, were raised and superior single plants were selected to develop superior genotypes. Simultaneously few crosses were advanced for mapping population.

8.3. Identification of trait specific donors through germplasm evaluation: Total 100 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 color, 100-seed weight, seed coat colour, 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 colour *etc.* Total 25 accessions of wild *Vigna* species of cowpea were maintained and evaluated in *Vigna* garden of IIPR.

8.4. Sharing of material: During reporting period, a set of ninety six diverse genotypes was sown and single plant harvested seeds were supplied to NIPGR, for re-sequencing purpose.

9. "Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India" (DAC)

Quality seed production of high yielding varieties of different pulse crops namely, mungbean (Shikha) & urdbean (IPU 02-43) and pigeonpea (IPA 203) during *kharif* 2020 were conducted at farmers' field of Kanpur Dehat at IIPR-New Research Campus, Kanpur, farmers asociated with Chandauli, Sonbhadra, Ghazipur and Varanasi districts during the year with an objective to easy dissemination of quality seed production technology and easy reach of quality seed to the farmers'. While, quality seed production of chickpea, field pea and lentil during *rabi* 2019-20 were taken and realized in the month of June 2020, following the mandate of the project through Farmers' Participatory Seed Production on framers field of Kanpur Dehat and Hamirpur districts. The production under the project, a total of 127 qtls mungbean (foundation & certified seed of three varieties *i.e.* Virat, and Shikha) were produced. However, during *rabi* 2019-20, three varieties of chickpea (JG 14 and yield about 463 qtls), field pea (yield about 93.60 qtls as per the assessment of UP Seed Certification Agency) and 5 ha of lentil (expected yield about 54.05 qtls as per the assessment of UP Seed Certification Agency) were sown on farmers' field of Kanpur Dehat, Fatehpur and Hamirpur districts. Total quality seed produced under "Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India" is 779.05 qtls. during the year.

10. Development of improved Indian common bean (*Phaseolus vulgaris* L.) lines resistant to *Anthracnose* by employing molecular breeding (DST-SERB)"

10.1. *Anthracnose* disease screening: A total of 100 common bean genotypes were evaluated against *Anthracnose* disease including both susceptible & resistant checks during *Kharif* 2020 at ICAR-

Table 7: Quality Seed Production of Pulse crops during the year 2020

Crop	Variety	Category of quality seed produced (qtls)	
		Foundation Seed (qtls)	Certified Seed (qtls)
Chickpea	RVG 202	186.00 qtls	277.60 qtls.
Fieldpea	IPF 4-9	73.60 qtls	20.00 qtls
Lentil	IPL 316	54.05 qtls	-
Mungbean	Shikha	6.80 qtls	96.00 qtls
Urdbean	IPU 02-43	26.00 qtls	39.00 qtls.
Pigeonpea	IPA 203	(to be harvested in March-April, 2021)	
	Total	**346.45 qtls**	**432.60 qtls**

NBPGR, Regional station, Shimla. *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 EC 931194, IC 337275, EC 931228, IC 340947, EC 25517, EC 931216, EC 931275 and IC 43572 were shown resistance reaction against *Anthracnose* disease. These genotypes might be further confirmed for resistance reaction against *Anthracnose* disease through molecular marker study.



Fig. 12: Visual Appearance of anthracnose disease infection on plant stem, pods, and leaves

Plant Biotechnology

Institute Projects

Genomics enabled crop improvement

Molecular dissection of response to terminal heat in chickpea

In this project, QTL mapping for heat stress tolerance in chickpea has to be carried out by phenotyping the segregating mapping population across environment and years. For this, chickpea mapping populations involving heat stress susceptible and tolerant genotypes are developed and being advanced to immortal stage (Table 1). These 6 populations were advanced to F_5 stage during *Rabi* season 2019-2020 and sown at IIPR main farm during *Rabi* 2020-2021 in order to advance the population to F_6 stage. These F_6 populations will be screened for heat stress susceptibility and tolerance in coming years.

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

Trait mapping for plant ideotypic traits in pigeonpea

Association analysis with trait BLUP values following MLM Q+K model identified 22 MTAs for traits namely days to initial flowering, days to fifty per cent flowering, days to maturity, plant height, and number of primary branches at P< 0.05. Maximum of 6 MTAs each for DFF, and DM traits were identified followed by 5 MTAs for IFL, 4 MTAs for PH and 1 MTA for PB traits. 15 MTAs each from 2016-17 and 2017-18 data set and 13 significant MTAs from combined data set at p<0.05 were identified. The phenotypic variation explained by these MTAs varied from 2 to 30.76%. MTAs which explains >10% of phenotypic variations were considered as a major QTLs/MTAs. 12 out of 22 MTAs has explained >10% of total phenotypic variations of a particular traits. Predicted candidate genes related to flowering traits such as Glycosyltransferase, cold-responsive protein kinase 1, NRT1/ PTR FAMILY 5.4 and root phototropism protein 2 in the trait linked marker vicinity

Marker assisted gene introgression for drought tolerance in elite chickpea

Moisture stress is major constraint for most of the legume crops including chickpea. Eventually it affects the plant growth, biomass and reproductive stage of crop growth. Marker added gene introgression of important traits for yield attributed traits for biotic & abiotic stress management became very often in many food crops. In this project, we mobilized "QTL hotspot" in elite chickpea cultivar and developed three marker assisted backcross (MABC) chickpea lines (*viz*; IPC L4-14, IPC L4-16 and IPC L19-1) for drought tolerance was developed in DCP 92-3 genetic background. The advance lines were evaluated under AICRP on Chickpea multi-location trials during 2018-19 and one of the lines IPC (L4-14) has been promoted to next level (AVT 2) during 2019-20 for selecting superior lines, for drought conditions. 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 also been submitted for AVT1 in AICRP chickpea during 2019-20. This was further extended to KWR 108 and GNG 1581 genetic background respectively and materials are at different stage of backcross generation (BC_2F_1, BC_2F_2, and BC_3F_1). Further project reporting is being covered in subproject "Marker-assisted gene introgression for abiotic stress tolerance and their effect on primary metabolites in chickpea" under newly developed theme.

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

Urdbean (*Vigna mungo*) crop has a unique importance in Indian farming system 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 their different stages of development.

Trait	Cross	Status
Powdery mildew (PM) resistance	LBG 17 (R) x IPU 02-43 (S)	F_3
Photo thermo insensitivity (PTI)	PGRU 95016 (R) x Uttara (S)	F_2

Genomic DNA isolation and genotyping of parental lines using adzuki bean and blackgram SSR markers is in progress (Fig 1).

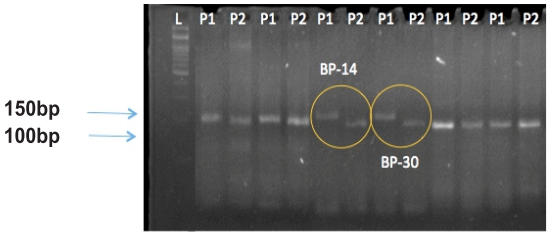


Fig. 1: SSR screening of Parents (P1: LBG 17, P2: IPU 02-43) of the Powdery Mildew population. BP: Blackgram Primer, L: DNA Ladder.

Transgenic technology for genetic improvement in pulses improvement

Genetic engineering for development of pod borer resistant chickpea using multigene approach

The *cry*IAc and *cry*2Aa gene cassettes having the pod specific promoter was sub cloned into marker free pCambia based binary vector. The binary vectors developed were used for transformation of *Agrobacterium tumefaciens* LBA4404 strain that was confirmed for authenticity using the Keto Glycoside test. Freeze thaw method (Chen *et al.* 1994) was employed for transformation of the Agrobacterium strain. Further confirmation of the orientation of cloning of the desired gene cassette in the binary vector was done by reverse mating (transfer of the binary plasmid back into *E. coli*). The plasmid DNA from the *E. coli* is to be confirmed by appropriate restriction analysis or PCR.

In addition, in order to identify wound inducible genes/promoters, genome wide identification of WIP (Wound Induced Protein) and chitinase gene family has been executed in chickpea. *WIP* gene family is a novel class of polypeptides that are usually <100 amino acids in length. Here we report genome wide identification of 10, 6 and 18 WIP genes in chickpea, *Medicago* and *Arabidopsis*, respectively. Chromosomal locations revealed the localization of the WIP genes to be confined to only two of the chromosomes in all the three plant systems, disclosing conserved synteny (Figure 1). Gene duplication studies revealed a predominant role of tandem duplications in the evolution of the gene families resulting in clustered organization . Interestingly, WIP genes were found to be intronless and encoded proteins with high intrinsic disorderness. Expression analysis based on transcriptomic data reveals that WIP genes in chickpea are up-regulated in response to *Fusarium* infection but did not show any significant changes in response to simulated herbivory (*Helicoverpa armigera*) in chickpea. Similarly, genome wide identification of the chitinases gene family in chickpea revealed the presence of 27 genes. Of which, six enzymes belonged to the GH19 family and the remaining belonged to the GH18 family. Three genes namely *Car_chit-1*, *Car_chit-2* and *Car_chit-13* revealed enhanced expression in chickpea plants infested with *Helicoverpa* and in response to *Fusarium* infection.

The project results provide us with next generation strategies using marker free gene constructs for the development of marker free transgenic plants under tissue specific and potential wound inducible promoters. Further functional characterization of the multi-stress responsive WRKY TF and, wound and pathogen inducible genes and promoters would lead us towards identification of novel roles.

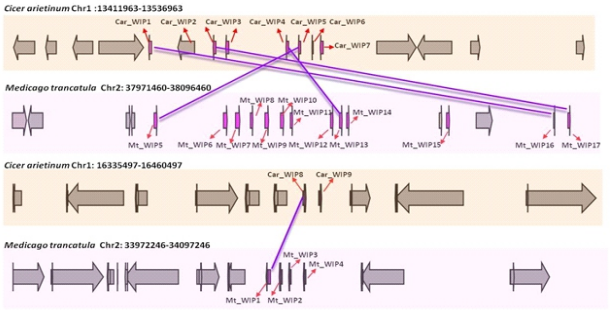


Fig. 2: Conserved synteny and collinearity analysis of WIP proteins between chickpea and *Medicago*. Blue lines indicate collinear gene pairs

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

The primary objective was to genetically transform green gram for whitefly tolerance using the tma 12 gene that was to be procured from CSIR-NBRI, Lucknow through MTA. Previous experiments had revealed non reproducibility of published *in vitro* regeneration systems in our cultivars of choice. Hence, consistent efforts have been made to develop a genotype independent efficient system that is amenable to *Agrobacterium* mediated genetic transformation too and embryonic axis has been chosen as the choice explant.

Agrobacterium mediated genetic transformation of green gram cultivars ML 267 and SML 668 using embryonic axis as explant was conducted using *nptII* gene of choice based on optimized conditions from previous lab experiments. The regenerating plantlets that survived the selection pressure and responded to rooting media but could not be hardened successfully were used to test for presence of *nptII* and 4 of 5 samples tested were found positive.

This subproject is now reconstituted as subproject 7 under Theme II of Divisional Megaproject: Genomics, Genetic Engineering and New Breeding Technologies for Pulses Improvement for the year 2020-2021.

Development of regeneration and transformation protocol in grasspea (*Lathyrus sativus* L.)

The primary objective of this project was to develop highly efficient regeneration and transformation protocol as well as identification of key genes involved in ODAP biosynthesis pathway which are pre-requisite for the improvement of grasspea using genetic engineering approaches. We have optimized highly efficient and reproducible regeneration system in grasspea using embryonic axis explant. The regeneration protocol was then tested for *Agrobacterium* mediated transformation using a vector carrying GUS and *npt*II gene. The rate of obtaining kanamycin resistant shoots was in the range of 29.7% in Pusa 24 and 29.3% in Mahateora. Some of these putatively transformed kanamycin resistant shoots were tested for PCR using forward primer from 35S promoter and reverse primer from the GUS gene, 75% of them were produced an expected 1088 bp amplicon, suggesting optimised regeneration protocol is amenable for *Agrobacterium*-mediated transformation in grasspea. However, rate of establishment of kanamycin resistant shoots in soil is very low and needs further refinement. In order to identify and characterized the candidate genes for ODAP biosynthesis pathway, genomic sequence of ODAP synthase gene was aligned with the cDNA sequence and gene structure, number of exons and introns present in the gene were identified (Fig 1).

To further characterize the putative ODAP synthase gene, the ODAP synthase gene was PCR amplified in a panel of eight genotypes consisting of low and medium-ODAP containing genotypes. All were yielded a single amplicon of ~1320 bp in all the selected accessions when run on agarose gel (Fig 2). Sequencing of PCR product is in progress to identify nucleotide variations, if any, present between low and medium-ODAP containing genotypes.



Fig. 3: Structure of ODAP synthase gene of grasspea.

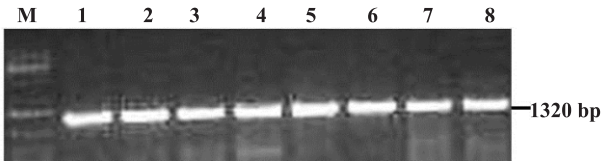


Fig. 4: Gel electrophoresis showing PCR products of ODAP synthase gene amplified from a set of grasspea genotypes.

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

The Project envisages test bed optimization of speed breeding protocols for rapid generation advancement in chickpea, by reducing seed to seed cycle. A total of 17 genotypes of chickpea (JG 14, JG 11, JAKI 9218, KWR 108, KPG 59, GNG 1581, JG 16, RVG 202, JGK 5, GCP 105, RSG 888, HC5, ICC 96029, BGD 9971, ICC 96030, SA-1, BG 3043) with five replications were assesses under light intensity of 1000-1100 lux (fluorescent white lights), temperature 22-25°C (Regime 22h L/2h D), and 60-70% RH in Puff Insulation Chamber, Division of Plant Biotechnology. Six chickpea genotypes repsonsded in the simulated conditions, with 50% flowering within a range of 40-60 days after sowing, and subsequent seed set with a span of next 30 days. In another strategy, pods at different stages of development have been harvested from field-grown plants and the developing green seeds were subjected to germination under minimal media and water in Plant Tissue Culture Facility, Division of Plant Biotechnology. 20-24 days old immature chickpea seeds, after anthesis, were found suitable for germination under *in vitro* conditions. Taken together, these two strategies can significantly reduce seed to seed cycle and accelerate generation turn around time for rapid generation advancement in chickpea.

Identification and evaluation of potential *Bt* strains for managing lepidopteran pest of pulse crops

The chitinolytic activity of *Bt* strains was determined by using spectrophotometric method and its biological activity was quantified against j2 root knot nematodes. (Table 1). The *Bt* strain, F8.IIPR was subjected to mass multiplication in nutrient broth and its spore crystal mixture was extracted and

purified. The SCM was used for developing sodium alginate microcapsules by deploying the protocol described by Khorramvatan *et al*. (2014). The stability of the microencapsulated product was estimated and the size of the microencapsulated product was recorded (Fig 1).

Screening of wild pigeonpea derivatives against pod borer

Twenty two out of 41 pigeonpea entries had pod borer infestation; similarly forty out of 41 pigeonpea entries had podfly infestation (Fig 2) during *Kharif* 2019; seven out of 41 Pigeonpea entries had bruchid infestation. Only two entries *viz*., WDBCE5-4-2-1; WD12-2-3 had ≤10 % pod infestation by pod fly. Overall 6 entries (Table 2) were found to have fallen under least susceptible category based on pest susceptibility rating as described by Lateef and Reed (1980). The floral characters such as streak pattern and petal colour were recorded (Table 3).

Table 2: Chitinolytic activity of *Bt* strains and its efficacy against root knot nemateode (RKN) juveniles

Bt strain name	OD value 420 nm (pooled mean)	Mean % mortality of juvenile RKN*
Ak2	0.4627	0.33 (57.14)
F1	0.480	56.00 (48.58)
F4	0.522	55.33 (48.04)
F5	0.499	91.67 (73.31)
F8	0.525	89.00 (70.78)
C.D.	0.033	10.042
SE(m)	0.01	3.146
SE(d)	0.015	4.45
C.V.	3.574	9.148

* Values within parenthesis are arcsine transformed

Table 3: Screening of pigeonpea wild derivatives against pod borer, pod fly and bruchids

Category Genotype	Least susceptible (3)	Least susceptible (4)	Least susceptible (5)	Moderately susceptible (6)
No. of derivatives	6	9	8	5
Name of derivatives	WDBCE31-1-6 WDBCE54-2-1 WD12-2-3 IPAWD281 WDN2 1362-4-7 Early 3	WDBCE45-3 WDBCE63-4-6 WDBCE63-4-7 WDBCE66-2-2 WDBCE94-1-1 WD5-9-4 WDN2 1362-1-5 WDN2 1364-2 WDN2 1364-3-5	WDBCE31-1-3 WDBCE44-4-1 WDBCE45-2-1 WDBCE54-2-2 WDBCE66-2-1 IPAWD202 WDN2 1362-4-8 WDN2 1364-3-1	WDBCE56-5-2 WDBCE63-4-2 WDBCE94-3-1 WDN2 1364-3-11 AL1747

Table 4: Floral characters of pigeonpea wild derivatives

Petal colour	Streak pattern	No. of pigeonpea entries
Yellow	Sparse	15
Orange yellow	Dense	8
Purple	Dense	5
Yellow	Absent	9
Yellow	Medium	7
Yellow	Dense	1

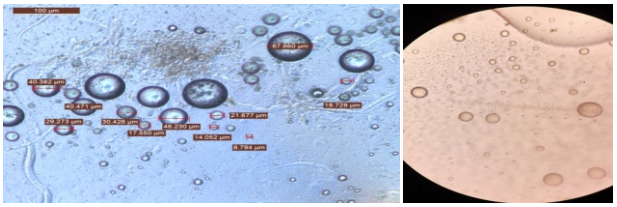


Fig. 5: Microencapsulation of *Bt* strain

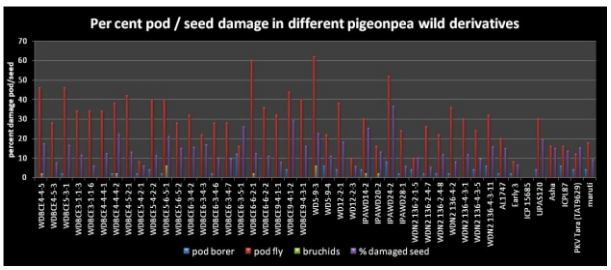


Fig. 6: Screening of pigeonpea wild derivatives against pod borer, pod fly and bruchids

Genomics, genetic engineering and new breeding technologies for pulses improvement.

Theme I: Genomics for pulses improvement

Molecular mapping of heat stress tolerance QTLs and understanding heat stress induced transcriptome dynamics in chickpea

The new project was formulated based on leads from previous project entitled "Molecular dissection of response to terminal heat in chickpea". The bi-parental mapping population developed in previous project will be utilized in this project for mapping heat stress tolerance QTLs in chickpea as sown in (Table 1). In order to get immortal mapping population, all six populations are sown in IIPR main field during *Rabi* 2020-2021 in order to advance the population to F_6 stage. The F_6 population will be screened for heat stress susceptibility and tolerance in coming years.

Molecular diagnosis of *Fusarium* sp. infecting chickpea and pigeon pea

Fusarium oxysporum f.sp. ciceris genome sequence files (SRA) has been retrieved from EMBL-ENA site and the assembly were generated using SPAdes tools with K-mer selection based on read length. The genome assembly size of 55.87 Mb was generated which posses a total of 4627 contigs with more than 1000 bases long and with a highest contig length of 490 kb. The N50 value of this assembly is 41.47 kb and GC content of 47.77%. The miniature impala (mimp) transposable elements (TS) are tightly associated with virulence genes of Fusarium in case of *Fusarium oxysporium f.sp. lycopersici*. Hence, we were intended to identify the mimp TS in *F.o.f.sp.ciceris* using python script and identified 46 such mimp transposable elements. The 5 kb flanking sequence on either side of mimp has been retrieved from assembled genome to identify the virulence genes and polymorphism present in these virulence genes. This virulence genes-based polymorphism can be effectively utilized to discriminate the races of *Fusarium ciceris* in coming days.

Marker-assisted gene introgression for abiotic stress tolerance and their effect on primary metabolites in chickpea

During last cropping session 2019-20, several backcrosses lines were made in KWR108 and GNG 1581 genetic background of chickpea and harvested a total of 41 crossed seeds. These seeds were sown during 2020-21 cropping season; however the further molecular analysis is under process. The biochemical analysis of resistance starch (RS) in chickpea was preliminary tested and it use in combination with pulse-rice food matrix system significantly decrease glycemic index (GI) and increase RS content.

Molecular dissection of loci for powdery mildew resistance and photo-thermo- insensitivity in urdbean

Panel of 96 contrasting urdbean genotypes has been prepared and sown at RS Dharwad for Phenotyping against powdery mildew (Fig 2). Orthologous and heterologous gene(s) providing resistance to powdery mildew are being searched for further genotyping and association mapping. Parental polymorphism screening of DPU 88-31 X LBG 17 population against powdery mildew is being done using SSR markers. F2 Leaf sample of DPU 88-31 X LBG 17 cross has been collected and further genotyping will be done using SSR markers.



Fig. 7: Urdbean genotypes sown at RS Dharwad for phenotyping against the powdery mildew

Identification of genes/QTLs for salinity tolerance in Urdbean and earliness in lentil

Urdbean (*Vigna mungo*), a less input demanding short duration crop with wide adaptability is an important pulse crop in our country after chickpea and pigeonpea. It can be cultivated in different types of soils; however, saline, alkaline soil and water logging conditions are not suitable for its cultivation. Currently, about 6.74 mha area is salt affected which is supposed to increase upto 16 mha by 2050 due to industrialization and ever-increasing population. In effort to develop salinity tolerant lines, it is proposed to screen a set of 80 lines including advance breeding lines to identify putative tolerant lines followed by its utilization for molecular mapping and marker assisted selection. This will be followed by genotyping of the lines *via* SSR markers, population structure study and marker trait association. Besides these activities, the available genome sequnces of *V. mungo, V. marina* and other *Vigna sp.* will be used for comparative genomics analysis, for salinity specific genes.

Lentil (*Lens culinaris*), a cool season crop, invariably encounters terminal moisture and heat stresses, which leads to forced maturity and lower

yields. Possibilities of forced maturity can further increase in coming years by rising global temperature due to climate change and also due to delay sowing after late harvesting of rice. Consequently, in India, about 11.7 million ha of rice area currently remains fallow due to late harvesting of rice. These situations leave a window of 100-110 days for growing lentil. It would be desirable to develop early maturing cultivars fitting well within this time gap expressing the highest yield potential that will be able to escape/avoid forced maturity that can become more serious in coming years due to global warming. In current proposal, our endeavor is to map the genomic loci regulating the days to flowering in lentil using the RILs population already available with us through SSR markers. A set of RILs developed by crossing L 4603 x Precoz (150 RILs) will be used for the same. The mapped loci will be further validated in different populations segregating for the same traits.

Theme II: Pulse improvement through genetic engineering and new breeding technologies.

Precision plant breeding and rapid generation advancement in chickpea

The Project intends to asses the effect of LED lights of various light intensities on rapid generation turnaround/advancement in chickpea geneotypes. A panel of 18 chickpea genotypes (JGK-5, ICC 96030, GNG1581, JAKI9218, BGD9971, JG16, JG14, RVG-202, KWR 108, HC-5, IPC 06-77, JG 11, GCP 105, RSG 888, ICC 96029, MLT-SA1, KPG-59, DCP 92-3) were grown in red light (650-700 nm), blue light (approx. 450 nm) and green light (approx 550 nm) and white light (400-700 nm) and their morphogenetic responses shall be assessed *viv a vis* their growth in fluorescent light.

Another aspect of the project is development of platform for precision plant breeding using genome editing techniques (CRISPR/Cas9 or Cpf1). Currently, bioinformatic analyses are being conducted to identify locus or traits for agriculturally importance like DH inducer towards generation of *HIEdits* in chickpea.

Molecular approaches for improving the nutritional quality of grasspea (*Lathyrus sativus* L.) and pea (*Pisum sativum* L.)

In effort to reduce β-ODAP content in grasspea by down-regulation/knocking out β-ODAP biosynthesis pathway related genes by genetic engineering/genome editing technology, we are focused on developing a robust genetic transformation protocol, identification and characterization of the candidate genes encoding the key enzymes of ODAP biosynthesis pathway and optimising CRISPR/Cas based genome editing in grasspea. Besides, we have also initiated the work on fieldpea to address the problem of flatulence.

Although, we have developed Agrobacterium-mediated transformation in my previously concluded project, however, the establishment of kanamycin resistant transformed shoots in the soil is very low. Therefore, we are also optimising the Gene gun method of transformation in grasspea. About 200 gene gun transformed seedlings were transplanted in pots filled with soils and their hardening, establishment, histochemical GUS assay and molecular analysis is in progress. Further, to initiate the CRISPR/Cas-based genome editing in grasspea, CRISPR/Cas vector is finalised and their procurement from Addgene repositories is in progress.

In field pea, genome-wide identification of genes involved in Raffinose family oligosaccharides (RFOs) biosynthesis pathway led to the identification of two genes for Raffinose synthase (RS), two genes for Galactinol synthase (GolS) and one gene for stachyose synthase (STS) in pea (*Pisum sativum*) (Table 1).

Table 5. Raffinose family oligosaccharides (RFOs) biosynthesis pathway related genes in pea

Gene name	Locus ID	Chrom-osome	Exon No.	Protein length
GolS				
PsGolS1	Psat6g153600.1	6	4	325
PsGolS2	Psat3g018520.1	3	3	334
RS				
RS1	Psat0s2597g0160.1	Scaffold	3	798
RS2.1	Psat1g055560.1	1	4	782
RS2.2	Psat1g055560.2	1	3	603
STS				
PsSTS	Psat0s3224g0200.1	Scaffold	4	853

Transforming *Vigna* for tolerance to whitefly (*Bemisia tabaci*)

In an effort to develop an efficient multiple shoot regeneration system in green gram, DCN and embryonic axis were tested previously that gave a maximum of 2-5 shoots per explant. In another effort, decapitated embryonic axis (DEA) with half cotyledon was again tested for *in vitro* multiple shoot



regeneration and results revealed 4-11 shoots per explant. Though the results were not uniform within the same batch, they suggest DEA as a potential explant for further *in vitro* regeneration and transformation studies.

Reproducibility of reported *in vitro* regeneration system in cowpea was evaluated in the cultivar RC 19. Using decapitated embryonic axis as explant and BAP @ 1.5 ppm as phytohormone of choice, the number of shoots regenerated / explant were found to be in the range of 9-20 with an average of 13.3 within 45 days; root initiation was recorded on basal media itself (MSB5). Gibberellic acid (GA_3) was used for shoot elongation. To summarize, the reported *in vitro* regeneration system could be reproduced in the cultivar RC19 of cowpea (*Vigna unguiculata*)



Multiple Shoots regenerated from single DEA explant - excised during sub culturing

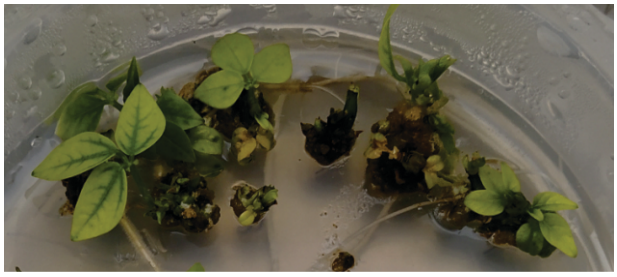


Fig. 8: *In vitro* regenerating multiple shoots of cowpea cv. RC 19 originating from single decapitated embryonic. axis explant

SP8: Gene identification and development of triple gene technologies for pod borer resistance in transgenic chickpea (July- Dec 2020).

Bacillus thuringiensis, is known insect pathogenic bacterium that infects a wide variety of species, mainly caused by the synthesis of crystal toxins with varying amino acid sequences among host-specific strains. *Bacillus thuringiensis* F6.IIPR was isolated from chickpea fields in Fatehpur, Uttar Pradesh, India, and the spore crystal mixture was highly toxic to *Spilosoma obliqua* larvae. Preliminary characterization of the isolate, done under a separate project, revealed the presence of bipyramidal and cuboidal cry proteins with the protein profiling revealing unique bands. Here, we report the draft genome sequence of *B. thuringiensis* isolate F6.IIPR, which will assist in deciphering the genome structure, function and identification of the putative pesticidal genes.

Whole genome sequencing of the isolate *Bt* isolate F6.IIPR by Illumina Hi-Seq X platform using NEBNext Ultra II DNA library prep kit adaptors to generate 1.3 GB data comprising of 8.7 million paired-end DNA sequencing reads of length 150 nucleotides was done. The quality of the data was assessed using FastQC, trimmed using Trimmomatic, and then De Novo assembly was performed using Unicycler, a hybrid assembly pipeline for bacterial genomes. There were 391 contigs, an estimated genome length of 6,342,611 bp, and an average G+C content of 34.7%. The N50 length, which is defined as the shortest sequence length at 50% of the genome, is 90,602 bp. The L50 count, which is defined as the smallest number of contigs whose length sum produces N50, is 22.

The *Bt* isolate F6.IIPR genome was annotated using the RAST tool kit with the results revealing 6,887 protein coding sequences (CDS), 84 transfer RNA (tRNA) genes, and six ribosomal RNA (rRNA) genes. Many of the genes have a homology to

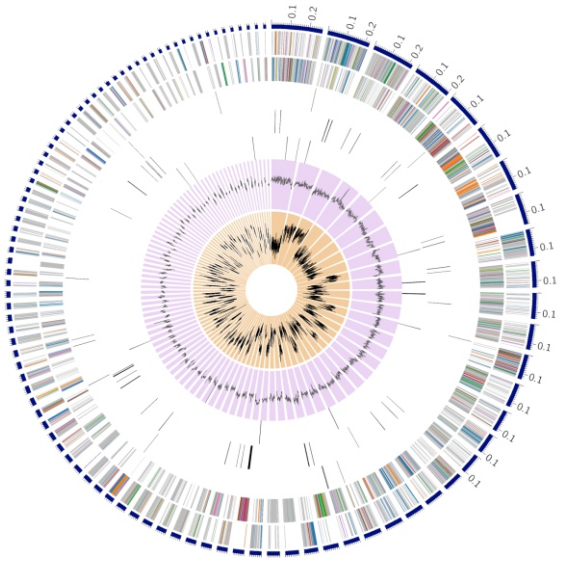


Fig. 9: A circular graphical display of the distribution of the genome annotations of *Bt* F6.IIPR Outer to inner rings, the contigs, CDS on the forward strand, CDS on the reverse strand, RNA genes, CDS with homology to known antimicrobial resistance genes, CDS with homology to know virulence factors, GC content and GC skew.

recognised transporters, virulence factors, and drug targets. The genome revealed 1681 potential toxins, with 1352 toxins having one domain, 326 toxins having two domains, and 3 toxins having three domains. The genome sequence of *Bt* F6.IIPR provides an insight into the virulence of this crop pathogen and how it evolves to be immune to *Bt* toxins.

Development of liquid bioformulation of indigenous *Bacillus thuringiensis* strains for enhancing its shelf life and field-efficacy against pod borer

This project was initiated in June 2020. The spore crystal mixture of F8.IIPR and Ak2.IIPR was mass multiplied, extracted, purified and stored for formulation development. The invert emulsion was prepared using six different vegetable oils to find out its suitability for enhancing the physical stability of invert emulsion formulation. The invert emulsion of three formulations viz., IE1, IE6 and IE8 were found to be 80%, 100% and 100% stable, respectively on 18th day after preparation.

Externally Funded Projects

Molecular approaches for mapping of novel gene(s)/ QTL(s) for resistance/ tolerance to salinity stress in chickpea mapping salt tolerant genes using SNP genotyping

The 201 recombinant inbreed line (RIL) population derived from DCP92-3 x ICCV10 was used in this study. Extensive analysis of the phenotyping and genotyping data by Axiom®Cicer SNPArray was performed to identify a total of 28 major effect and minor effect QTLs explaining up to 28.40% phenotypic variance explained by the population. We identified QTL clusters on CaLG03 and CaLG06 each harboring major QTLs for yield component traits under salinity that were of particular interest (Fig 3). Also retrieved 763 predicted genes from QTLs region (~3.3MB) from CaLG03 and 156 genes from ~0.1Mb QTL region in CaLG06. Also retrieved 763 predicted genes from QTLs region (~3.3MB) from CaLG03 and 156 genes from ~0.1Mb QTL region in CaLG06.

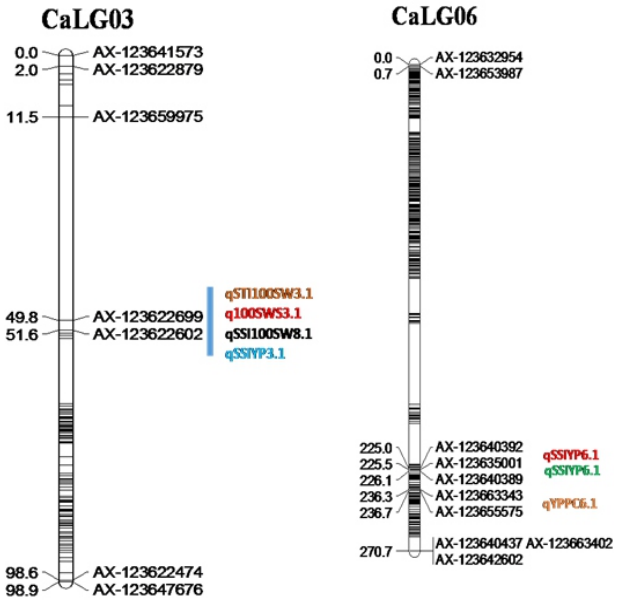


Fig. 10: Showing major QTLs for various salinity tolerances related traits identified on ICCV 10 × DCP 92-3 derived mapping population

NPFGGM Network project on functional genomics in chickpea.

High quality genomic DNA was isolated from 170 RIL populations (K850 x IPC 2004-52) segregate 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 IPC2004-52 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. Identification of putative QTLs was disease in genomic region of CaLG1, CaLG3, CaLG4, CaLG5 and CaLG7 for late wilting of *Fusarium ciceris* in chickpea (Fig 4). 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.

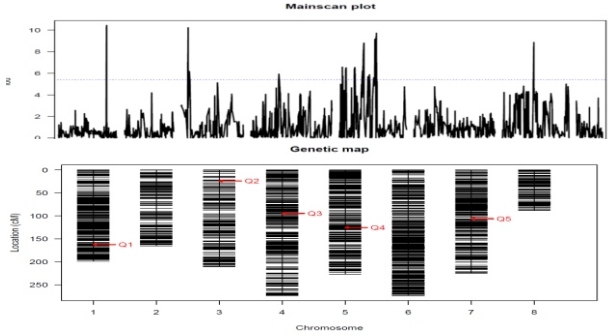


Fig. 11: High-density genetic linkage map & trait mapping for late wilting of fusarium wilt in chickpea (*C. arietinum* K 850 x *C. arietinum* IPC 2004-52).

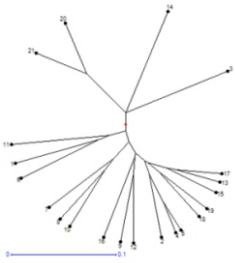
Externally funded project: ICAR-NPFGGM: Genetic mapping of *Fusarium* wilt (FW) and sterility mosaic disease (SMD) in pigeonpea

In this project, genetic mapping for *Fusarium* wilt (FW) and sterility mosaic disease (SMD) in pigeonpea has to be done. For mapping SMD resistance loci, F_3 mapping population derived from Maruti x Bahar genotypes is being advanced to F_4 stage during *kharif* 2020-2021 at IIPR main station. As well, BC_1F_2 plants derived from (maruti x Bahar) x Maruti is being screened for SMD incidence at IIPR-region station, Dharwad during the *Kharif* season 2020-21 and results of the segregants are yet to come. Similarly, $F_{2:3}$ mapping population derived from Maruti x Bahar is being screened for fusarium wilt incidence in wilt sick plot located at IIPR farm (main campus).

Fusarium udum (casual agent of *Fusarium* wilt in pigeonpea) genome sequence available in public domain was used to generate refined genome assembly using various genome assembler packages since existing genome assembly has no information on genes and moreover genes are fragmented. Hence, it is not useful for homologous gene identification. The refined genome assembly generated using SPAdes V 3.14.1 keeping k-mer size of 55 has resulted with genome size of 62.23 Mb, a total contigs of 1488 and the largest contig size of 452.8 kb. BUSCO analysis for assessing genome assembly and annotation completeness revealed that the assembly consists of 99.94% (4471/4494) completeness based on order hypocreales. This assembly possesses 25,016 retroelements, 2,619 DNA transposable elements, 4857 simple sequence repeat elements and 14,262 complete protein coding genes. Primers has been designed for 2744 SSR loci and these will be utilised to discriminate races of *Fusarium udum*. Out of these 14262 genes, 1486 genes has standard secretary signal peptides transported by the Sec translocon and cleaved by Signal Peptidase I (Lep) and 1414 genes has signature domains of carbohydrate-active enzyme. 4 mimp (Miniature Impala) TE and its associated virulence genes in *F. udum* were identified.

DBT network project on genetic enhancement of minor pulses genotyping of popular minor pulses

Variety panel for popular national cowpea cultivars (21), green gram (38) and blackgram (22) cultivars was developed that were genotyped using SSRs in effort to assess genetic variation present amongst the cultivars and also to identify potential SSR markers that may aid in cultivar identification. Cowpea was genotyped using 60 adzuki bean and 27 cowpea specific SSR markers while green gram was genotyped using 45 adzuki bean and 21 green gram specific SSR markers.



Comparative analysis revealed a large number of polymorphic primers that could be categorized into two groups – those generating missing alleles and the other generating a polymorphic allele. Molecular weight scores analysis using DARwin grouped the cowpea cultivars into two clusters. Maximum cultivars (17) fell in one cluster that further grouped into 6 sub clusters. The other cluster had only four cultivars of which IT3895-1 and GC 4 were found as independent entries and did not group with any other cultivar. GC 5 and GC6 grouped together in this cluster. This indicates that cultivars grouping in cluster II are relatively genetically distant from the remaining. Most of the popular cultivars grouped together indicating less genetic diversity amongst them. A number of SSR markers have been identified that are polymorphic amongst cultivars and may aid in developing a SSR-set for cultivar identification amongst cowpea. Several adzuki bean and green gram SSR markers have been identified that reveal polymorphism amongst greengram cultivars, however, reproducibility of these primers in green gram is still being tested.

The heterologous system adzuki bean SSR markers as well as Blackgram specific SSR markers were used for screening generated amplicons for polymorphism amongst the varieties in urdbean. 60 adzuki bean SSR markers and 42 blackgram SSR markers were used for genotyping of the 22 popular varieties of the blackgram. SSR markers CEDG074, CEDG256, CEDG097, CEDG257, CEDG305 were found to be polymorphic.

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

In effort to create improved lines tolerant to YMD, a F_4 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. Screening for

polymorphism is being done using SSR Markers from Blackgram too. 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.

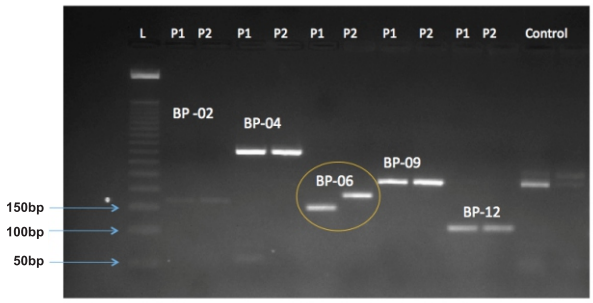


Fig. 12: SSR screening of Parents (P1: DPU88-31, P2: LBG685) of the MYMIV population. BP: Blackgram Primer, L: DNA Ladder.

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

Stability of transmission and expression in the transgenic chickpea (IPCa2) and pigeonpea line (IPcc1) were assessed based on selfing, sib-mating and crossing with elite genotypes (chickpea JG 14 and ICC 4958; pigeonpea UPAS 120). Screening of 10 independent lines of transgenic chickpea and pigeonpea indicated distorted segregation pattern in the T1 progenies. WGS platform (Illumina HiSeq2000) for identification of site of integration on transgene in genome of chickpea (IPCa2) indicated possible site of integration in pseudo-molecule 5. Comparative proteomic analyses (iTRAQ) of transgenic chickpea (IPCa2) vis-a-vis untransformed control to establish substantial equivalence was also performed.

Efficacy of E2Y45 600SC g/l against gram pod borers, *Helicoverpa armigera* and *Spodoptera litura* on chickpea.

In order to study the efficacy of E2Y45600SC against insect pest of chickpea the present experiment was laid out in RBD design at main farm of ICAR-IIPR. *Kabuli* chickpea variety 'Shubra' was sown on 22nd November 2020 and recommended agronomic practices were followed except insecticidal spray. The experiment comprises of 8 different treatments viz., E2Y45 600SC@ 25, 41.66, 58.33 ml/ha and 83.33 ml/ha; chlorantraniliprolle 18.5SC @ 125 ml/ha; Emamectin benzoate @ 220 g/ha and chlorpyriphos 20 EC @ 2500 ml/ha and an untretated control were maintained.

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

The current work is proof-of-concept of amenability of the system for precise genetic modification to increase yield potential in chickpea. The transcription regulator encoded by the BIG SEEDS1 (BS1) gene from the model legume Medicago truncatula, negatively regulates primary cell proliferation and plays a key role in the control of the size of plant organs, including seeds; seed pods, and leaves. The deletion of this gene in legumes lead to significant increase in the size of plant organs, including leaf and seed.

Previously in lab designed were transcribed *in vitro* and their efficiencies were tested against PCR target fragment using recombinant Cas9 nuclease. Out of 13 tested sgRNAs, only 8 were cleaved by the Cas9, of which three sgRNAs were synthesized initially for gene-editing studies. pUC gRNA shuttle and p201N Cas9 vectors were procured from Addgene, USA. Three constructs having 3 different sgRNAs has been prepared and confirmed by PCR, restriction digestion and sequencing.

Desi chickpea (cv. DCP 92-3) were used for the genetic transformation experiments. Explants were bombarded with p201N cas9 vectors containing sgRNA and nptII gene. T0 plants were generated using three constructs targeting three different locus of BS1 gene. The regenerants were established based on kanamycin selection in containment facility. Self seeds were harvested from established T0 plants and resown in the containment facility. Detailled analysis of T1 plants are in progress. Attempts are being made to generate more transformants based on kanamycin selection and other sgRNAs constructs.



Crop Production

Long-term effect of nutrient management and cropping system

Long-term effect of pulses in diversified rice (low land) based cropping system

Four rice-based cropping systems viz., rice-wheat (RW), rice-chickpea (RC), rice-wheat-mungbean (RWMb), and rice-chickpea-rice-wheat (RCRW) were evaluated at three fertilizer management systems *viz*., control (CT), integrated nutrient management (INM, crop residues + biofertilizers *viz*., *Rhizobium* for pulses and phosphate solubilising bacteria for cereals + farmyard manure at 5t/ha + 50% NPK) and inorganic fertilizers (RDF, recommended dose of N, P, K, S, Zn and B). Rice (Pant Dhan 12) was transplanted on first week of July, while, wheat (PBW 343) and chickpea (JG-16) were sown on mid-November. The study revealed the followings.

- RWMb system had the higher system productivity and Rice yield was higher in R-W-Mb system followed by R-W-R-C and the lowest yield was in conventional RW system (Fig 1) and similar trends was found in 2019-20.
- Soil chemical study revealed that legume RWRC and INM had higher K pools at 0-20 cm and 20-40 cm soil depth. Also, RWMb and INM resulted in higher aggregated N and P content at surface and sub-surface soil depths.
- Pulse inclusive cropping systems and INM had higher weed emergence in surface soil over rice-wheat and chemical fertilizer because more accumulation of weed seeds but, an opposite result is visible in the lower depths.
- Grain legume inclusion and integrated nutrient management increased P solubilisation in lowland rice-based cropping systems. INM increased soil organic P pools over RDF treatment. In control treatment there was marked reduction of major soil functional pool.
- The study also revealed that maximum nodulation in chickpea was in INM applied plots.



Fig. 1: Wheat and chickpea under different crop rotations / nutrient management treatments in long-term experiment (rice-based)

Maize and bajra based (upland) cropping systems

Four cropping sequences, each maize-based *viz*., maize-wheat (MW), maize-wheat-mungbean (MWMb), maize-wheat-maize-chickpea (MWMC) and pigeonpea-wheat (PW) (Table 1) and bajra-based *viz*., bajra-wheat (BW), bajra-wheat-mungbean (BWMb), bajra-wheat-bajra-chickpea (BWBC) and pigeonpea-wheat (PW) (Fig 2) were evaluated at three nutrient management practices *viz*., control (CT), integrated nutrient management-INM (crop residues + bio-fertilizers 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 cultivars sown during the year 2019-20 were DKC 8144 (maize hybrid), Proagro 9450 (bajra hybrid), UPAS 120 (pigeonpea), HD 2967 (wheat), JG 16 (chickpea) and IPM 02-3 (Mungbean). The study revealed the followings.

- Wheat yield was higher in MWMC system followed by MWMb and the lowest yield was under conventional MW system. Similar findings due to legume inclusion in terms of system productivity was found in bajra based cropping system.
- Soil chemical study revealed that PW and INM had higher macro- and micro-aggregated N and P compared with the remaining systems. Pigeonpea-wheat system and INM recorded higher weed emergence in surface and sub-surface soil depth over other cropping systems and nutrient management.
- MWMb and MWMC with INM increased soluble P at both soil depths that highlights pulses increase the P variability in soil than MW and RDF. Also, pulse based systems and INM increased total inorganic P. Pulse inclusion in MW system and INM increased the microbial P in soil it indicated a higher microbial activities under pulse based system over continuous cereal-cereal rotation.



Fig. 2: Wheat under different crop rotations/ nutrient management treatments in long-term experiment (maize/bajra based)

Nutrient Management

Bio-engineering approaches for improving lentil productivity in rice-relay system

A field study was conducted during 2018-2020 aiming to improve the traditional rice-relay cropping with strategic agronomic interventions with the objectives of understanding the ecological requirement of lentil for surface seeding method of crop establishment and studying the influence of different agronomic interventions such as rice residue retention (standing stubble), seed soaking (hydro-priming), clay coating of seeds, macro and micronutrient spray, and biofertilizer treatment in relayed lentil. Results revealed that under rice-relay lentil, puddled transplanted flooded rice (PTPR) had an advantage (Fig 3) over non-puddled transplanted rice (NPTPR), as soil ecology under PTPR favoured higher germination of lentil crop (surface-seeding). Lentil seed-soaking for 4 h (hydro-priming) increased germination rate and improved establishment of lentil. However, the clay-coating had no prominent advantage over dry-seeding. Foliar spray of urea (2%) and micronutrients increased the lentil productivity. Among the different crop management practices treatments *utera* (hydro-priming) with standing rice stubble (20 cm) + urea spray (2%)+ micronutrient spray and *utera* (hydro-priming + seed treatment with bio-fertilizer & fungicides) with standing rice stubble (20 cm) + urea spray (2%) micronutrient spray improved plant stand and increased the lentil crop productivity.

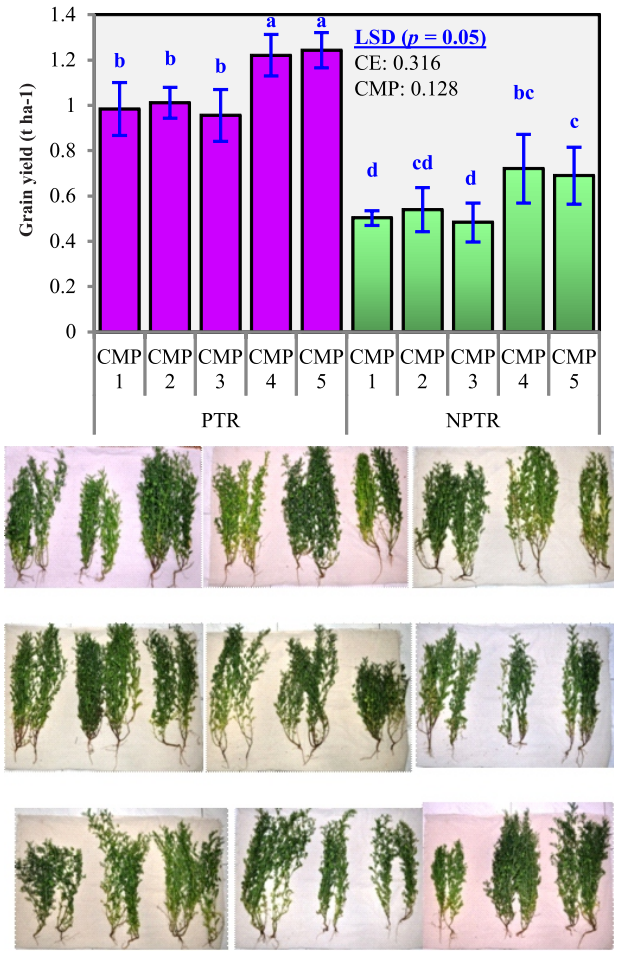


Fig. 3: Grain yield (t/ha) of relay lentil as influenced by rice wet-tillage and integrated crop management practices (left); Plant architecture and vigour of lentil cultivars under rice relay system under surface-seeding (right)

Further, thirty lentil genotypes evaluated in rice ecology (PTR) showed notable cultivar variations for root architecture nodulation, growth and yield attribute. Cultivars LL-669 and KLS 2018 were observed as the best performer under rice-relay production system.

Genotypic variations in plant establishment with surface-seeding in pulses

The released cultivars of lentil, urdbean and mungbean (30 cultivars each) were evaluated for plant establishment potential with surface-seeding in simulated lowland puddled rice ecology with the objectives of studying to identify potential genotype and seed characters for rice-relay-pulse system(s) for improved crop establishment. Results showed that irrespective of crops/cultivars seed soaking improved the plant establishment and seed position had a direct influence on germination rate (soil contact of seed hilum). Glossy and bold seeded urdbean cultivars had low germination and plant establishment. Higher soil moisture increased root penetration and better plant establishment in urdbean and mungbean. Likewise, in lentil, small to medium seeded cultivars were having improved plant stand (Fig 4). In general mungbean germination was very fast under relay system. Higher soil moisture also favoured the establishment of mungbean following surface-seeding method. In absence of adequate soil moisture, a strong root networking system was observed in mungbean, irrespective of cultivars. Fast coleoptiles growth was unique in mungbean, which is considered as a non-desirable plant trait in relay crop(s).



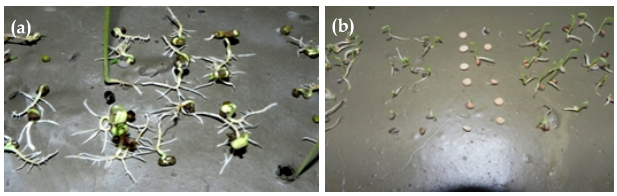


Fig. 4. Surface spreading of mungbean roots and plant establishment with surface seeding technique (a); plant establishment of lentil cultivars with surface seeding (b)

Pulse specific variation in soil phosphorus mobilization

Four winter pulse crops *viz*. chickpea, lentil, fieldpea and lathyrus and a cereal crop (wheat) were grown with and without fertilizer-P application in moderately-alkaline soil of Kanpur in Uttar Pradesh. Before the test crops experiment, the soil was depleted in phosphorus by omitting fertilizer P supply and growing pearl millet during the rainy season. The objectives of the study were to quantify the P mobilization capacity of different pulses under fertilized and non-fertilized (P) soil conditions. The plant functional traits, like nodulation and root characters were studied and correlated with change in rhizospheric activities. Soil acidification is an important process of nutrient mobilization in the rhizosphere in alkaline soils. Among the pulses, chickpea and lathyrus had higher rhizospheric acidification potential that subsequently increased the Olsen-P in the rhizospheric soil. However, crop response to fertilizer P was observed in lentil and wheat over other pulses.

Soil phosphorus dynamics and its release kinetics under pulse based cropping system

A field experiment was initiated during *kharif* 2019-20 in an *Inceptisol* to study the soil phosphorus (P) dynamics and its release kinetics form different organic sources. It is required for better understanding of P chemistry and its sustainable management under cereal-legume cropping systems (pearl millet-chickpea and pigeonpea-wheat) and nutrient management practices. The study revealed the followings.

- Overall system productivity was higher compared to control (by 13% in pigeonpea-wheat) and (6% in pearl millet-chickpea) with poultry manure applied at 1 t/ha.
- Leaf chlorophyll content (41%), nitrate reductase activity (20%), plant biomass (36%) and other growth parameters were higher following incorporation of crop residue (50% of crop residues) in pigeonpea.
- Soluble phosphorus fraction was higher (23%) in the residue added plots compared to control in rhizosphere soils of chickpea than the bulk soils. Similar trend was followed in respect of soil microbial biomass carbon (Fig 7).
- P solubulization study revealed that potential P mineralization was maximum with poultry manure applied at 1 t/ha (by 33%) over control.

Organic farming in pulses

Organic farming is a production system that avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, genetically modified organisms and livestock food additives. It promotes the use of crop rotations and cover crops, and encourages balanced host/predator relationships. Here, organic residues and nutrients produced on the farm are recycled back to the soil. Cover crops and composted manure/FYM are used to maintain SOM & fertility besides other naturally occurring rocks and minerals (e.g. rock phosphates). Keeping in view of these benefits, premium products accrued and following recommendations of RAC of the institute, a programme on Organic Farming in Pulses' was initiated during 2017. In the beginning, long duration pigeonpea 'IPA 203' was taken up during 2017-19 at New Research farm in ICAR-IIPR, Kanpur. The studies on long duration pigeonpea suggested that the crop performance was good as it yielded a maximum of 19.3 q/ha under organic cultivation, which was comparable to that of chemical farming and further, adjustment of row spacing could yield more. From 2019-20, a field experiment on bajra-chickpea was initiated to start up organic farming on sustainable cropping system mode following the package of practices envisaged for both organic and recommended system (Fig 8).

The study revealed that significantly higher yield and its attributes in chickpea could be realized through organic practice only. Chickpea grain yield to the tune of 28.93 q/ha was realized under organic farming practice compared to 25.48 kg/ha in inorganic/recommended practice only (Fig 9). Consequently, net return enhanced to the tune of INR 10869/- in organic practice (Table 1). However, due to higher input cost (FYM at 5 t/ha), organic production system had a comparatively lower BCR (which could be lowered following incorporation of crop residues, and biofertilizers etc). Further increase in productivities in chickpea could also be achieved (by 290 kg/ha) following foliar supply of organic forms of Zinc (Biozinc) and phosphorus (Biophos).

Table 1: The details of package of practices followed in organic and recommended system

Operation	Organic package	Recommended package
Crop. System Kharif 1) RDF Rabi 1)RDF 2)MYR	Pearl millet-chickpea Pearl millet :(100% NPK-FYM) Chickpea: 100 % NPK-FYM; 100% NPK-FYM+foliar (Biophos+Biozinc) at flowering and pod development	Pearl millet-chickpea Pearl millet (100% RDF-NPK) Chickpea: 100 % RDF-NPK; 100%RDF+ Foliar (DAP+$ZnSO_4$) at flowering and pod development
Variety	Pearl Millet: Proagro 9450 (Hybrid) Chickpea : IPC 11-112	Pearl Millet: Proagro 9450 (Hybrid) Chickpea : IPC 11-112
Seed Treat.	Biofertilizers (*Rhizobium*)	Biofertilizers (*Rhizobium*)
Sowing method	Flat planting	Flat planting
Date of sowing	July and Nov	July and Nov
Manure/Fertilizer	Farm yard manure @ 5 t/ha (balancing the nutrients) at sowing	DAP @ 100kg/ha + MOP at sowing
Weeding	Manual weeding	Chemical weed control (recom.)
Pesticides	*Neem kabach* (5 ml/litre) once at pod development	Indoxacarb (1 ml/litre) once at pod development
Other practices	Following organic practice	Following inorganic/ recommended practice

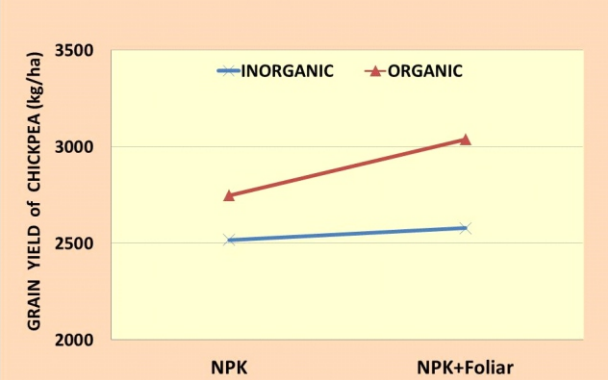


Fig. 5: Productivity trend in chickpea under organic and inorganic or recommended packages

Table 2: Grain yield, its attributes and economics of chickpea 'IPC 11-112' under organic vis-a-vis recommended practice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Total harvest biomass (kg/ha)	Harvest index (%)	Seed index (g)	Seeds / pod	Pods/ plant	Net return (INR)	BCR
Organic	2893	2685	5578	51.9	21.6	1.42	54.9	105434	4.29
Inorganic	2548	2187	4735	54.0	20.5	1.43	47.8	94565	4.79
CD (0.05)	191	478	542	NS	0.95	NS	NS	8327	0.315
Organic NPK (FYM)	2748	2650	5399	50.9	21.45	1.41	53.6	99523	4.14
Organic NPK (FYM) + Biophos & Biozinc (foliar)	3038	2720	5758	52.9	21.75	1.42	56.2	111345	4.44
Inorganic NPK	2518	2143	4661	54.2	20.43	1.42	44.9	93402	4.78
Inorganic NPK + Phos & Zinc (foliar)	2578	2231	4809	53.8	20.55	1.44	50.8	95728	4.80
CD (0.05)	320	NS	650	NS	NS	NS	NS	NS	NS

Precision Water Management

Tillage sprinkler irrigation in fieldpea

A field experiment was carried out during 2019-20 in green seeded dwarf fieldpea 'IPFD 10-12' to study the effect of irrigation (sprinkler irrigation *vis-à-vis* normal flood irrigation) applied 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. The study showed that tillage options despite their inherent differences in terms of time and frequency of tillage could not influence grain and straw yield of fieldpea although higher crop yield was harvested following better crop management practices (with average of 1900 kg grain yield/ha). Crop response to normal/sprinkler irrigation was nullified by significant rainfall events (Fig 10). Crop water use effciency, productivity per day, water productivty and other important parameters represented in Fig 6, 11 revealed that crop performance to ZT (on par with RT and CT) was conspicous as fieldpea 'IPFD 10-12' could perform better in terms of grain yield, biomass, economics despite being similar on statistical front. Thus, following adopting ZT, there could be saving in cultivation cost and increase in productivity of crops as a consequence of lower water use, higher water use efficiency, its productivity and BCR (Fig 12 and 13).

Contrary to tillage practices, no significant difference in crop responses (in terms of grain yield, biomass, yield attributes, water use efficiency and economics) following irrigation schedules due to frequent rainfall events (10 rainy days) was observed during rabi 2019-20 (Fig 11 and 12). Therefore, the study also suggested the fact that appropriate rainfall forecast and the quantum of precipitation received during crop growth and development could change irrigation scheduling decisions (time, frequency and quantum of irrigation to be applied to a crop).

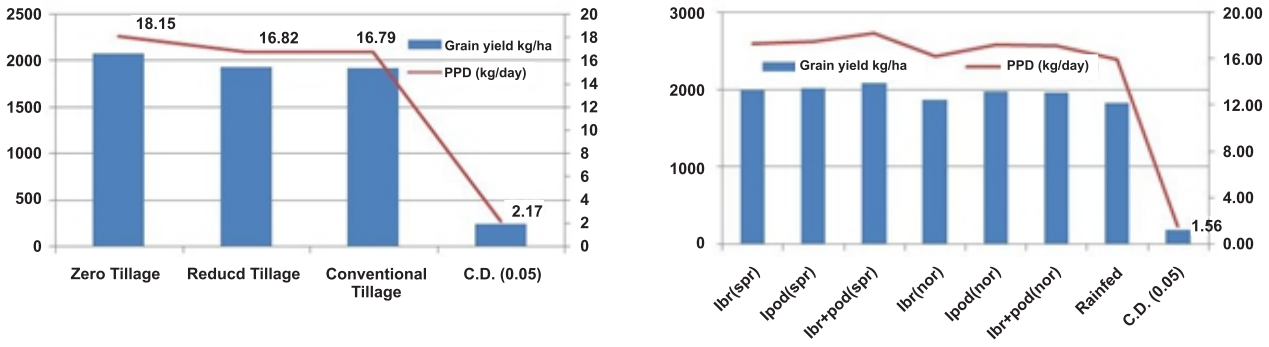


Fig. 6: Meteorological situatiuon at ICAR-IIPR, Kanpur*
***Crop duration: 115 days (Nov 24 to Mar 18), Rainfall: 121.5 mm (10 rainy days), $Temp_{Max}$:31°C ; $Temp_{Min}$: 1.5°C; Seasonal Evapn:109.95 mm**

Scaling input use efficiency in chickpea with hydrogel and foliar supplementation

A field experiment was carried out during 2019-20 to study the effect of hydrogel and foliar supply of agrochemicals in chickpea 'JG 16' for enhancing nutrient and water use efficiencies under rainfed/limited irrigated situation. Treatments consisted hydrogel application at 0, 2.5 & 5.0 kg/ha and foliar supplementation at flower initiation and pod development (with water spray as control, urea 2%, thiourea 500 ppm, salicylic acid 100 ppm, and NPK of 19:19:19 grade at 0.5%). Hydrogel products constitute a group of polymeric materials which renders them capable of holding large amounts of water in their three-dimensional networks. However, thiourea is an organosulphur compound with chemical structure as SC $(NH_2)_2$ which is structurally similar to urea (S changes O). Being a reagent in organic synthesis, thiourea boosts crop productivity and helps in understanding of redox regulatory mechanism in plants, and therefore, helps in understanding the plant stress tolerance mechanisms better. In the experiment, crop rotation was used Jowar hybrid (MH 8508) - chickpea (JG 16) to realize sustainable performance of crops including *rabi* pulses (chickpea). The effect of polymer hydrogel + foliar spray of agrochemicals on chickpea JG 16 revealed that the effect of hydrogel was inconspicuous while that of agrochemicals was evident (Fig 14, 15 and 16). Two years study on jowar-chickpea cropping systems conclusively proved the followings.

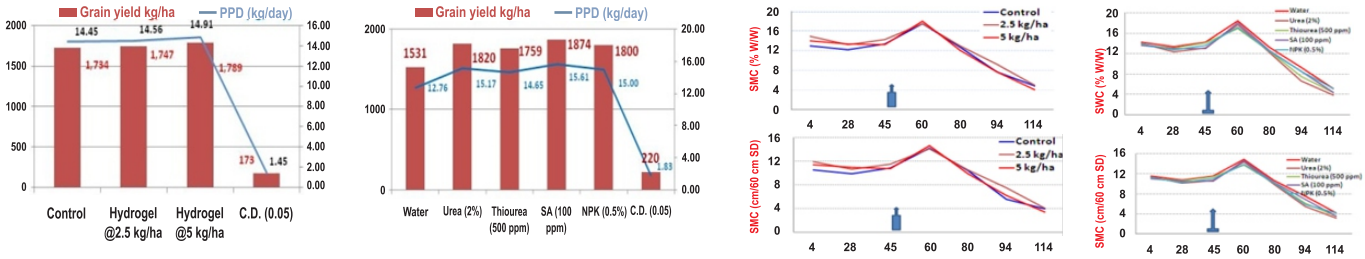


Fig. 7: Effect of hydrogel and foliar spray of agrochemicals on grain yield, PPE and profile SMC in chickpea'JG 16'
***PPD: Productivity per day and SMC : profile soil moisture content**

- There is no scaling in chickpea productivity or profit following application of hydrogel (even at higher dose of 5 kg/ha). The least BCR is at this highest hydrogel polymer use.
- Salicylic acid A at 100 ppm was advantageous in respect of enhancing chickpea grain yield (22.4%), WUE (20.1%), WP (15.3%), and net return (31.2%) over those in water spray.
- Fertilizers like, urea (2%) or NPK (0.5%) application were also equally effective (although lesser in scale) with that of SA at 100 ppm in chickpea.

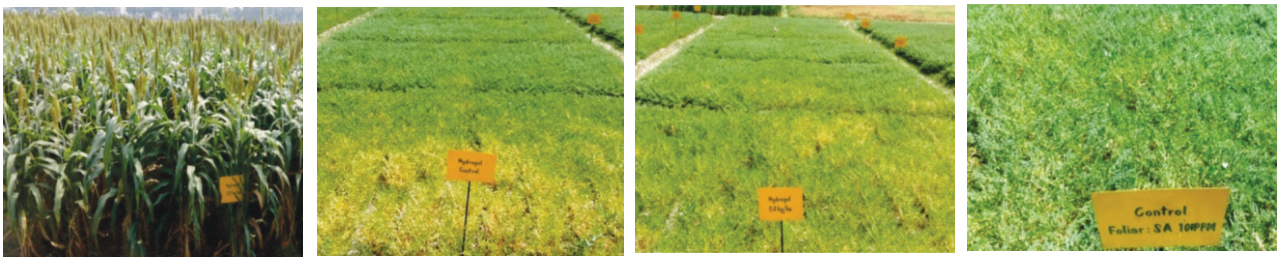


Fig. 8: A high yielding jowar crop in jowar-chickpea system (Left) and the performance of chickpea at maturity in control, hydrogel at 5kg/ha & SA 100 ppm, respectively (right)

Weed Management

Weed management in rice-chickpea cropping system

The field experiment on effect of crop establishment techniques and weed control measures under conservation agriculture (CA) system was conducted during 2019-20 in rice-chickpea cropping system. Four tillage based crop establishment methods were included viz., (i) puddled transplanted rice (PTR) – conventional till (CT) chickpea (PTR-CTC), (ii) PTR - zero till (ZT) chickpea (PTR-ZTC) (30 cm rice residue retention in chickpea), (iii) zero till direct seeded rice (ZTDSR) – ZT chickpea (ZTDSR-ZTC) (residue retention in both crops), (iv) conventional till direct seeded rice (CTDSR) – CT chickpea (CTDSR-CTC) along with three weed control practices. The study revealed that

- PTR had lower weed density at 45 and 90 DAS. Whereas, ZTDSR-ZT had significantly lower weed density and dry weight over PTR-CTC at 90 DAS. Pendimethalin (PMT)-hand weeding (HW) and oxyflurfen -propaquizafop were at par. Rice root length (cm) was significantly influenced by tillage and weed management practices at 0-15 cm depth. ZTDSR-ZT and CTDSR-CT had higher root length over PTR-ZTC and PTR-CTC. CTDSR gave significantly higher rice yield over PTR, also ZTDSR-ZT system recorded significantly higher chickpea yield. PMT-bispyribac-Na gave significantly higher rice yield. Herbicidal treatments had edge over hand weeding in rice. The grain yield of chickpea followed the sequence of CTDSR-CTC = ZTDSR-ZTC > PTR-CTC > PTR-ZTC in 2019-20.
- Chickpea after DSR system (ZTDSR-ZTC and CTDSR-CTC) recorded significantly higher grain yield than after PTR system (PTR-CTC). PMT 1 kg a.i./ha fb bispyribac-Na 20 g a.i./ha gave higher rice yield while chemical + HW proved better in chickpea. The system productivity in terms of chickpea equivalent yield followed the sequence of CTDSR-CTC (4.59 t ha^{-1}) > ZTDSR-ZTC 4.21 t ha^{-1}) > PTR-CTC (4.16 t ha^{-1}) > PTR-CTC (4.08 t ha^{-1}) in 2019-20 (Table 2).

- In surface soil PTR had higher ammonical-N than ZTDSR, while, ZTDSR had higher nitrate nitrogen at subsurface soil. ZTDSR-ZT had the water soluble K, available K than PTR-CTC. Similarly, P fractionation was also tested and showed similar trend. The carbon fractions revealed that ZTDST-ZTC had higher TOC and SOC compared to the PTR-CTC. Also, Cfrac1 (very labile pool) and Cfrac3 and Cfrac4 (non-labile pools) were higher under conservation agriculture than PTR-CTC.

Table 3: Effect of crop establishment techniques and weed control practices on grain yield of rice & chickpea in 2019-20.

Treatment	Rice (t/ha)	Chickpea (t/ha)
Crop establishment practices		
PTR-CTC	4.93	2.30
PTR-ZTC	5.07	2.17
ZTDSR-ZTC	4.87	2.37
CTDSR-CTC	5.82	2.40
C.D: (0.05)	0.05	0.03
Weed control practices		
W1: Buta./PMT fb Bis (rice) PMT fb Quizal. (chickpea)	5.36	2.26
W2: Buta./PMT fb almix (rice) Oxyf. fb Propaquiz. (chickpea)	5.01	2.23
W3: Buta./PMT fb HW (rice) PMT fb HW (chickpea)	5.15	2.44
C.D.(0.05)	0.07	0.04

Weed management in pulses with post-emergence (POE) herbicides

· Field experiment was conducted on chickpea during *rabi* 2019-20 with post-emergence herbicide *viz.* topramezone in chickpea with three doses (20.6, 25.7, and 30.9 g a.i./ha) at four days (14, 21, 28, 35 DAS), unweeded control (UWC), and weed free check (WFC) to assess their phytotoxicity and efficacy. The experiment was laid on randomized block design with three replications.

· Topramezone at recommended dose (20.6 ml a.i./ha) did not show any phytotoxicity in chickpea across growth stages. Topramezone 20.6 ml a.i./ha at 14 DAS resulted in significantly lower weed densities of total weed (TWD), narrow-leaved (NL) and broad-leaved (BL) compared with the remaining treatments. Also, this treatment recorded higher weed control efficiency (64%) at 60 DAS.

· Topramezone 20.6 ml a.i./ha at 14 DAS also resulted in significantly higher grain yield (2.85 t/ha) than rest of the treatments. A demonstration plot of 200 m^2 was maintained and recorded a yield of 2.72 t/ha.

· Genotype tolerance in chickpea against topramezone (30.7 ml ai/ha) and imazethapyr (120 ml a.i./ha) with 1.5X dose revealed that ICC 12337(b), ICC12316, GLW 69, JSC 37 ICCILO 4004 were having minimal phytotoxicity against imazethapyr, whereas topramezone had very negligible toxicity (<3 score) in chickpea. Weed density was significantly lower under spraying of imazethapyyr and topramezone over unweeded control. Topramezone reduced weed density to a higher extent compared to imazethapyr. Similarly in fieldpea, the effect of topramezone 25.7 ml a.i./ha (1.25X) on IPFD 10-12, IPF 5-19, EC 499761, IPFD 2-5, P 2016 revealed that it was also having minimal phytotoxicity (<3 score).

Table 4: Weed density, its control efficiency and grain yield of chickpea under topramezone applied at different stages

Treatment	TWD	NL	BL	WCE (%)	Yield (t/ha)
20.6 g a.i./ha at 14 DAS	8.5	3.2	7.5	64.0	2.85
25.7 a.i./ha at 14 DAS	9.7	2.1	9.3	58.9	2.12
30.9 g a.i./ha at 14 DAS	12.8	0.7	12.8	45.5	2.30
20.6 g a.i./ha at 21 DAS	6.1	2.5	4.8	74.6	2.43
25.7 g a.i./ha at 21 DAS	5.7	2.1	5.4	75.5	2.35
30.9 g a.i./ha at 21 DAS	9.2	1.8	8.9	61.0	2.45
20.6 g a.i./ha at 28 DAS	8.0	0.7	8.0	65.9	1.69
25.7 g a.i./ha at 28 DAS	10.1	1.4	9.9	56.9	1.96
30.9 g a.i./ha at 28 DAS	9.7	1.8	9.4	58.3	1.52
20.6 g a.i./ha at 35 DAS	8.8	2.9	8.3	62.7	1.43
25.7 g a.i./ha at 35 DAS	18.8	1.8	18.7	20.9	1.60
30.9 g a.i./ha at 35 DAS	13.2	0.7	13.2	44.6	1.62
PMT-QZP	19.1	5.5	17.9	25.2	1.79
UWC	22.2	5.8	20.8	0.0	0.53
WFC	0.0	0.0	0.0	100.0	2.69
C.D. (0.05)	10.1	1.2	5.4	-	0.70

Management of purple nut sedge (Cyperus rotundus L.) in pulse based cropping system

The field experiment on integrated *Cyperus* management was conducted during 2019-20 with diverse treatments on weed management during summer. Results revealed that sesbania and halosulfuron-methyl in summer reduced motha and weed density. In rice, ethoxysulfuron (Ethoxy) 15 g a.i./ha also reduced this weed density significantly. Ploughing + irrigation + glyphosate (GLYPS) gave significantly higher rice and chickpea yield. Pendimethalin (PMT) - bispyribac sodium (BISPY) fb PMT- quizalofop (QUIZP) had higher yield in component crop and system productivity (Table 5).

Table 5: Grain yield of rice, chickpea and system under different *Cyperus* management practices.

Treatment	Rice (t ha^{-1})	Chickpea (t ha^{-1})	System productivity (CEY)
Intervention during summer			
SMB - GLYPS	3.00	1.85	4.50 (1.05)
Sesbania - GLYPS	3.04	1.27	2.41
Irrigation + GLYPS	3.31	1.3	2.63
Irrigation + HALME	3.20	1.58	2.79
Sorghum + GLYPS	3.43	1.88	3.18
Plow + Irr. + GLYPS	4.03	2.58	4.10
C.D. (0.05)	0.19	0.15	0.18
Weed control practices			
PMT - Ethoxy fb. PMT- QUIZP	3.16	1.62	3.07 (1.07)
PMT - BISPY fb. PMT- QUIZP	3.51	1.89	3.47 (1.03)
C.D. (0.05)	0.12	0.06	0.09

Mungbean yield is given in parentheses (t/ha).



Conservation agriculture (CA) and climate resilient agriculture

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

A field experiment was initiated from *kharif* 2015 to study the performance of summer mungbean under conservation practices. Three rice residue management practices *viz.*, 30 cm stubble, rice residue burning and no residues, two tillage practices for summer mungbean *viz.*, zero tillage and conventional tillage, and five mungbean varieties *viz.*, IPM 2-3 (60 days); IPM 2-14 (65 days); HUM 16 (58-60 days); Samrat (55-58 days); IPM 205-7 (50-52 days) were considered. It revealed that the increase in grain yield of mungbean was 24.4% under ZT over CT and due to residue retention it was 9.3%. The grain yield of mungbean variety IPM 205-7 was 20.4% higher than IPM 2-14. The sequence for grain yield of mungbean varieties was IPM 205-7 (1478 kg/ha) > Samrat (1387 kg/ha) > HUM 16 (1288 kg/ha) > IPM 2-3 (1277 kg/ha) > IPM 2-14 (1227 kg/ha). All mungbean varieties have performed better under conservation agriculture (CA) over conventional practices (CP). On an average 32.5% higher grain yield of mungbean was recorded under CA over CP (Fig 17 and 18).

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 >Samrat >HUM 16 > IPM 2-3 >IPM 2-14. Similar to grain yield of mungbean, system productivity in terms of mungbean equivalent yield was significantly higher under ZT (4239 kg/ha), residue retention (4316 kg/ha) and IPM 205-7 (4191 kg/ha) over CT (3819 kg/ha), residue burning (3845 kg/ha) and IPM 2-14 (3919 kg/ha), respectively. The adverse effect of residue burning was clearly visible in system productivity also. System productivity of all mungbean varieties was higher under CA (13.9%) over CP. Similarly, significantly higher net return was recorded under ZT (INR 190905/ha), residue retention (INR 194795/ha) and IPM 205-7 (INR 185781/ha) over CT (INR 160255/ha), residue burning (INR 163135/ha) and IPM 2-14 (INR 168289/ha), respectively. BCR was also significantly higher in ZT (2.82), residue retention (2.85) and IPM 205-7 (2.77) over CT (2.53), residue burning (2.55) and IPM 2-14 (2.60), respectively (Fig 19 and 20).

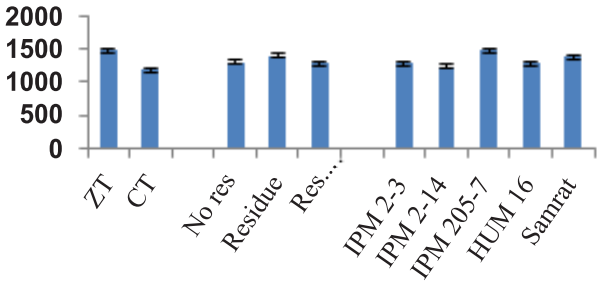


Fig. 9: Effect of tillage residue management and varieties on mungbean grain yield.

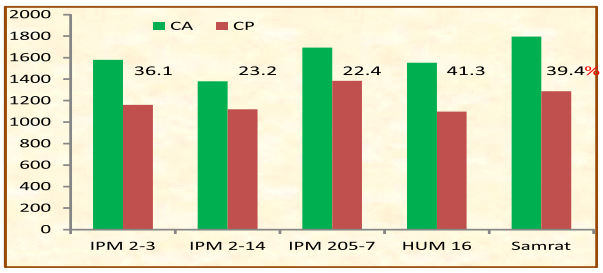


Fig. 10: Grain yield of mungbean varieties under CA and CP

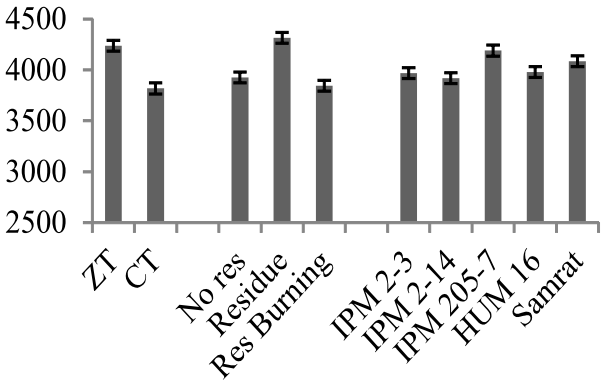


Fig. 11: System productivity (kg MEY/ha) under different practices

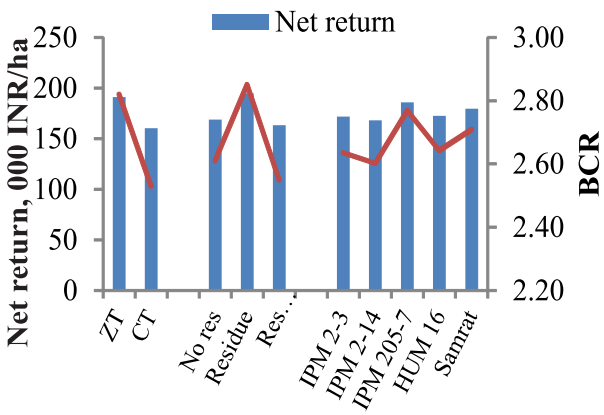


Fig. 12: Net return and BCR under different management practices

Pulses in upland cropping systems under CA practices for climate resilience

A field experiment was started during 2018 to design a cropping system with higher system productivity, resource-use efficiency and soil health for climate resilience. Ten diversified upland cropping systems *viz.,* Rice (DSR)-wheat (R-W), Rice (DSR)-wheat-mungbean (R-W-Mb), Rice (DSR) + dhaincha–wheat–mungbean (R+Dh-W-Mb), Rice (DSR) – chickpea + mustard (6:2) (R-C+Md), Rice (DSR)–mustard–mungbean (R-Md-Mb), Maize-wheat (M-W), Maize–wheat–mungbean (M-W-Mb), Maize– chickpea + mustard (6:2) (M-C+Md), Pearl millet – lentil + linseed (4:2) (Pm-L-Ls) and Maize+ dhaincha (*In-situ GM*)– chickpea–mungbean (M+Dh-C-Mb) were considered. During *kharif* season of 2019, rice yield varied between 3589 to 3804 kg/ha, maize between 3525 to 3786 kg/ha and pearlmillet 2793 kg/ha. Wheat productivity was ranged from 5600 to 5806 kg/ha and chickpea 1649 kg/ha. The summer mungbean yield ranged from 1207 to 1340 kg/ha.

The system productivity in terms of mungbean equivalent yield (MbEY) was maximum in R-W-Mb (2972 kg/ha) followed by M-W-Mb (2899 kg/ha), R+Dh-W-Mb (2868 kg/ha) and least in Pm-L+Ls (1286 kg/ha). The results further revealed that system productivity can be significantly increased with the inclusion of summer mungbean in rice-wheat and maize-wheat system under CA (Fig 21). Net return was maximum in M+Dh-C-Mb (INR. 1 16 659/ha) followed by M-W-Mb (INR. 1 08 165/ha) and least under Pm-L+Ls (INR. 30 394/ha). BCR also followed similar trend with highest value in M+Dh-C-Mb (2.74) followed by M-W-Mb (2.15) and R-W-Mb (2.05), and the least under Pm-L-Ls (1.51) (Fig 22).

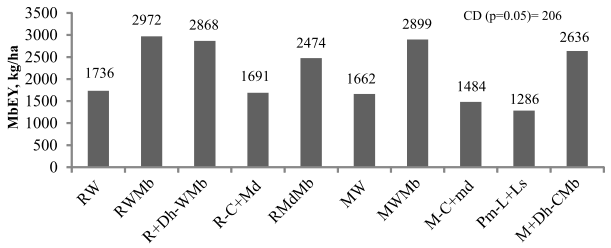


Fig. 13: System productivity (MbEY, kg/ha) of different cropping systems under CA

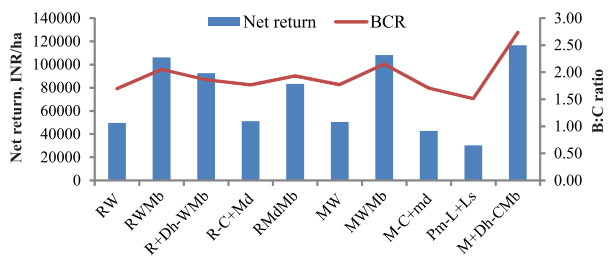


Fig. 14: Net return and BCR under different cropping systems under CA

Farm Mechanization

Enhancing efficiency of abrasive dehusking unit of IIPR Mini Dal Mill for different pulses

Different emery grades were evaluated for milling of different pulses in universal testing mill. For milling of pigeonpea, chickpea, lentil, mungbean, urdbean and fieldpea crops, emery grits of 24, 16, 20, 20, 30 and 30 mesh sizes found suitable for maximum dehusking. Based on the observations, three combination rollers were developed. Three combination rollers of different grits, viz., i) Roller-I with 24:30 mesh; ii) Roller-II with 18:24:30; Roller-III with 14:16:20:24:30 were fabricated. Emery roller, made from commercially available grinders, used in IIPR Mini Dal Mill was used to compare new rollers. An experimental dal mill was fabricated for testing and evaluation of combination rollers. Milling of pigeonpea, mungbean, urdbean and lentil were evaluated for different combination rollers. Maximum pitting of 44.4% was obtained with three grit combination roller followed by two grit combination roller (41.7%). Pitted grains from first pass were treated with oil @ 0.7%. Treated grains were alternately sundried and overnight heaping for two to three days before II pass through emery rollers. The findings are given in Table 6.

Table 6. Dal recovery in two passes:

	Pigeonpea		Mung bean	Lentil	Urd bean
Roller	WT	OT	OT	NT	OT
I	69.2	68.2	68.8	73.2	67.8
II	71.2	69.8	72.6	75.5	70.4
III	65.6	63.6	66.6	71.3	63.6
IV	68.6	66.6	70.4	72.6	68.2

WT: Water Treatment; OT: Oil Treatment; NT: No Treatment

Based on the performance of combination emery rollers, emery roll of IIPR Mini Dal Mill was modified (Fig 23). New model of IIPR Mini Dal Mill is using three grit combination roller (18:24:30). Improve model is being fabricated by sole authorized manufacturer, M/s Bharat Heavy Machines, Kanpur. However, emery rollers used in the mill are being fabricated by commercial abrasive manufacturer. The modified model of IIPR Mini Dal Mill, mechanism is developed to collect milling by-product obtained from emery roller and rubber-steel disc vertical chakki, both, with the help of cyclone separator located in the middle of the mill. Earlier there was provision for collection of milling by-product from vertical chakki only.





Fig. 15: Improved IIPR Mini Dal Mill

Externally Funded Projects

Post-harvest management of pulses, value addition and by product utilization

Utilization of pulse milling by-products for edible use (Funded by: Ministry of Food Processing)

Pulses are mostly consumed after dehusking and splitting, in form of dal. With milling of 75% of pulses produced, pulse milling is third largest food processing industry after wheat and rice. Among total post-harvest losses, pulse milling contributes maximum (15-20%) in form of milling by-product which is utilized as low value cattle feed. In this project, effort is being made to use fiber and protein rich pulse milling by-product for edible purposes. Initially milling of pigeonpea grains were conducted to improve cooking quality of the pulse. Dal recovery in pigeonpea is about 70%. The 30% of by-product is generated contains about husk and cotyledon powder in equal proportion. Since in pigeonpea seed coat is 15% of grain mass, it is evident that 15% protein rich cotyledon powder gets mixed with fiber, phenol and anti-oxidant rich husk in the by-product. This by-product with bioactive compounds can be utilized for human consumption. Husk and powder components were fractionated and subjected to bio-chemical analysis. It was observed that about 30% of protein (20.6%) rich cotyledon powder can easily be separated from pigeonpea milling by-product. Husk fractions are rich in phenolic contents (845.55 mg GAE/100gm) and antioxidant activities (59.68 m mole TE/100 gm). Similar studies are being conducted for other pulses. Edible bakery product (biscuits) has been prepared using pigeonpea and lentil milling by-products.



Pigeonpea by product biscuits



Lentil byproduct biscuits

Development of protocols for procurement, safe storage and milling outturn of major pulses (Funded by: Department of Consumer Affairs)

In order to control market prices, decision was taken to create buffer stock of pulses by the policy planners, involving NAFED and MMTC for procurement and central and state warehousing corporations for providing storage infrastructure and public distribution. So far, these storage agencies have established procurement and storage norms for wheat and paddy. Therefore, this study was initiated by Department of Consumer Affairs to develop procurement norms, storage methods and milling outturn for stored pulses with ICAR-CIPHET, Ludhiana as lead center and eight cooperating centers located in different agro-ecological zones. ICAR-IIPR, Kanpur has been given pulse storage locations of UP and MP to evaluate storage conditions and lentil crop (Whole and dal) was entrusted for lab scale storage studies. Samples were collected from various locations, viz., Banda, Mahoba, Chhatarpur, Naugong, Sagar, Vidisha, Tikamgarh and Niwadi, from state warehousing go-downs. Urdbean, chickpea and lentil were stored in these warehouses. Whole lentil was also stored in gunny bags following standard storage protocols for lab scale studies. Lentil dal, with 10, 12 and 14% moisture were stored in 25, 50 and 75 micron polypropylene bags for shelf life studies. The samples were analyzed at the lab for various parameters as mention under Table 7.

Table 7: Parameters analysed under different pulses

Observations	Urdbean	Chickpea	Lentil
Fresh Grain (%) 8	3.06 - 96.73	91.84 - 99.27	91.16 - 98.48
Moisture Content (%)	11.30 - 13.60	11.00 - 15.30	11.90 - 13.20
Bulk Density (kg/m3)	884.8 - 923.2	794.4 - 913.6	886.4 - 940.0
Recovery (%)	78.60 - 93.80	73.40 - 79.20	89.80 - 91.60
Weevilled Grain (%)	0 - 0.40	0 - 1.45	0 - 0.14
Foreign Matter (%)	0.42 - 1.82	0 - 1.01	0.56 - 2.38
No. of Grains with egg (%)	0-0.99	0 - 14.86	0.0 – 0.0
Admixture (%)	0-0.31	0 - 1.23	0-2.72
Damaged Grain (%)	3.27-16.55	0.73 - 7.87	1.38-8.70

Technology Developed

- The rice-wheat-mungbean is remunerative cropping system under both conservation and conventional agriculture.
- Suitable mungbean cultivars identified under CA (Virat or IPM 205-7)>Samrat> IPM 2-3> HUM 16> IPM 2-14).
- Supplementary irrigation once to lentil at peak branching could be economical in absence of rainfall during rabi season. Similarly, seed priming (for 4 hours) in lentil was useful under rainfed condition.
- A two years trials showed that no improvement in chickpea 'JG 16' yield following polymer hydrogel application (at 5 kg/ha) even under rainfed/limited irrigation condition.
- Improvement in chickpea 'JG 16' grain yield was apparent following application of salicylic acid at 100 ppm applied at both flowering and pod development stages under rainfed/limited irrigation condition. However, in absence of SA (100 ppm), urea (2%) or NPK (0.5%) at flower & pod development could also help in scaling crop performance under the said condition.
- Organic farming in chickpea under pearl millet-chickpea system revealed that significantly higher yield in pulses (chickpea) can be realized with organic practice alone (applied through FYM application supplemented with Biozinc and Biophos foliar sprays at flowering and pod development stages).
- In nine years of field trial on conservation agriculture, system productivity was significantly higher in conservation agriculture consisting of transplanted rice followed by wheat and summer mungbean under zero tillage with residue retention (compared to rice-wheat system under conventional practices).
- Under climate resilient cropping system under CA, system productivity in terms of chickpea equivalent yield was maximum in rice-wheat-mungbean followed by rice+dhaincha (GM) - wheat-mungbean, maize-wheat-mungbean and the least in pearlmillet – lentil + linseed.
- Under rice-relay lentil production system, puddled transplanted rice (PTPR) have an advantage over non-puddled transplanted rice (NPTPR) as PTPR resulted in higher germination of the lentil crop (surface seeding) in sandy-loam soil of Kanpur. PTPR led to higher grain yield ($p < 0.05$) of rice over NPTPR.
- Appropriate crop management practices amalgamated with RCTs (retention of 30 cm rice stubbles, zero tillage and appropriate rice establishment method viz., unpuddled transplanting/direct seeding) could play a key role in scaling crop productivity and profitability in rice fallow.
- Clodinafop-propargyl + Na-acifluorfen (IRIS) 122.5 g a.i./ha at 10-15 DAS in kharif mungbean and topramezone 20.6 ml a.i./ha at 14 in chickpea had minimum phyto-toxicity and higher weed control efficiency in mungbean and chickpea under alluvial soil.



Crop Protection

A. Institute Funded Project

Plant Pathology

Pigeonpea

Host plant resistance against wilt

Total 1332 pigeonpea lines were screened in the wilt sick field at IIPR Research Farm during *Kharif*, 2020-21 for identification of new sources of resistance against *Fusarium udum* (Race-2) causing wilt disease. Pigeonpea variety, Bahar was used as susceptible check.

Observations on wilt disease incidence have been recorded at fortnightly intervals. Out of 600 advance breeding materials, some lines (IPA 19-37, IPA 19-40, IPAE 15-06, IPA 15-02, IPA 18-8, IPA 19-68, IPAE 15-03, IPAE 17-03, IPA 18-04, IPA 15-21, IPH 09-05, IPA 16-18, IPA-67, IPAC-68, IPA10W-2-9, IPA 10W-14, IPA 10W-3-8, IPA 10W-12, IPA 10W-18, IPA 10W1-8, IPA 10W 20-2, IPA 10W 20-4, IPA 10W 2-0-1, IPA 10W 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 identified as promising entries against *Fusarium* wilt.

Out of 48 genotypes received from ICRISAT, six genotypes (ICPWS 1923, ICPWS 1918, ICPWS 1931, ICPWS 1924, ICPWS 1914, ICPWS 1921) performed well. A total of 115 genotypes of AICRP centres along with check variety Bahar were planted for evaluation.

Reaction of 29 genotypes of pigeonpea (KPL 44, ICP 8862, KPL 49, IPA 38A, IPA 38B, GPS 33, BSMR 736, BSMR 853, KPBR 80-2-1, PI 397430, KPL 43, IPA 40, Sujatha, ICP 8858, IC 8859, Banda Palera, BWR 377, ICP 89046, ICP 93812, ICP 89048, ICP 89049, ICP 14722, ICP 9174, ICP 93011, AWR 74/15, JAW 5-6A, BDN 1, BDN 2, ICP 8863) used as donors have monitored in the wilt sick plot.

Out of 1500 advance breeding materials, some lines (IPA 19-37, IPA 19-40, IPAE 15-06, IPA 15-02, IPA 18-8, IPA 19-68, IPAE 15-03, IPAE 17-03, IPA 18-04, IPA 15-21, IPH 09-05, IPA 16-18, IPA-67, IPAC -68, IPA 10W-2-9, IPA 10W-14, IPA 10W-3-8, IPA 10W-12, IPA 10W-18, IPA 10W1-8, IPA 10W 20-2, IPA 10W 20-4, IPA 10W 2-0-1, IPA 10W 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 identified as promising entries against *Fusarium* wilt.

Host plant resistance against *Phytophthora* stem blight

A total of 601 early and medium duration pigeonpea lines were planted for evaluation against *Phytophthora* stem blight (PSB) resistance in sick field during *Kharif* 2020-21. UPAS-120 and ICP 7119 was sown as check after every two rows of test entry. PSB incidence was recorded fortnightly intervals in different genotypes. Based on the mean disease incidence of the three replications, some of the pigeonpea lines *viz.*, IPA 15-08, IPAC -79, IPAPB 7-2-1-7, IPAPB -7-2-1, KPBR -80-2-1, IPAC -3, IPA 15-01, IPA 15-07, IPA 15-03, IPA 17-01, IPA 18-04, IPH 9-05, IPAP -19-08, IPH 18-02, IPH 18-01, IPH 18-09, IPAE 15-05, IPAB -2019-1-6, IPAB 10-67, IPAC -2 and IPA 16E-7) were identified as promising entries.

Out of 48 genotypes received from ICRISAT, three genotypes (ICPBN 19-01, ICPBN-19-08, ICPBN 19-09) were performing well. A total of 115 genotypes of AICRP centres were planted for evaluation against *Phytophthora* stem blight resistance. A set of 80 accessions of wild derivatives belonging to two different genera (*Cajanus, Rhynchosia*) were screened for identifying the resistant sources for further use in PSB resistant breeding programme.



Fig. 1: (a) View of *Phytophthora* stem blight sick field (b) identified potential donors

Chickpea

Host plant resistance against wilt

- Out of 274 elite breeding (IPC) lines *viz.*, IPC 2016-31, IPC 2013-209, IPC 2011-31, IPCK 2012-306, IPCK 2011-31, IPC 07-56, IPC 97-29 (7 lines) were highly stable resistance for five years and 12 lines *viz.*, IPC 18-118, IPC 18-152, IPC 19-163, IPC 19-171, IPC 19-185, IPC 18-130, IPC 18-29, IPC 07-56, IPC 97-29, IPC 10-72, IPC 2007-04, IPCK 2013-209 were moderately resistant against *Fusarium* wilt of chickpea.

- Out of 310 NBPGR accessions, only one accession namely, IC 244324 showed resistance reaction against *Fusarium* wilt of chickpea caused by the fungus *Fusarium oxysporum* f. sp. *ciceri* (Race-2). About, five entries *viz.*, IC 275448, IC 275775, IC 468839, IC 396583 and IC 269439 showed moderately resistance reaction

Host plant resistance against *Ascochyta* blight

- Out of 129 wild chickpea lines, 11 lines *viz.*, ILWC 21, ILWC 30, ILWC 50, ILWC 95, ILWC 182, ILWC 185, ILWC 188, ILWC 223, ICC 182, ICC 17151, ICC17164, were identified as resistant and 6 lines *viz.*, ICC 17155, ICC 17116, ILWC 238, EC 600099, EC 6000100, ICC 17150 were identified as moderately resistant against *Ascochyta rabiei*.

Lentil wilt

Host plant resistance against wilt

Host plant resistance is aspect of any disease management strategy. Wilt disease of lentil is the most important and widely occurring disease causing substantial yield loss. Identification of resistance against wilt caused by *Fusarium oxysporum* f. sp. *lentis* is pre-requisite for the development of wilt resistant varieties of lentil. With this view, a wilt sick plot has been developed wherein wilt susceptible lentil genotype (L9-12) used as check showed >75% plant mortality. One hundred eight genotypes of lentil were evaluated for identification of wilt resistance. Lentil genotype, L 9-12 used as susceptible check was sown after every two rows of test genotypes. Data on disease incidence recorded periodically differentiated test genotypes based on disease reactions. Lentil genotype IG 54 showed resistance against wilt in the second year of testing also. Lentil genotype IG 26 was also found to be resistant against wilt. Genotypes IPL 161450, IG 129309, IG 136670, IPL 121802, IPL 171373, IPL 141570, IPL 220, IPL 315, IPL 171385, IG 3790, IPL 406 showed moderately resistant reaction. Isolations made from infected plants of lentil from the sick plot during the crop season indicated involvement of wilt pathogen in >90% samples.



Fig. 2: A view of lentil wilt sick plot

Mungbean and Urdbean

Host plant resistance against YMD and UCD

Forty eight genotypes of urdbean were screened during *Kharif* 2020 against yellow mosaic and crinkle diseases in field conditions using infector row technique. Out of them 16 genotypes (PLU 856, IPU 10-1, IPU 99-31, IPU 85-15, IPU 11-6, IPU 10-16, IPU 6-2, IPU 99-204, IPU 12-9, IPU 99-2, IPU 88-31, IPU 12-4, IPU 12-29, IPU 13-10, IPU 13-1 and IPU 99-4) showed resistant reaction (0 or 1 category in 0-9 disease rating scale) against YMD and four genotypes (IPU 6-2, IPU 99-2, IPU 96-06 and VDN-7) were found free from crinkle disease. Two genotypes, IPU 6-2 and IPU 99-2 showed resistance reaction against YMD and free from crinkle disease also.

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

- Using multiplex PCR, mating types were identified. From the mating type (MAT) study, all the *A. rabiei* isolates were amplified a fragment of 490 bp size which was corresponding to mating type 2 (MAT-2) and a band of 700 bp corresponding to mating type 1 (MAT-1) were found absent in all the isolates. This confirmed that, only single mating type (MAT-2) present in Indian isolates of *A. rabiei*.
- The four pathotypes (I, II, III, IV) and six physiological races were delineated based on the differential reaction of the disease. The most predominantly distributed pathotype was pathotypes III (52.27%) in all the chickpea growing regions of the North India states except Uttarakhand isolates, followed by least virulent pathotype I (22.7%), virulent pathotype II (9.1%) and highly virulent with aggressive pathotype IV (15.9%) Among the six physiological races identified, the most predominant races were race 5 (25%) followed by race 1 (22.73%), race 6 (18.18%), race 4 (18.18%), race 3 (9.09%) and race 2 (6.82%). Because of the prevalence of single mating type in India, we found less diversity in *A. rabiei* compared to isolates of other countries.
- RAPD-SCAR markers were designed for *Ascochyta rabiei* identification.
- Fifteen representative isolates of *Ascochyta rabiei* from different geographical regions of the northern India were identified by molecular technique through sequencing of ITS region of the fungus with ITS primers (ITS1 and ITS4) through PCR amplification (Figure 2) and



sequencing. The obtained sequences were submitted to NCBI gene bank and their accession numbers are MT218392, MT252602, MT252603, MT252604, MT252605, MT252606, MT252607, MT252608, MT252609, MT252610, MT252611, MT252612, MT252613, MT252614, MT252615.

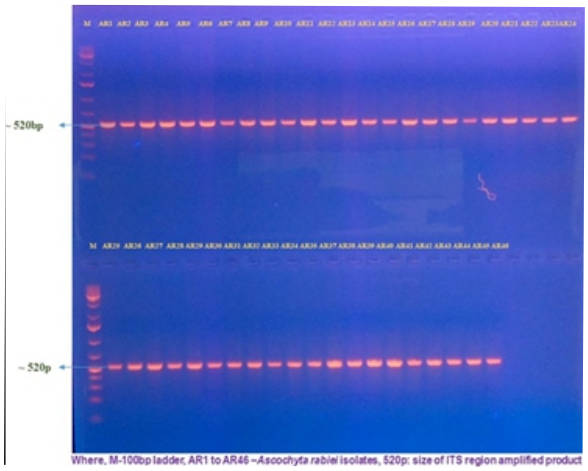


Fig. 3: PCR amplification of *A. rabiei* using ITS primers

- Molecular diversity data revealed that out of 58 RAPD markers, 43 markers were produced polymorphic band among the 44 isolates with the PIC value ranged from 0.01 to 0.28. Maximum PIC value were revealed by the markers *viz.*, OPA18 (0.2160), OPAU 12 (0.2496), OPB 06 (0.2275) and OPB 09 (0.2805). In cluster analysis isolates were categorized into six different clusters based on 72 % similarity. The cluster VI consists of AR-11 and AR-5. The isolate AR-5 found to be diverge from the rest of the isolates and clusters.
- The best set of SCAR marker pairs designated as SCAR1F/SCAR1R were developed with a detection sensitivity of 0.30 ng of genomic DNA. This is the first RAPD-SCAR marker having sensitive and species specific for detection of *A. rabiei.*

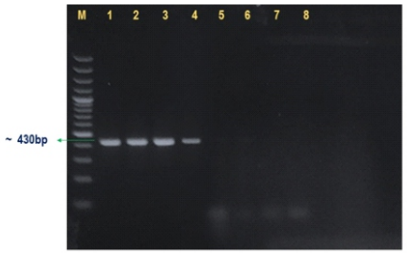


Fig. 4: SCAR marker specificity of PCR amplified products of *Ascochyte rabiei* isolates (Lane 1-4) and other fungal species (Lane 5-8) by using SCAR primers (SCAR1F/SCAR1R), (M-100 BP marker, 1. *Ascochyta rabiei*- Kanpur isolate, 2. *Ascochyta rabiei*- Ludhiana isolate, 3. *Ascochyta rabiei*- New Delhi isolate, 4. *Ascochyta rabiei*- K Samba isolate, 5. *Fusarium oxysporum f.sp.ciceri*, 6. *Rhizoctonia bataticola*, 7. *Botrytis cinerea*, 8. Negative control)

Talc based formulation (DALHANDERMA) of *Trichorderma asparallum* for soil borne diseases in pulses

Isolate IIPRTh-31 (*Trichoderma harzianum*) was found the most promising. Large scale testing of talc based formulation of IIPRTh-31 named as DALHANDERMA was undertaken at farmer's field during *Kharif* and *Rabi* 2018-19 in Kanpur Dehat, Hamirpur, Jaloun, Banda and Chitrakoot districts.

Characterization of microbes

- Seven isolates of *Botrytis cinerea* infecting chickpea were molecularly characterized using ITS 1 and 4 primers and their genbank accession numbers are MT250958, MT250959, MT250960, MT250961, MT250962, MT250963, Mt250940. The antagonistic phylloplane microbes such as *Chaetomium globosum* and *Trichoderma asperellum* identified as effective against *A. rabiei* and *B. cinerea* and their ITS sequences genbank numbers are MT250938 and MK879406, respectively.
- The PPM which were effective under *in vitro* conditions were moderately effective against *A. rabiei* and *Botrytis cinerea* fungi as compared to fungicides under pot conditions.
- Minimum Botrytis gray mold disease rating scale 5 was observed in treatment, ST with *Trichoderma asperellum* @ 10 gm/kg+ fungus inoculation @ 20 DAS followed by 5 in ST with *Bacillus subtilis* (PPM 15) + *Bacillus subtilis* (PPB 15) @ 10 gm/kg+ fungus inoculation @ 20 DAS where disease rating was 5.2 when compared to control (9.0) (Figure 7B).

Evaluation of antagonistic phylloplane microbes under pot condition

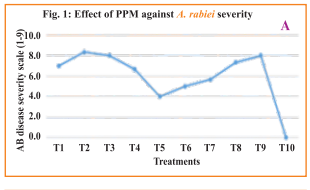
- Chickpea seed treatment with *Bacillus subtilis* @ 10 gm/kg+ fungus inoculation @ 20 DAS observed minimum *Ascochyta* blight disease rating scale of 4 followed by 5 in ST with *Bacillus subtilis* (PPM 15) + *Bacillus subtilis* (PPB 15) @ 10 gm/kg+ fungus inoculation @ 20 DAS.
- Minimum *Botrytis* gray mold disease rating scale 5 was observed in treatment, ST with *Trichoderma asperellum* @ 10 gm/kg+ fungus inoculation @ 20 DAS followed by 5 in ST with *Bacillus subtilis* (PPM 15) + *Bacillus subtilis* (PPB 15) @ 10 gm/kg+ fungus inoculation @ 20 DAS where disease rating was 5.2 when compared to control (9.0).

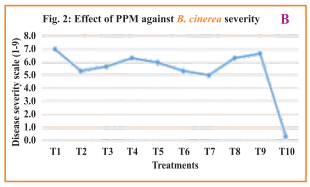
The phylloplane microbes are moderately effective against *Ascochyta* blight and Botrytis gray mold pathogens of chickpea when compared to fungicides under pot conditions.

Table 1: Treatment details for *Ascochyta* blight management

Treatments name	Treatments details
T1	ST with Bavistin @ 0.2% + fungus inoculation @ 20DAS
T2	ST with COC @ 0.2% + fungus inoculation @ 20DAS
T3	ST with mancozeb @ 0.2% + Bavistin 0.2% + PPM 15 @ 10gm/kg + fungus inoculation @ 20DAS
T4	ST with PPM 15 @ 10gm/kg + fungus inoculation @ 20DAS
T5	ST with PPB 15 @ 10gm/kg + fungus inoculation @ 20DAS
T6	ST with PPM 15 + PPB 15 @ 10gm/kg + fungus inoculation @ 20DAS
T7	ST with *Trichoderma asperellem* @ 10gm/kg + fungus inoculation @ 20DAS
T8	ST with *Trichoderma asperellem* @ 10gm/kg + Mancozeb 0.2% + fungus inoculation @ 20DAS
T9	Control (WST) + + fungus inoculation @ 20DAS
T10	Control (WST) + without inoculation

- PPM used for seed treatment and also sprayed one day before pathogen inoculation
- PPB 15: *Bacillus subtilis*
- PPM 15: *Bacillus subtilis (Large in size)*





Entomology

Characterization of HearNPV- IIPR05 isolate

Phylogenetic analysis: The coding region of core genes, *polyhedrin* (*polh*), *per os infectivity factor* (*pif-1*) and *late expression factor* (*lef-8*) were amplified from the virus isolate using the specific primers. The partial nucleotide sequences of three genes were submitted in GenBank (Accession Numbers MN603765, MN603764 and MN603763, respectively). The genetic relatedness of our isolate and other baculovirus species recognized by the International Committee on Taxonomy of Viruses (ICTV) was determined by phylogenetic analysis of three concatenated core genes (*polh, pif-1* and *lef*-8) of the isolate. The phylogenetic tree generated from concatenated amino acid sequences of three core genes following UPGMA analysis revealed that our isolate belonged to the genus *alphabaculoviruses* of the family *Baculoviridae*. Further the isolate clustered with ICTV recognised NPV species belonging to the Group-II NPVs. Therefore, the isolate was appeared to be a member of *alpha baculo virus* and Group II NPV as per the 9th ICTV classification system and was designated as HearNPV-IIPR05 isolate.

Morphology: The morphology of the purified OBs of virus isolate extracted from individual virosed larvae of *Helicoverpa armigera* was studied under electron microscope (SEM and TEM). The shape and size of OBs was recorded on the longest edge. The OBs exhibited irregular shape, a typical character of OBs of NPV belonging to *Alphabaculovirus*. Further, the OBs in SEM micrograph measured between 0.57-1.46 µm in diameter on the longest edge.

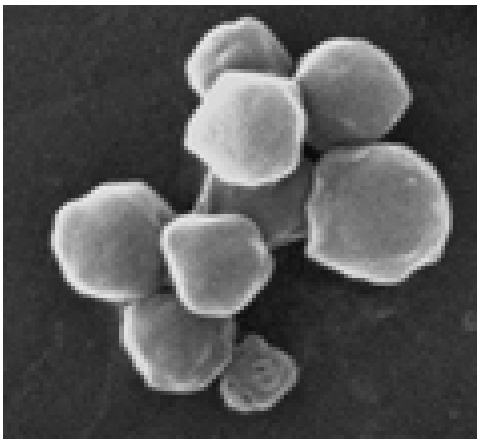


Fig. 5: OB morphology under Scanning Electron Microscope

Assessment of yield loss in blackgram due to direct feeding by Whitefly, *Bemisia tabaci*

An experiment was conducted in the net-house to assess the yield loss in blackgram (LBG 685) caused due to direct feeding by the whitefly, *Bemisia tabaci* (Gennadius). Different population loads of avirulent adult whiteflies like 500 adults (T1), 100 adults (T2) and 50 adults (T3) were released per 10 plants covered with 60-mesh nylon net. Release was not made in the control.

The pots were covered well before germination of the seeds. The number of adults established in T1 (16.26 adults per plant) was significantly higher than T2 (0.93) and T3 (0.54). The number of 3rd and 4th instars was also significantly higher in T1 than T2 and T3 (Table 1) in all the upper, middle and lower leaves observed. Immature stages were observed in higher numbers in the middle leaves as compared to lower and upper. In the treatment (T1) with the highest population of adults (16.26) as well as immature stages (15.96); the number of pods per plant (4.21), pod weight (3.15 g), number of seeds per pod (6.45) and seed weight (3.77 g) were observed at par with other treatments with lower population loads and control. Therefore, it was concluded that up to population level of 16.26 adult whiteflies per plant, there occurs no significant reduction in yield due to direct feeding by whiteflies.

Population monitoring of Whitefly, *B. tabaci* in greengram and blackgram crop ecosystem

Whitefly population data was recorded in greengram and blackgram crop ecosystem through yellow sticky traps at weekly interval. In summer, peak population was observed in 25th and 26th SMW whereas in *kharif* season, the peak was observed at 35th SMW. Blackgram recorded higher population in summer and greengram in *kharif*.

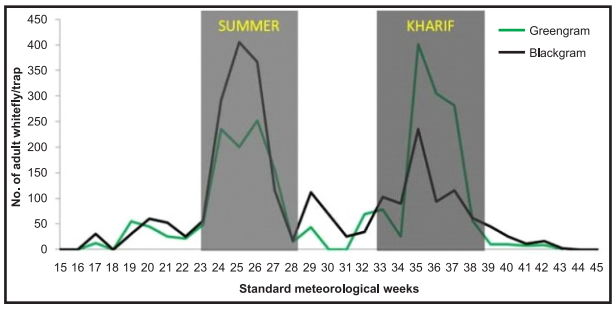


Fig. 6: No. of adult whiteflies per trap in greengram and blackgram crop ecosystem

Apart from this, 137 genotypes of blackgram and 111 genotypes of greengram were screened during summer 2020 for their extent of attractiveness to whitefly, *B. tabaci,* in terms of number of adult whiteflies per plant which ranged from 3 to 75.67 in blackgram and 1 to 25.67 in greengram.

Comparative toxicity of insecticide formulations against tobacco caterpillar, *Spodoptera litura* (Fabricius) infesting legumes

The toxicity of five different insecticide formulations *viz.,* Chlorantraniliprole 18.5 SC, Emamectin benzoate 5 SG, Chlorpyrifos 20EC, Plethora® (Novaluron 5.25 + Indoxacarb 4.5 SC) and Fipronil 5 SC was evaluated against second instar larvae of common cut worm, *Spodoptera litura* (Fabricius). Emamectin benzoate 5 SG was found to be the most suitable insecticide formulation for managing tobacco caterpillar, *S. litura* followed by Chlorantraniliprole 18.5 SC and Chlorpyrifos 20 EC. The probit analysis revealed the lowest median lethal concentration (LC_{50}) for Emamectin benzoate 5 SG followed by Chlorantraniliprole 18.5 SC, Chlorpyrifos 20 EC, Plethora® (Novaluron 5.25+Indoxacarb 4.5 SC) and Fipronil 5 SC.

Chitinolytic activity and formulation of *Bt* strain

The chitinolytic activity of *Bt* strains was determined by using spectrophotometric method and its biological activity was quantified against j2 root knot nematodes. (Table 1). The *Bt* strain, F8.IIPR was subjected to mass multiplication in nutrient broth and its spore crystal mixture was extracted and purified. The SCM was used for developing sodium alginate microcapsules by deploying the protocol described by Khorramvatan *et al.* (2014). The stability of the microencapsulated product was estimated and the size of the microencapsulated product was recorded.

Table 1: Chitinolytic activity of *Bt* strains and its efficacy against Root Knot Nemateode (RKN) juveniles

Bt strain name	OD value 420 nm (pooled mean)	Mean % mortality of juvenile RKN*
Ak2	0.462	70.33 (57.14)
F1	0.480	56.00 (48.58)
F4	0.522	55.33 (48.04)
F5	0.499	91.67 (73.31)
F8	0.525	89.00 (70.78)
C.D.	0.033	10.042
SE(m)	0.01	3.146
SE(d)	0.015	4.45
C.V.	3.574	9.148

* Values within parenthesis are arcsine transformed

Table 2: Probit analysis on different insecticide formulations against 2nd instar *S. litura*

Tr. No.	Insecticides	LC_{50} (%)	Slope	Pearson Chi-square	df	95 % Fiducial limit		LC_{95} (%)
						Lower	Higher	
T_1	Chlorantraniliprole 18.5 SC	0.00211	1.2192 ±0.1372	9.1206	6	0.00137	0.00304	0.04708
T_2	Chlorpyrifos 20 EC	0.01763	1.5660 ±0.4095	2.1769	3	0.00355	0.03170	0.19799
T_3	Plethora	0.03526	1.7220 ±0.3277	0.3927	3	0.02093	0.04869	0.31806
T_4	Emamectin benzoate 5 SG	0.00206	1.3794 ±0.2994	20.0794	6	0.000716	0.00427	0.03212
T_5	Fipronil 5 SC	0.41968	1.8902 ±0.3776	5.0139	3	0.31053	0.69807	3.11240

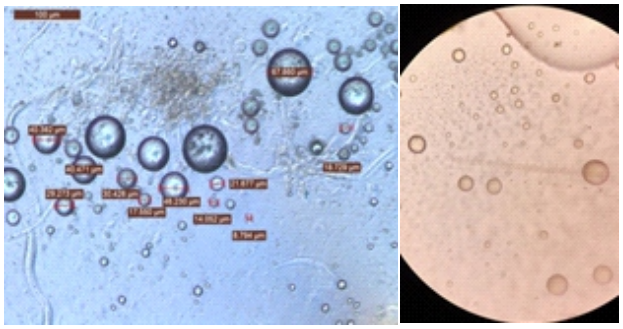


Fig. 7: Microencapsulatation of *Bt* strain

Development of *Bt* based Bioformulation

This project was initiated in June 2020. The spore crystal mixture of F8.IIPR and Ak2.IIPR was mass multiplied, extracted, purified and stored for formulation development. The invert emulsion was prepared using six different vegetable oils to find out its suitability for enhancing the physical stability of invert emulsion formulation. The invert emulsion of three formulations *viz.*, IE1, IE6 and IE8 were found to be 80%, 100% and 100% stable, respectively on 18th day after preparation.

Screening of wild pigeonpea derivatives against pod borer

Twenty two out of 41 Pigeonpea entries had pod borer infestation; similarly forty out of 41 pigeonpea entries had podfly infestation (Fig 2) during *Kharif* 2019; seven out of 41 pigeonpea entries had bruchid infestation. Only 2 entries *viz.*, WDBCE5-4-2-1; WD12-2-3 had ≤10 % pod infestation by pod fly. Over all 6 entries were found to have fallen under least susceptible category based on pest susceptibility rating as described by Lateef and Reed (1980). The floral characters such as streak pattern and petal colour were recorded.

Table 3: Screening of pigeonpea wild derivatives against pod borer, pod fly and bruchids

Category/ Genotype	Least susceptible (3)	Least susceptible (4)	Least susceptible (5)	Moderately susceptible (6)
No. of derivatives	6	9	8	5
Name of derivatives	WDBCE3-1-1-6 WDBCE5-4-2-1 WD12-2-3 IPAWD28-1 WDN2 136-2-4-7 Early 3	WDBCE4-5-3 WDBCE6-3-4-6 WDBCE6-3-4-7 WDBCE6-6-2-2 WDBCE9-4-1-1 WD5-9-4 WDN2 136-2-1-5 WDN2 136-4-2 WDN2 136-4-3-5	WDBCE3-1-1-3 WDBCE4-4-4-1 WDBCE4-5-2-1 WDBCE5-4-2-2 WDBCE6-6-2-1 IPAWD20-2 WDN2 136-2-4-8 WDN2 136-4-3-1	WDBCE5-6-5-2 WDBCE6-3-4-2 WDBCE9-4-3-1 WDN2 136-4-3-11 AL1747

Table 4: Floral characters of pigeonpea wild derivatives

Petal colour	Streak pattern	No. of pigeonpea entries
Yellow	Sparse	15
Orange yellow	Dense	8
Purple	Dense	5
Yellow	Absent	9
Yellow	Medium	7
Yellow	Dense	1

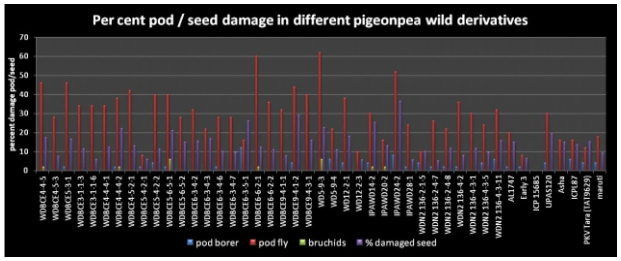


Fig. 8: Screening of pigeonpea wild derivatives against pod borer, pod fly and bruchids

Antagonistic activity of actinobacteria strains against dry root rot and fusarium wilt causing pathogens of chickpea

Dry root rot (*Rhizoctonia bataticola*) and Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*) are most important soil-borne diseases and causes considerable yield losses in chickpea. Actinobacteria are an important group of gram-positive bacteria and considered as promising source for biological activities. The dual-culture method was used to evaluate the antagonistic potential of 48 actinobacteria strains against *R. bataticola* and FOC, which were obtained from Pathology Section, Division of Crop Protection, ICAR-Indian Institute of Pulses Research. Of 48 actinobacteria strains screened, 13 strains (AIN 6, AIN 23, AIN 26, AIN 28, AIN 29, AIN 37, AIN 38, AIN 39, AIN 40, AIN 45, AIN 51, AIN 55, AIN 56) and 12 strains (AIN 11, AIN 28, AIN 32, AIN 40, AIN 41, AIN 44, AIN 45, AIN 49, AIN 52, AIN 55, AIN 56, AIN 59) have demonstrated >50%

growth inhibition of *R. bataticola* and FOC, respectively (Fig.1). *Streptomyces* sp. IIPR:KR01:01 and *Streptomyces* sp. IIPR:CH03:01strains showed highest growth reduction of *R. bataticola* (57.08%) and FOC (54.17%), respectively (Table 1). On the basis of per cent growth inhibition of *R. bataticola* and FOC, actinobacteria strains were grouped into 8 and 7 cluster, respectively. The present study indicated that the selected actinobacteria strains have the good *in vitro* antagonistic potential against target fungal pathogens. Further, greenhouse and field evaluations are needed to state these as potential biocontrol agents against *R. bataticola* and FOC in chickpea.

Inhibitory action of actinobacteria crude extract against dry root rot and *Fusarium* wilt causing pathogens of chickpea

Potential actinobacteria strains were further screened by following food poison technique and estimated the per cent Inhibition in Diameter Growth (PIDG). The actinobacteria strain, *Streptomyces ginkgonis* IIPR:HD01:05 had demonstrated 55.48% and 36.8% highest PIDG of *R. bataticola* and FOC, respectively.

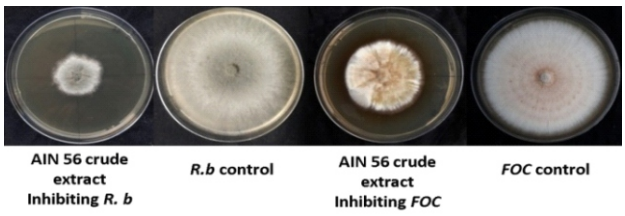


Fig. 9: Per cent inhibition in diameter growth of dry root rot and fusarium wilt causing pathogens of chickpea by potential actinobacteria crude extract

Insecticidal activity of herbaceous plant extracts against *Spodoptera litura* (Fab.)

Tobacco caterpillar, *Spodoptera litura* is a serious polyphagous insect pest and responsible for great economic losses in cultivated crops. In recent past plant derivates are becoming substitute to the chemical insecticides for the management of insect pest. Phytochemicals of six herbaceous plants (*Phyllanthus niriru*, *Cyperus rotundus*, *Euphorbia hirta*, *Boerhivia diffusa*, *Parthenium hysterophorus* and *Cynodon dactylon*) was extracted from entire plant using ethyl acetate (Fig. 3). Oral toxicity of herbaceous plant EtoAc extracts against *S. litura* (3rd instar larvae) was evaluated in the laboratory using surface diet contamination method. The larvicidal effect of different crude extracts at 5 µg/ml concentration and 100 µl/3.8 cm^2 dosage on *S. litura* was observed throughout the larval period. The

Table 5: Toxicity of herbaceous plants extract against *Spodoptera litura*

Herbaceous Plants	Concen-tration (µg/ml)	Dosage (µl/3.8 cm^2)	Larval Mortality (%)
Phyllanthus niruri	5	100	39±1.00^b (1.59)
Cyperus rotundus	5	100	36±1.00^b (1.56)
Euphorbia hirta	5	100	22±0.58^d (1.34)
Boerhavia diffusa	5	100	22± 1.53^d (1.35)
Parthenium hysterophorus	5	100	26±1.53^c (1.42)
Cynodon dactylon	5	100	75±1.00^a (1.88)
Methanol (99.9%)		100	0^e
Control (autoclaved water)		100	0^e
	S.Em±		0.04506
	Variance		0.037

Values in parenthesis are log10 transformed values, Means followed by same letters do not differ significantly (p>0.05) by Tukey HSD

highest per cent larval mortality (75%) was observed from *Cynodon dactylon* crude extract treatment followed by *Phyllanthus niruri* (39%), *Cyperus rotundus* (36%), *Parthenium hyseterophorus* (26%), *Boerhavia diffusa* (22%) and *Euphorbia hirta* (22%) treatments. The estimated lethal concentration (LC_{50}) of *C. dactylon* crude extract was low (1.45µg/ml) compared to *P. hyseterophorus* (4.09 µg/ml), *C. rotundus* (5.74 µg/ml), *P. niruri* (6.75 µg/ml), *B. diffusa* (10.92 µg/ml) and *E. hirta* (13.62 µg/ml). While, low LC_{99} value was observed with *E. hirta* (21.56 µg/ml) followed by *B. diffusa* (30.31 µg/ml), *C. dactylon* (45.67 µg/ml), *P. niruri* (130.42 µg/ml), *C. rotundus* (143.34 µg/ml) and *P. hysterophorus* (213.9 µg/ml) crude extracts. The present investigation had evidenced EtoAc extract from *C. dactylon* demonstrated the highest *S. litura* larval mortality and low LC_{50} value compared to other herbaceous plants extracts. Additional studies, on the elucidation of the active phytochemicals from *C. dactylon* EtoAc extract further authenticate its botanical insecticidal nature against *S. litura*.

Population fluctuation of insect pest in major pigeonpea and chickpea growing agro-climatic zones of India

A pest scout data in pigeonpea (leaf webber, plume moth, pod borer) and chickpea (pod borer) crops



Fig. 10: Herbaceous plants used for extraction of insecticidal phytochemicals

including daily insect pest counts for three successive seasons (2015/16—2017/18) at western and eastern plateau hills (agro-climatic zones) of India was analysed for spatio-temporal dynamics. Longer infestation (different crop phenological growth stages) behaviour of leaf webber and pod borer in pigeonpea and chickpea, respectively influenced their increased mean counts (incidence). Weekly mean counts of leaf webber, plume moth and pod borer in both the crops varied significantly between the seasons. Linear incremental change in mean counts of leaf webber and pod borer on pigeonpea and chickpea, respectively was observed across the seasons (inter-seasonal). Intra-seasonal built-up of plume moth (pigeonpea) and pod borer (pigeonpea and chickpea) mean counts was also noticed. On pigeonpea, leaf webber and plume moth mean counts never reached an economic threshold level (3 larvae/plant), but crossed the advisory level (1.5 larvae/plant). It was observed that there was incremental rise in pod borer mean counts and crossing economic threshold level over seasons in chickpea (1 larvae/meter row length), while it was not the case in pigeonpea (1 larvae/ plant).

Primary infestation of bruchids in cowpea and mungbean at field level

A systematic methodology was developed to identify

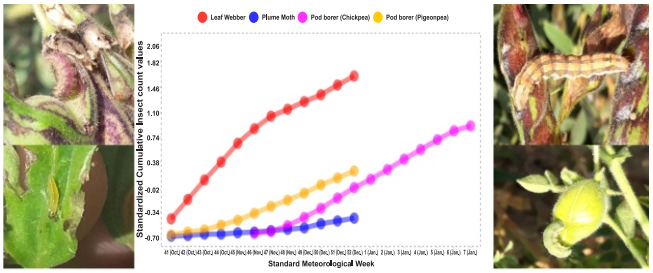


Fig. 11 : Inter and intra seasonal variations of insect pest in pigeonpea and chickpea crops

the crop stage where bruchids initiate the primary infestation on standing crop and its subsequent losses at storage level arising due to field-carry-over infestation in mungbean, cowpea and pigeonpea. The infestation parameters on seeds/pods were recorded at definite intervals from open and caged plants starting from first Weeks After Flowering Initiation (WAFI) till harvest in separate RCBD layouts at field level for mungbean, cowpea and pigeonpea. Further, at storage, the bimonthly observations for one year were recorded from grains harvested from the open and caged plants representing each interval which were stored in cloths bags separately.

Results revealed that field infestation on seeds/pods started from 3rd, 4th and 7th WAFI in three crops, respectively (Fig. 1b & c). The infestation found incremental towards crop end and overall, the infestation on observed pods at field level did not cross 6 %. Field-carry-over experiment confirmed the perpetuation of infestation and damage in the grains representing the respective WAFI on three crops where field infestation was recorded. The results obtained through systematically designed methodology explicit timeline of bruchid infestation at field level and the impact of field-carry-over infestation under storages. This would help to identify and intervene a timely insecticidal schedule in the existing IPM schedule to break the bruchid field-carry-over chain.

Post-harvest management of secondary infestation by bruchids at storage level

An irradiation experiment was conducted for post-harvest management of secondary infestation by bruchids at storage level, the pre-infested seeds along with adults were exposed to six irradiation treatments (Doses) in Grays along with a control in CRD with three replications. Irradiation doses at 50 and 100 Gy exhibited 26.66 and 63.33 per cent adult mortality, respectively which were significantly differed with control (1.20 %) and the other higher doses recorded cent per cent mortality. Similarly, hatching success and survivability into adults was

significantly lesser at 50 Gy (16.62 and 7.15 %) and 100 Gy (6.96 and 3.18 %) when compared to control (83.16 and 74.19 %) and at other higher doses hatching success and survivability into adults was nil. Cowpea seeds irradiated at doses up to 300 Gy did not significantly affect the seed viability (Fig. 2b). Among the irradiation doses tested, irradiation of cowpea at 200 Gy adversely affected the oviposition, hatching success and survivability into adults, however, the same dosage did not affect the germination of cowpea seeds. The results opens window to further investigate effect of irradiation on other bruchid species, grain biochemical parameters (when pulses stored for food purpose) and seed cellular macromolecules (when stored for seed purpose).

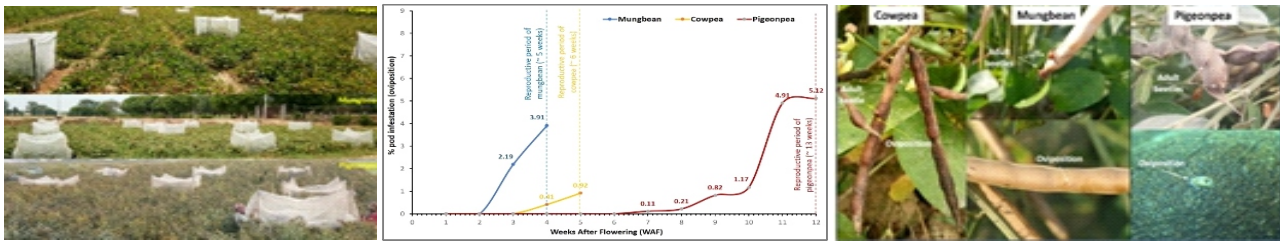


Fig. 12: a. Caged conditions in mungbean, cowpea and pigeonpea for bruchid field infestation studies. b. Bruchid field infestation windows (weeks) on mungbean, cowpea and pigeonpea. c. Bruchid field infestation on pods of mungbean, cowpea and pigeonpea.

Nematology

Screening for resistance against root-knot nematode, *Meloidogyne javanica*

Pigeonpea

Seventeen genotypes/lines of pigeonpea were evaluated for their resistance against root-knot nematode, *Meloidogyne javanica*. Threee genotypes WRGE 121, AKTE-12-04 and KPL 44 were moderately resistant and remaining 14 genotypes were susceptible to *M. javanica*.

Mungbean

Twenty nine lines of mungbean were evaluated for resistance against *M. javanica*. None of the lines was found resistant. Two lines IPM 312-394-1 and NDML 17-07 were moderately resistant. Remaining all lines were either susceptible or high susceptible to *M. javanica*.

Urdbean

Twenty one lines of urdbean were evaluated for resistance against *M. javanica*. None of the lines was found resistant. Seven lines namely, DKU 90, GJU 1509, IPU 17-1, IPU 2-43, KPU 514-75, KPU 52-87, KUG 479 were moderately resistant. Fourteen lines were susceptible and two were highly susceptible to *M. javanica*.

Chickpea, lentil, fieldpea

Forty genotypes of chickpea, 19 lines of lentil and 30 lines of fieldpea were screened against root knot nematode, *M. javanica*. None of the genotypes/lines was found resistant or moderately resistant. All the genotypes/lines screened were susceptible or highly susceptible to *M. javanica.*

Screening for resistance against pigeonpea cyst nematode, *Heterodera cajani*

Pigeonpea

One hundred nine lines of pigeonpea were screened against *Heterodera cajani* in 3x2 feet cemented pots filled with nematode infested soil at a level of 5-8 cysts/100 cc soil. Five lines namely, WD 2019-7, WD 2019-47, WDBCE 9-4-3-1, WDBCE 4-5-3-9 and WDBCE 6-3-5-1 were observed highly resistant. Ten lines namely, WD 2019-2-2, WD 2019-24-2, WDN2 136-2-4-8, WDBCE 6-3-4-2, WD 12-2-1, WDBCE 3-1-1-3, WD 2019-37, WD 2019-40-1, WD 2019-40-2 and WD 2019-45-1 were resistant, 32 lines were moderately resistant and remaining lines were either susceptible or highly susceptible to *H. cajani*.

Urdbean

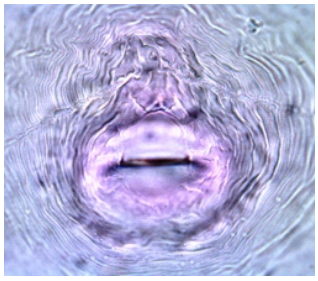
Twenty one lines of urdbean were evaluated against *H. cajani*. One line GJU 1509 was observed as resistant and six lines namely, IPU 11-02, KPU 514-75, KUG 479, MU 52, SBC 50 and TU 94-2 were observed as moderately resistant. Rest of all the lines were either susceptible or highly susceptible to *H. cajani*.

Mungbean

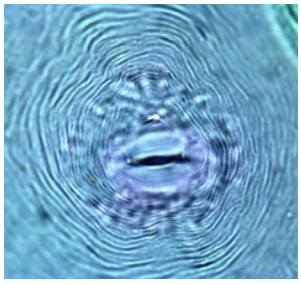
Out of 29 lines screened against pigeonpea cyst nematode, *Heterodera cajani*, two lines were moderately resistant and rest all lines were showing resistance. This indicated that mungbean is poor host of *Heterodera cajani*.

Identification of species of population collected from different locations

Four root knot nematodes populations were collected from Pusa, Bihar, Jaipur, Rajasthan, Faizabad, Uttar Pradesh and local Kanpur population. These populations were multiplied using single egg mass. The galled root were stained in lactophenol acid fuchsin and about ten perineal patterns were cut from each population and observed under microscope to identify species of root knot nematode populations based on perineal patterns. The species of root knot nematode population collected from Pusa was identified as *Meloidogybe incognita*, the populations of Faizabad and Kanpur were identified as *M. javanica*. The population of Jaipur was mixture of both the species that *M. incognita* and *M. javanica*.



Meloidogyne javanica



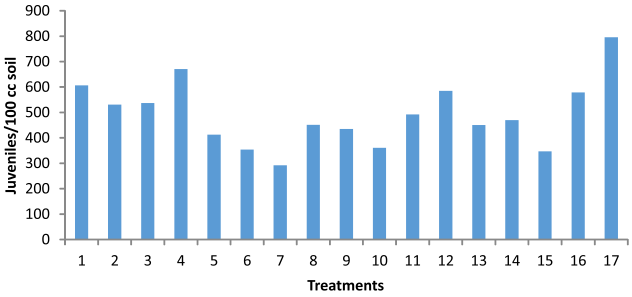
M. incognita

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

The evaluation of five varieties of *Brassica juncea*, five varieties of *B. napus*, four varieties of *B. carinata* and two varieties of *Eruca sativa* as biofumigant crops for root-knot nematode management was re-evaluated second time. The 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 1000/100cc soil. Three replications were taken for each variety along with one control. Two hundred gram of 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 IPFD 14-2 were sown in each pot and maintained for two and half month to record galling.

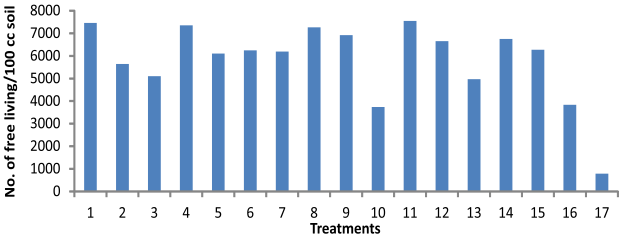
The nematode population was reduced in all the treatments where chopped leaves were incorporated in soil over control. However, maximum reduction was 63.3% in GSL-2 variety of *Brassica napus* followed by 56.4% in Karan Tara of *Eruca sativa* followed by 55.6% in Neelam and 54.6% in Sheetal variety of *Brassica napus*.



Brassica juncea	B. napus	B. carinata	Eruca sativa
1. Rohini	6. Neelam	11. Kiran	15. Karan tara
2. RGN-73	7. GSL-2	12. Pusa Aditya	16. T-27
3. Urvashi	8. GSC-5	13. PC-5	17. Control
4. Vasundhara	9. GSL-1	14.Pusa Swarnim	
5. RB-50	10. Sheetal		

Fig. 13: Effect of different varieties of rapeseed and mustard on the juvenile population of root knot

The incorporation of chopped leaves of rapeseed and mustard increased tremendously the populations of free living nematodes compared to control. The increase ranged from 3741 to 7546 nematodes/100 cc soil. Maximum free living population was observed in Kiran variety of *Brassica carinata*.

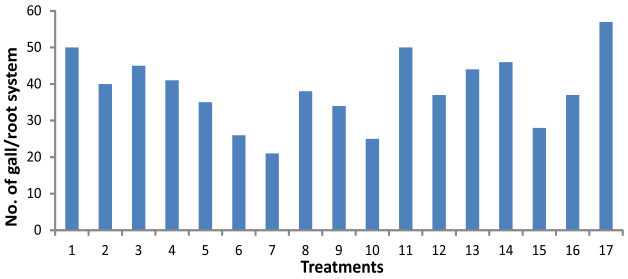


1. Rohini , 2. RGN-73, 3. Urvashi, 4. Vasundhara , 5. RB-50, 6. Neelam, 7. GSL-2, 8. GSC-5, 9. GSL-1, 10. Sheetal, 11. Kiran, 12. Pusa Aditya , 13. PC-5, 14. Pusa Swarnim, 15. Karan tara, 16. T-27, 17. Control (C)

Fig. 14: Effect of different varieties of rapeseed and mustard on the free living nematodes

After sowing of five seeds of fieldpea variety IPFD 14-2, the plants were grown for about two and half months before uprooting and recording of galling on the roots. Galls were comparatively less in all the treatments compared to control. The Lowest galls (21 galls/root system) were recorded in pots which were bio-fumigated with GSL-2 variety followed by 25, 26 and 28 galls/root system in posts biofumigated with Sheetal, Neelam and Karan Tara, respectively compared to 57 galls/root system in control.





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)

Fig. 15: Effect of bio-fumigation on the number of gals on root of fieldpea variety IPFD 14-2.

Field evaluation of four varieties as bio-fumigant crops for the management of root-knot nematode

The trial was taken at New Research Centre, IIPR, Kanpur in Field No. F-16. Seven treatments *viz.*, four varieties of bio-fumigant mustard crop, GSL-1, Neelam, Kiran and Karan Tara, one green manure crop *Sesbania*, one nematicide carbofuran 3G and control were taken. Four replications were taken for each set of covering under polyethylene and uncovered. The plot size was taken 2 x 2.5 m. The mustard varieties along with green manure crop were grown on equivalent area of plot size for about one and half months. The plants were cut, chopped and mixed with the soil followed by light watering on 17/11/2019. One set of treatments with four replications was covered with polyethylene and other set was kept as such.

Ten days after covering that is on 27th Nov. 2019, the covers were removed and soil samples were collected to record the juvenile population. Same day sowing of fieldpea variety IPFD 14-2 was sown. Three months after sowing plant growth parameters were recorded. On 20th March 2020, the harvest of the crop was done. Due to lockdown, the crucial data on gall index at harvest could not be recorded. Also the juvenile population recording, soil samples could not be taken immediately after harvest. Soil samples were collected after watering the plots one month after harvest. The data was collected on the biomass, grain yield,

The reduction in juvenile population in all treatments over control was significantly after 10 days of treatments. The covering of plots after treatment gave more control than without cover.

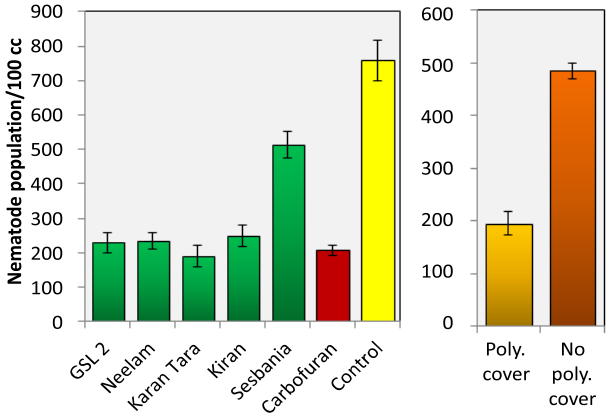
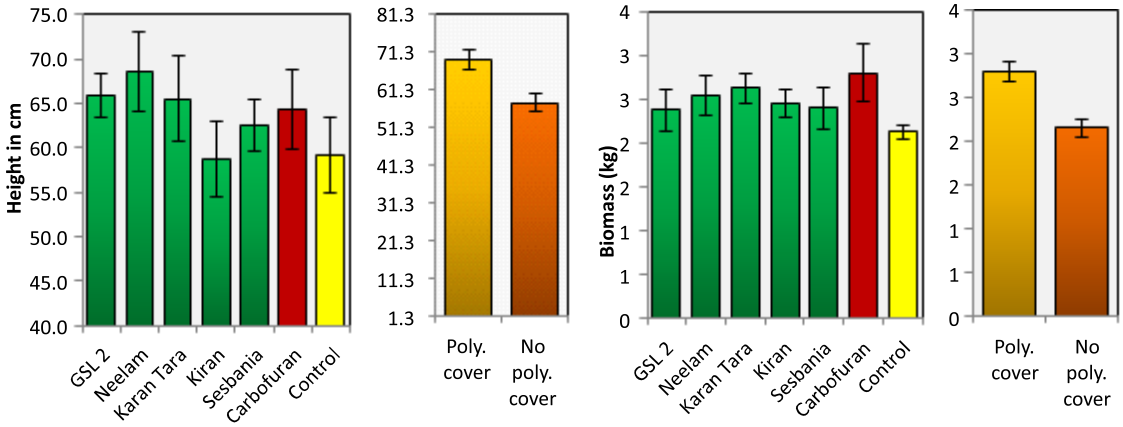


Fig. 16: Juvenile population in soil after 10 days of treatment and covering

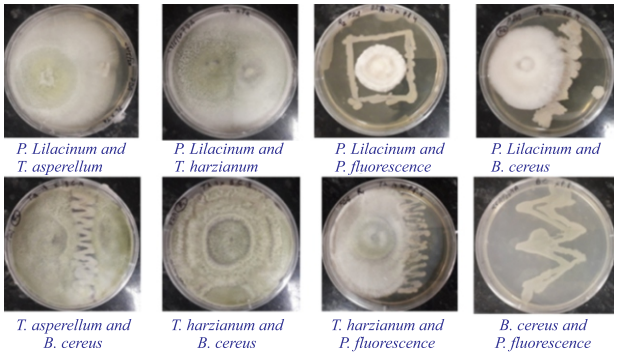
The plant height was more in bio-fumigated plots. Maximum plant height was recorded in cultivar Neelam treatment followed by GSL 2. The covering of plots after treatment also improved the plant height. Similarly, the biomass and grain yield were also improved compared to control and also covering with polyethylene after treatment improved biomass and grain yield. Maximum biomass and grain yield was recorded in Karan Tara treatment (Fig. 6). The final juvenile population was recorded more in covered plots compared to uncovered plots. However, the population in all bio-fumigant treatments was lower as compared to control.



Compatibility test of best strains of nematode biocontrol agents

Dual culture assay experiment was carried out to identify the inter relationship behavior among five biocontrol agents namely, *Paecilomyces lilacinus, Trichoderma harzianum, T. asperellum, Bacillus cereus* and *Pseudomonas fluorescence*. It was observed that all the strains were showing mutually inclusive growth behavior .

	P. lilacinum	*T. harzianum*	*T. asperellum*	*B. cereus*	*P. fluorescence*
P. lilacinum	NA	+	+	+	+
T. harzianum	+	NA	+	+	+
T. asperellum	+	+	NA	+	+
B. cereus	+	+	+	NA	+
P. fluorescence	+	+	+	+	NA



P. Lilacinum and T. asperellum | *P. Lilacinum and T. harzianum* | *P. Lilacinum and P. fluorescence* | *P. Lilacinum and B. cereus*

T. asperellum and B. cereus | *T. harzianum and B. cereus* | *T. harzianum and P. fluorescence* | *B. cereus and P. fluorescence*

B. Externally funded Projects

Innovative and contextual Agromet advisory services for climate smart agriculture (Development of pest and disease forecasting model)

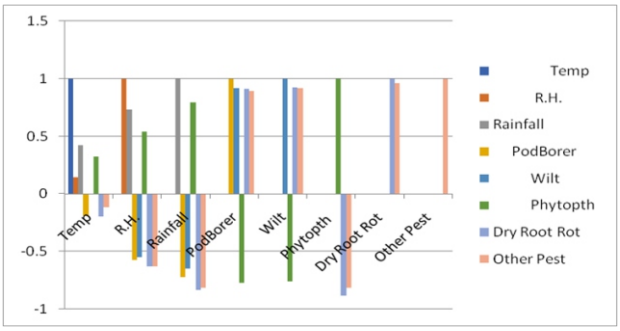
Weather parameters are reported to influence the growth and development of plant pathogens; Pests determine the course and severity of pests and pathogens incidence in chickpea and pigeonpea. The present study was aimed at analysing the relationship between weather parameters and *Fusarium* wilt disease incidence in Pigeonpea and chickpea. Observations on different weather parameters such as maximum temperature, minimum temperature, rainfall, and relative humidity, wind and wilt incidence were collected from last decades (2008-09 to 2018-19) from farmers' fields of Bundelkhand region. The data on weather parameters were converted to monthly averages to estimate the association between weather variables and pod Borer and wilt incidence (%) in pigeon pea. These weather parameters in previous studies reported significant impact on wilt and pod borer incidence in pigeonpea and chickpea. After performing correlation analysis, it was found that wilt incidence was highly correlated (Positive) with maximum temperature and minimum temperature and correlation coefficient was significant. However, the correlation coefficient between wilt and rainfall, was not significant. Present results revealed that temperature played a crucial role in the incidence of wilt. These findings were very helpful for building a forecasting model to predict the occurrence of wilt and pod borer in pigeonpea and chickpea.

Table 6: Coefficient correlation of Kurara block

	Temp	*R.H.*	*Rainfall*	*Pod borer*	*Wilt*	*Phytoph- thora*	*Dry root rot*	*Other pests*
Temp	1							
R.H.	0.145044	1						
Rainfall	0.424256	0.730975	1					
Pod borer	-0.19028	-0.57572	-0.72238	1				
Wilt	-0.00672	-0.5508	-0.64714	0.92117	1			
Phytophthora	0.321823	0.539904	0.794299	-0.77146	-0.75694	1		
Dry root rot	-0.19668	-0.62742	-0.83304	0.912092	0.925287	-0.8807	1	
Other pests	-0.11581	-0.62839	-0.81413	0.892483	0.920635	-0.81609	0.963515	1

- Correlation analysis of Kurara Block revealed that the correlation between temperatures with wilt incidence, pod borer, dry root rot and other pests was found to be negative with average value of -0.00672, -0.19208, -0.19668, -0.11581, respectively. Whereas correlation between

Rainfall and *Phytophthora* was positive with average value of 0.424256, 0.321823.



- Relation between relative humidity with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value -0.57572, -0.5508, -0.62742, -0.62739, respectively. Whereas correlation between rainfall and *Phytophthora* was positive with average value of -0.730975, -0.539904.

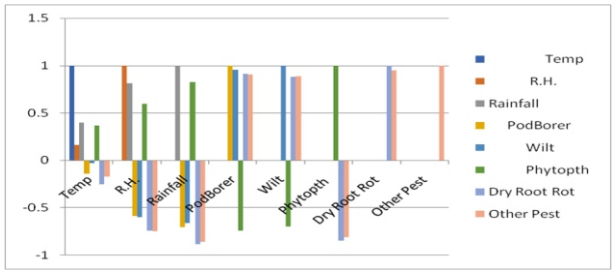
Table 7: Coefficient correlation of Maudaha block

	Temp	*R.H.*	*Rainfall*	*Pod borer*	*Wilt*	*Phytophthora*	*Dry root rot*	*Other pests*
Temp	1							
R.H.	0.19398	1						
Rainfall	0.405926	0.803601	1					
Pod borer	-0.14909	-0.58648	-0.70217	1				
Wilt	-0.01615	-0.61016	-0.66338	0.961528	1			
Phytophthora	0.363898	0.582411	0.81164	-0.73688	-0.69778	1		
Dry root rot	-0.26691	-0.73657	-0.88001	0.913938	0.887888	-0.84097	1	
Other pest	-0.18743	-0.73967	-0.85952	0.911105	0.8942	-0.80158	0.947022	1

- Correlation analysis of Maudaha Block reveals that the correlation between temperatures with wilt incidence, pod borer, dry root rot, and other pests was negative with average value of -0.01615, -0.14909, -0.26691, -0.26691, respectively, Whereas correlation between rainfall and *Phytophthora* was positive with average value of 0.405926, 0.363898. Another relation between relative humidity with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value –0.61016, -0.58648, -0.73657, -0.73967, respectively. Whereas correlation between rainfall and *Phytophthora* was positive with average value of 0.803601, 0.584211.

Table 8: Coefficient correlation of Muskara block

	Temp	*R.H.*	*Rainfall*	*Pod borer*	*Wilt*	*Phytoph-thora*	*Dry root rot*	*Other pests*
Temp	1							
R.H.	0.164634	1						
Rainfall	0.40064	0.812438	1					
Pod borer	-0.14111	-0.58555	-0.70314	1				
Wilt	-0.02944	-0.60074	-0.66262	0.956288	1			
Phytophthora	0.36709	0.595672	0.824466	-0.7398	-0.69902	1		
Dry root rot	-0.25149	-0.74282	-0.88204	0.914835	0.881295	-0.84488	1	
Other pests	-0.16957	-0.7452	-0.85908	0.908501	0.889717	-0.80702	0.946592	1

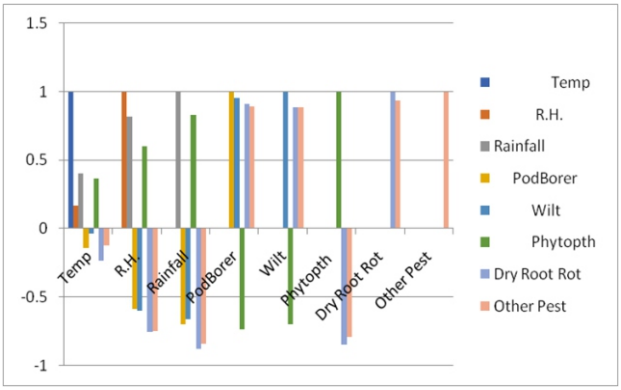


- Correlation analysis of Muskara block reveled that the correlation between temperatures with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value of -0.02944, -0.14111, -0.25149. -0.16597, respectively, Whereas correlation between Rainfall and *Phytophthora* was positive with average value of 0.40064, 0.36709 another Relation between Relative humidity with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value –0.60074, -0.58555, -0.36709, -0.7452, respectively. Whereas Correlation between rainfall and *Phytophthora* was positive with average value of 0.812438, 0.595672.

Table 9: Coefficient correlations of Sumerpur Block.

	Temp	*R.H.*	*Rainfall*	*Pod borer*	*Wilt*	*Phytophthora*	*Dry root rot*	*Other pests*
Temp	1							
R.H.	0.16403	1						
Rainfall	0.403021	0.817032	1					
Pod borer	-0.1421	-0.59034	-0.70502	1				
Wilt	-0.03752	-0.60469	-0.66454	0.955563	1			
Phytophthora	0.36578	0.600547	0.830185	-0.74041	-0.6998	1		
Dry root rot	-0.23605	-0.75551	-0.88328	0.91211	0.883809	-0.84822	1	
Other pests	-0.12641	-0.74958	-0.84658	0.891688	0.883559	-0.79357	0.938579	1

Correlation analysis of Sumerpur Block revealed that the correlation between temperatures with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value of -0.03752, -0.1421, -0.23605, -0.12641, respectively. Whereas correlation between rainfall and *Phytophthora* was positive with average value of 0.403021, 0.36578. Another relation between relative humidity with wilt incidence, pod borer, dry root rot, and other pests was found to be negative with average value –0.60469, -0.59034, -0.75551, -0.74958, respectively. Whereas correlation between rainfall and *Phytophthora* was positive with average value of, 0.817032, 0.600547.



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

Diversity of viruses involved in YMD of minor pulse crops in India

In an endeavour to understand the diversity of viruses involved in causing yellow mosaic disease (Figure 1) in minor pulses (mungbean, urdbean, cowpea, horsegrame and mothbean) in the country, a survey was conducted. One hundred forty six samples collected from nine states (Utter Pradesh, Haryana, Punjab, Delhi, Rajasthan, Bihar, Karnataka, Tamil Nadu and Telangana) have been processed for the characterization of YMD causing viruses. Rolling circle amplification (RCA) was performed for 78 samples to enrich the viral DNA. Of them, the amplification of genomic components has been completed for 77 samples. Out of 77 samples, sequences of the genomic components of viruses causing YMD have been obtained from 20 samples and submitted at NCBI database. Fifty three full length DNA molecules of three viruses, MYMIV (#9 each of DNA-A and DNA-B), MYMV (#10 DNA-A and #13 DNA-B) and HgYMV (#6 each of DNA-A and DNA-B) have been assembled. Sequence data obtained so far indicate association of three virus species; *Mungbean yellow mosaic India virus* (MYMIV), *Mungbean yellow mosaic virus* (MYMV) and *Horsegram yellow mosaic virus* (HgYMV).



Fig. 17: Symptoms of yellow mosaic in different crops. A=Urdbeen, B=Cowpea, C=Mothbean, D=Horsegram, E=Mungbean

The DNA-A of MYMIV had 1-9% and DNA-B 4-7% nucleotide sequence diversity among the studied population. The DNA-A of MYMV had 1-4% and DNA-B 2-7% nucleotide sequence diversity among the studied population. The DNA-A of HgYMV had 1-8% and DNA-B 2-5% nucleotide sequence diversity among the studied population. Mixed infection of three viruses (MYMIV, MYMV and HgYMV) was found with YMD affected mothbean sample collected from Belgaum, Karnataka, whereas one sample of YMD affected urdbean from Raichur yielded two viruses (MYMIV and MYMV). The

analysis of phylogentic relationship revealed that the virus species obtained from the pulse infected samples (MYMIV, MYMV and HgYMV) formed a separate cluster of both the DNA-A and DNA-B molecules (Figure 2).

Screening of pulses genotypes for bruchid resistance

Under this project, Screening of mungbean, urdbean and cowpea genotypes/lines was completed for bruchid (3 species; *C. chinensis, C. analis* and *C. maculatus*) tolerance following 'free choice' and 'no choice' assay in storage entomology laboratory, IIPR. Among 158 mungbean advance lines/wild accessions, four accessions were found highly resistant, 14 accession were found resistant, 10 were moderately resistant. Among 50 urdbean genotypes, all the lines were immune to *C. chinensis* as this species did not complete life cycle in any of the genotypes. Whereas against *C. analis* and *C. maculatus*, none of the lines was found highly resistant, 7 were found resistant, 21 were moderately resistant, 7 were moderately susceptible, 10 were susceptible and 5 were highly susceptible. Among 24 cowpea genotypes, none were found either highly resistant or resistant, only 1 line was moderately resistant.

Development of protocols for procurement, safe storage and milling out turn of major pulses

Status of pulses storage and stored pests at NAFED godowns across selected locations of UP and MP

The project team visited the state warehouse go-downs of UP and MP (9 locations) and collected stored pulses samples from the identified stacks for lab analysis of insect pest infestation parameters. Since ICAR-IIPR, Kanpur has been identified for storage studies of lentil, whole and *dal* of lentil has also been stored for lab scale storage studies. For lentil storage studies, grains procured from local *mandi* were stored in Gunny Bags to simulate go-down storage. Lentil at 10, 12 and 145 moistures stored in 25, 50 and 75µ PP bags for shelf life studies. Samples (whole seed and *dal* of lentil) are being analyzed on weekly, monthly and quarterly basis. The results revealed that the per cent oviposition on sampled grains were ranged between 0-18.86, 0-0.14 and 0-0.99, respectively for chickpea, lentil and urdbean across nine locations. Whereas, the per cent damaged/weevilled grains ranged between 0.73-7.87, 1.38-8.7 and 3.27-16.55, respectively for three crops sampled.

Bioprospecting plant essential oils for insecticidal properties against pulse beetle infesting stored legumes

Bioactivity of plant volatile oils

The plant volatile/essential oil from the plant species mentioned in table were identified for having biological activity against pulse beetle through contact toxicity. The essential oil from these plant species at 3.01 µl/cm^2 exhibited more than 80 per cent mortality in pulse beetle, *C. analis* in impregnated filter paper assay. The LC_{50} values for these potential EOs were ranged between 0.11 and 2.07 µl/cm^2 against pulse beetle, *Callosobruchus analis* (F.).

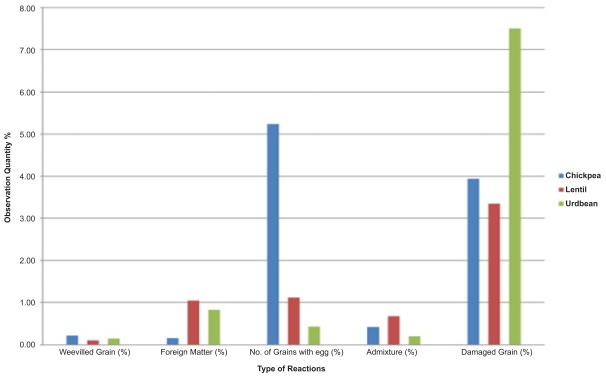


Table 10: Plant essential oils evaluated for insecticidal properties against pulse beetle

Sl. No.	Plant species	Family	Plant parts used
1	*Cymbopogon flexuosus*	Poaceae	Leaves
2	*Ocimum basilicum*	Lamiaceae	Leaves / aerial parts
3	*Curcuma longa*	Zingiberaceae	Leaves
4	*Mentha spicata*	Lamiaceae	Leaves
5	*Ecalyptus citridora*	Myrtaceae	Leaves
6	*Thuja occidentalis*	Cupressaceae	Leaves / aerial parts
7	*Coriandrum sativum*	Umbelliferae	Seeds
8	*Citrus limetta*	Rutaceae	Fruit peels

On the basis of % repellency and repellency index (RI<1), most of the EO were identified as repellents by area preference method and they were categorized as class-II (*O. basilicum*), class-IV (*T. occidentalis, C. limetta, C. sativum*) and class-V repellents (*M. spicata*, C. *flexuosus*, *E. citridora, C. longa*) against *C. analis*.

Basic Science

Mega-project 1 : Management & Analysis of production constraints in pulses as influenced by different abiotic stresses & 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

To mitigate drought stress in two contrasting chickpea genotypes *viz*. as JG 14 (bold seeded) and DCP 92-3 were subjected to water stress (no irrigation) under field condition. At flowering stage when crop reached terminal stress with receding soil moisture, 5µmole foliar spray of jasmonic acid was applied twice at 15 days interval and its physiological response was monitored using sensor-based technologies. Application of Jasmonic acid significantly contributed towards increased yield and yield attributes under drought as compared to the yield in crop without spray. Several modified responses were observed in chickpea when jasmonic acid was sprayed such as increase in the size of pods, more than 90% pods showing double seeds, increase in the pod number and reduction in the number of empty pods (Fig 1).

Sub-Project 2 : Identification and Physiological characterization of pigeon pea [*Cajanuscajan* (LMillsp.)] genotypes for cold tolerance.

In the year (2019-20), 08 genotypes of cold sensitive group and 08 genotypes of cold tolerant along with moderately tolerant group of pigeonpea and 14 crosses were taken for their physiological response to low temperature. Four (04) checks *viz*., IPA203, Bahar, NDA-1, and ICPL 7035 were also taken for comparison. The list of pigeonpea genotypes included in the study were NDA-1, Bahar, IPA203, NDA-2, MAL-13, ICP2275, IPACT-2, MA-6, IPACT-3, IPACT-24, RajendraArhar, IPA15F, Dholi-D, JBT46/27, IPACT-6, IPACT-14, IPAD1-17, IPAC 68, IPACT 22, ICPL 7035, and 14 breding lines received from CI Division . The temperature profile of the year during recording of physiological parameters is shown in the **Table 1**. During the period of December,2019 to Fbruary,2020 when temperature was sufficiently low physiological observation were taken.

Table 1. The temperature profile of different years

Parameters	Dec. 2019	Jan. 20	Feb. 20
Average minimum temperature (^{0}C).	10.11	10.91	11.63
RH%	79.07	96.09	78.79
Rain fall(m.m.)	20	0.70	30.40
No. of days with >10^{0}C	16.00	8.00	8.00

The effect of cold stress >10^{0}C on few morpho-physiological parameters such as NBI, chlorophyll, flavonols, anthocyanin and plant height showed no definite trend in tolerant , susceptible and breding lines of pigeonpea studied . Highest per cent pod retention after exposure to cold stress was observed in tolerant group (67.31%) which included varieties such as MAL-13, NDA-2 and ICP 2275. In susceptible group, the average percent pod retention was about 52% in varieties like Dholi –D, IPACT 22 and IPAD 1-17 having 29, 46 and 52% pod retention, respectively. While crosses made from Bahar x IPACT-79, IPACT-79xIPACT 80 and IPACT 79xIPACT 80 showed 68, 68 and 67% pod retention, respectively. In Plant efficiency parameters, including NDVI, photosynthetic rate, stomatal conductance and transpiration rate, no definite trend could be observed in tolerant, susceptible and breding lines of pigeonpea. However, tolerant group showed relatively higher stomatal conductance over susceptible group. Antioxidant enzymes including peroxidase and Super Oxide Dismutase showed higher activity in susceptible group as compared to tolerant group . on the other hand, the crosses could not show any definite trend. Tolerant group showed higher 100 seed weight and grain yield per plant over susceptible group.

Sub-Project 3: Screening for drought and heat tolerance in Lentil

A field experiment was conducted during *Rabi* season 2019-20 involving 52 genotypes of lentil for the second consecutive year for screening to heat tolerance. Sowing of the crop was done under timely (normal) and late sown (one month delayed)



conditions on raised beds in 2 replications following standard package of practices so that crop may be exposed to higher temperature (>30^{0}C) at flowering in case of delayed sowing. Crop vigor was recorded based at periodical intervals (15 Days) using green seeker hand held crop sensor (Green Seeker portable NDVI). Nitrogen balance index (NBI), chlorophyll index, flavnols and anthocyanin in leaves were measured using chlorophyll SPAD meter. Five plants from each genotype under late sown condition were tagged at weekly intervals for study of pod setting and development. Pollen viability was also measured by collecting the pollen from unopened flowers from field during morning hours. A general reduction in all the growth and yield parameters was observed in almost all the genotypes under late sown condition compared to normal sown crop. Some of the genotypes maintained good crop vigor, produced pods in terminal branches and grain filling at higher temperature (>30 ^{0}C). Based on the observation made in late sown crop it was found that genotypes IG 3522, IG 4112 and IG 2507, performed better and showed relatively higher tolerance towards heat stress.

Screening for drought tolerance in Lentil

A field experiment was conducted under rainfed condition during *Rabi*- season 2019-20 in 4 Dugout micro plots (Wet, Moderately wet, Moderately drought and Drought) with 45 genotypes of lentil in 2 replications at main research farm of the Institute for screening under drought condition. Soil samples were collected from all the microplots from 0-15 cm and 15-30 cm depth for monitoring of soil moisture at periodical intervals. Crop vigor was recorded at periodical intervals using green seeker hand held crop sensor (Green Seeker portable NDVI). Nitrogen balance index (NBI), chlorophyll index, flavnol and anthocyanin was measured using chlorophyll SPAD meter. Leaf relative water content (%) was also measured from all the genotypes. Performance of all the genotypes was found better in terms of growth, yield and yield attributes as compared to previous year due to high soil moisture as the crop was influenced by winter rains at crop establishment and flowering stage. Most of the genotypes performed better and registered higher crop vigor, RWC (%), NBI and Chlorophyll index values and produced higher biomass and yield. Performance of genotypes identified during previous season such as IG 3522, IG 3278, IG 2580, IG 2507, IG 3831, IG 2754, IG 2821 and IG 4258 was also found better. However, performance of these genotypes as drought tolerant needs to be confirmed under rainout shelter.

Sub-Project 4: Strategies for improving yield stability in Urdbean through photothermo – insensitivity

A field experiment was conducted to improve yield stability in Urdbean through photothermo – insensitivity. One hundred (100) selected high yielding genotypes of different geographical origin were grown at Kanpur 26.418 N longitude, 80.232 E latitude with temperature regime maximum temperature 46.5^{0}C during *kharif* and minimum 15.5^{0}C during pre-*rabi* sowings. The crop was raised in Augmented Block Design (ABD) with three date of sowings on 26.7.2020, 24 8.2020, 26.9.2020 in field under irrigated conditions at Kanpur. The crop was raised following standard agronomical package and practices. The qualitative and quantitave traits including date of germination, 1st flowering, 50% flowering,1st podding, 50 % podding, and maturity were recorded. The maximum and minimum temperatures of each day were collected from the meterological observatory along with average temperature and finally relationship between the mean temperature and number of buds, flowers and pods plant $^{-1}$ were recorded. Wide range of variations



Cold tolerant (NDA-2 left ; & ICP-2275) Cold susceptible (Dholi-D & ICPL-7035) genotypes in pigeonpea

Fig. 1: Cold sensitivity in pigeonpea

in phenological parameters were observed for days to 1st and 50% flowering. Some of the genotypes were found photothremo-insensitive based on their ability to flower and set pods at temperature as high as 43.9^{0}C and as low as 11^{0}C. These genotypes PU-19, IPU 99-179, IPU 99-213, PLU 65, PGRU 95016. were selected and identified as photothermo-insensitive blackgram genotypes at Kanpur as these genotypes take same days to flower during different time of sowing / season in the year (**Table 2**).In all selected genotypes date of flowering were same irrespective of year or season.

Sub-Project 5: Biochemical basis of heat tolerance in Chickpea (*Cicer arietinum* L.)

Estimation of esterase enzyme activity in the stigma of chickpea

Chickpea is an important cool-season food legume which is affected by heat stress and day temperatures above 32^{0}C during its reproductive stage are particularly detrimental leading to decrease in the yield. Stigma receptivity indicates the ability of stigma to support viable and compatible pollen. It gets affected by terminal heat stress in chickpea which ultimately results in significant yield losses. Stigma receptivity can be determined from the activity of esterase enzyme present on the stigma surface. Esterase activity was determined in the stigma of heat tolerant as well as heat susceptible genotypes of chickpea under normal as well as heat stress condition using -napthyl acetate as a substrate in the azo-coupling reaction with fast blue B. Esterase activity was found to be more under normal condition as compared to the heat-treated condition. Further, under the heat-treated condition, the esterase enzyme activity was found to be relatively more in the tolerant genotypes (ICCV 92944, ICC 1205 and Annigeri 1) as compared to the susceptible genotypes (ICC 10685 and Pant G 114) (**Fig. 3**).

Table 2: Effect of photo thermo-period on first flowering of different blackgram genotypes

Genotypes/date of sowings	20.6.2019 Photoperiod (13.47)	26.8.2019 Photoperiod (12.10)	26.7.2020 Photoperiod (13.6)	24.8.3020 Photoperiod (12.10)	26.9.2020 Photoperiod (12.3)
	1st flowering days after sowing				
PU-19	38	36	35	36	35
IPU 99-179	35	36	37	37	35
IPU 99-213	36	34	34	35	35
PLU 65	39	39	40	42	40
PGRU 95016	38	35	36	36	35

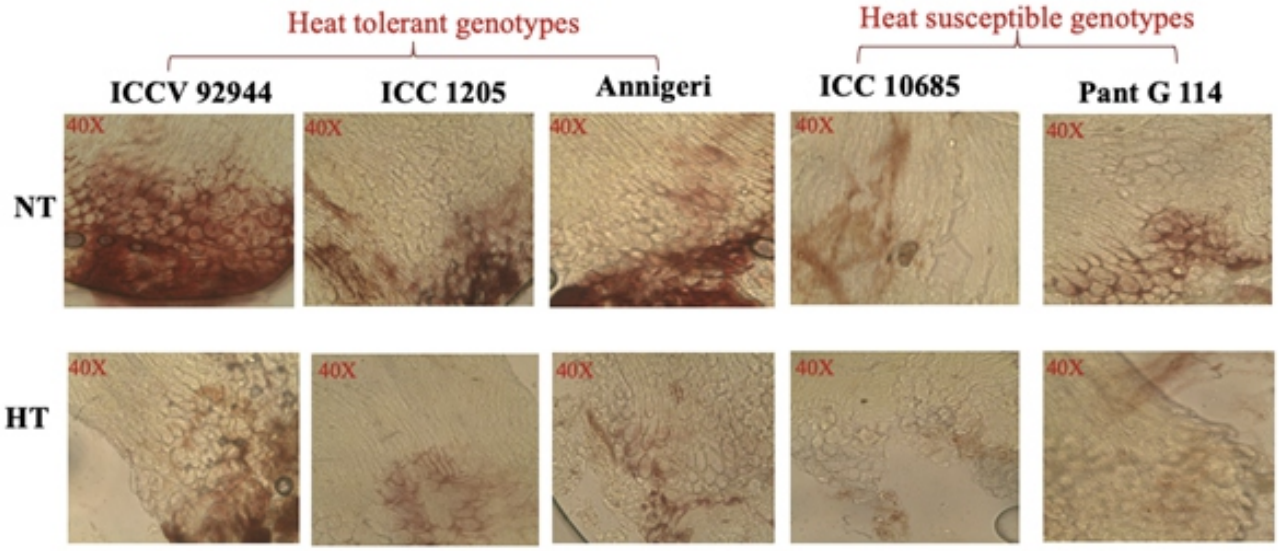


Fig. 2: Esterase activity in stigma of chickpea flowers under normal and heat stress conditions

Estimation of pollen viability of chickpea

Pollen viability was estimated using acetocarmine test in the flower of heat tolerant as well as heat susceptible genotypes of chickpea under normal as well as heat stress condition. It was observed that the viable pollens were more in tolerant genotypes as compared to the susceptible genotypes under the heat treatment condition. However, the viable pollens were less under heat treatment as compared to the normal condition (**Fig. 4**).

Peroxidase activity in the pollen and stigma of chickpea

The peroxidase activity was found to be more in pollen compared to the stigma. Further, its activity was found to be higher under heat treatment condition compared to the normal condition in both pollen as well as stigma. Peroxidase activity was found to be higher in heat tolerant genotypes compared to the susceptible genotypes in both pollen as well as stigma (**Fig. 5**).

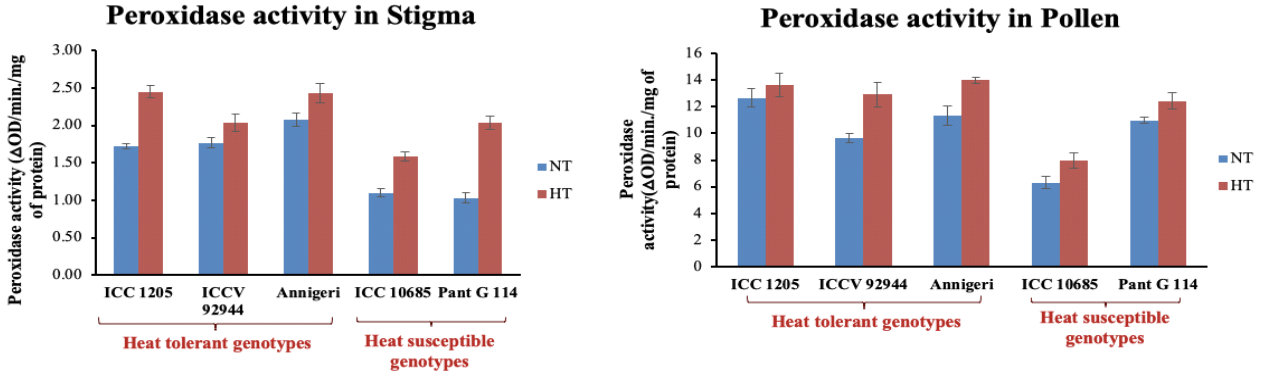


Fig. 3: Peroxidase activity in stigma and pollen of chickpea under normal and heat stress condition

Superoxide dismutase activity in stigma of chickpea

The superoxide dismutase (SOD) activity was estimated in the stigma of heat tolerant as well as heat susceptible genotypes of chickpea under normal as well as heat stress condition. The SOD activity was found to be more under heat treated condition as compared to the normal condition (**Fig. 6).**

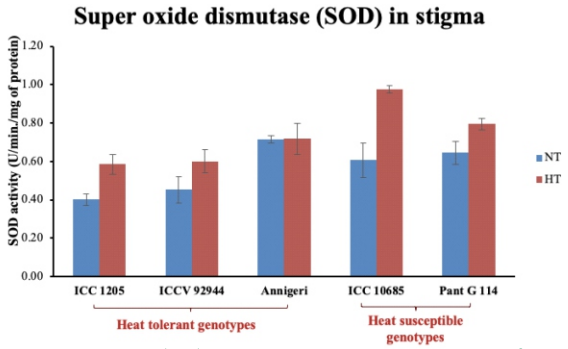


Fig. 4: Superoxide dismutase activity in stigma of chickpea under normal and heat stress condition

Biochemical basis of cooking induced changes in the green seeded chickpea:

Phenolic content in the green seeded chickpea genotypes determines the retention of green colour after cooking. The genotypes which retain green colour after cooking have lower phenolic content as compared to the genotypes which do not retain green colour after cooking (**Fig. 7**).

Mega-Project 2: Nutritional and phytochemical profile of cowpea and field pea with emphasis on their bioavailability and health promoting properties

The phenolic compounds such as phenolic acids and flavonoids are abundant in legumes. They play a crucial role in plants and are also known to benefit human health by means of their antioxidant function. The objective here was to extract and quantify the free and bound phenolics of field pea and cowpea using high performance liquid chromatography. Ten different standards of phenolic acids and flavonoids were used in this study (**Fig 8**). Retention times, limit of detection (LOD) and limit of quantification (LOQ) were determined for each phenolic standard (**h**). In field peas, gallic acid, and catechin hydrate were detected in all fifteen genotypes studied. However, protocatechuic acid, p-coumaric acid and ferulic acid were detected only in few genotypes. Unlike field peas, cowpeas were found to have a much diverse phenolic profile. Extraction and quantification of free and bopund phenolics of cowpea identified gallic acid, protocatechuic acid, catechin hydrate, p-coumaric acid and ferulic acid in all twelve genotypes used for this study but others such as caffeic acid, ellagic acid and quercetin were detected only in few genotypes.

Besides phenolics, pulses such as field pea and cowpea also have enough alpha galactosides that are known to cause flatulence as humans lack the

enzyme alpha galactosidase required for their breakdown. The objective here was to identify and quantify these oligosaccharides using HPLC-RI and know the effect of four different domestic processing methods a) soaking in normal water (1:5 ratio) for 12 hrs., b) soaking in water containing 0.03% sodium bicarbonate (1:5 ratio) for 12 hrs., c) pressure cooking of overnight soaked seeds, d) germination of pre-soaked seeds for 15, 24. 48 and 72 hrs. at 25C with 8 hrs. of day light. Verbascose, stachyose and raffinose were the major alpha galactosides detected in field pea while only stachyose and raffinose were detected in cowpeas. Verbascose was the predominant alpha galactoside in fieldpea while stachyose was predominant in cowpeas.

In field peas, verbascose content was reduced significantly in all the four treated samples but maximum reduction of nearly 74.6% was observed upon germination for 72 hrs. Likewise stachyose content also reduced in all the four treatments but maximum reduction of approximately 67.43% was noted upon germination for 72 hrs. Raffinose content was only marginally reduced and that too only in pressure cooking treatment. The concentration of other sugars such as sucrose and maltose were reduced upon soaking in normal water, soaking in water containing 0.03% sodium bicarbonate and cooking but as expected, their concentration enhanced upon germination (**Table 4**). The effect of these processing treatments on the alpha galactoside profile of cowpeas was quite similar to that observed for field peas. The amount of stachyose was observed to be reduced in all the treatments with maximum reduction of 79.43% noted in the treatment germination for 72 hrs. The amount of raffinose decreased slightly upon cooking while that of sucrose and maltose enhanced by 34.4 % in the treatment germination at 72 hrs (**Table 5**). Overall, the study revealed that the concentration of alpha galactosides in both field pea as well as cowpea can be significantly reduced by these indigenous processing treatments.

Table 3: Retention times (Rt), Absorbance wavelengths (Aw), Regression equations, linearity (R^2), Limits of detection (LODs) and Limits of quantification (LOQs) of the standard phenolic analytes. Results are mean of three independent experiments.

	Analytes	Rt (min)	λ (νμ)	Regression equations	R^2	LODs (mg/ml)	LOQs (mg/ml)
1	Gallic acid	3.9	254	y = 27.234x – 75.078	0.993	2.87	8.7
2	Protocatechuic acid	5.2	254	y = 54.261x - 9.5509	0.995	3.16	9.58
3	Catechin hydrate	8.4	238	y = 30.945x - 2.9964	0.996	4.35	13.18
4	Caffeic acid	9.1	238	y = 48.999x + 11.215	0.999	4.15	12.58
5	p-Coumaric acid	11.8	238	y = 34.226x - 18.251	0.999	4.56	13.82
6	Ferulic acid	14.2	238	y = 58.617x -52.89	0.999	4.48	13.58
7	Sinapic acid	15.2	238	y = 76.69x - 83.25	0.998	4.77	14.45
8	Ellagic acid	17.1	272	y = 183.37x - 95.853	0.999	2.26	6.85
9	Quercetin	22.3	272	y = 70.678x – 52.894	0.999	2.67	8.11
10	Kaempferol	25	272	y = 64.52x – 73.378	0.999	2.04	6.18

Mega 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

Pigeonpea rhizobial strains via IIPR-PR-48, 87,242, and 315 were evaluated under field condition and found IIPR-PR-315 is the potential strain for further registration, front line demonstration and mass production. Similarly, *Rhizobium* IIPR-MR-127 for Mungbean and *Rhizobium* IIPR-UR-32 for urdbean were identified as potential candidates. Up to 22% increase in nodule specific weight was recorded in case of inoculated plants. Based on available data urdbean rhizobia IIPR UR 32 was found most potential among the 4 cultures used. Germplasm lines of major pulses were evaluated and

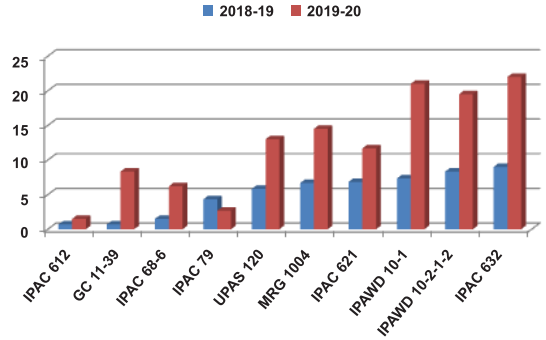


Fig. 5: Identification of pigeonpea genotypes with contrasting nodulation

identified the contrasting genotypes for nodulation traits. High nodulating genotypes performed better in terms of nodulation and biomass accumulation compared to low nodulating genotypes and check varieties under normal phosphorus (20kg P_2O_5/ha) condition. Based on available data IPU 99-141 and IPU99-95 (up to 80% higher nodulation) were found to be most potential genotypes.

Sub-project 2: Improving nodulation potential of Rajmash

A total of 10 selected rajmash genotypes along with 3 varieties were evaluated for confirmation of their nodulation potential under field condition. All the genotypes except released varieties were found positive for nodulation. Nodules were collected from 35 days old plant and nitrogenase activity was estimated using Acetylene Reduction Assay. Nodule number varied from 2-9/plant. Nodule specific weight varied from 2-16mg/nodule. Rajmash genotype IC417352, IC356018, EC150250 were found to be good nodulators (**Fig. 9 and 10**)

Among the ten rajmash genotypes tested, genotype IC356018 and EC150250 were found positive for nitrogenase activity.

Among 50 rhizobial strains isolated from different rajmash genotypes, 27 were evaluated for their nodulation potential under pot experiment. Nodule number varied from 1 to 11 per plant. Nodule specific weight varied from 0.002-0.005g/nodule (**Fig. 13, 14**). Rhizobial isolates IIPR-RR11, IIPR-RR14, IIPR-RR17, IIPR-RR40 were found to be most promising.

Ten selected Rajmash genotypes were evaluated for their host specificity towards selected Rhizobial isolates. Among them 5 genotypes showed good nodulation. Nitrogenase activity of nodules was estimated through Acetylene Reduction Assay. All the plant growth parameters as well as nodule specific parameters were recorded (**Table 7**). Best two genotypes were selected for further studies.

Table 4: Selection of potential urdbean *Rhizobium*

Treatments		Nodule number	Nodule Weight (g)	Nod. Specific Weight (g)	Root Weight (g)	Shoot Weight (g)	Yield (kg/ha)
T1	No Nitrogen fertilizer	12.33	0.048	0.0039	1.074	20.502	444.40
T2	100% Nitrogen fertilizer	24.67	0.175	0.0071	1.988	34.066	581.24
T3	75% Nitrogen fertilizer	18.67	0.093	0.0050	1.844	31.465	482.11
T4	75% N + Check *Rhizobium*	24.33	0.170	0.0070	1.574	35.047	510.56
T5	75% N + IIPR UR 3	29.00	0.168	0.0058	1.333	30.405	593.91
T6	75% N + IIPR UR 19	28.67	0.170	0.0059	1.561	34.555	453.46
T7	75% N +IIPR UR 32	33.67	0.184	0.0055	2.234	51.914	672.63
T8	75% N + IIPR UR 96	21.33	0.127	0.0059	1.825	35.049	523.35
C.D. Value		6.17	0.046		0.367	5.873	90.48

Table 5: Evaluation of host specificity of selected rhizobial isolates

Genotype	Nodule number	Nodule weight (g)	Nodule Specific weight (g)	Shoot weight (g)	Root weight (g)
IC417352	17.00 ± 1.732	0.286 ± 0.010	0.017	12.284 ± 0.440	5.896 ± 0.330
IC338795	9.00 ± 0.882	0.039 ± 0.003	0.004	7.834 ± 0.294	6.854 ± 0.248
IC356018	13.67 ± 0.762	0.239 ± 0.021	0.017	10.184 ± 0.543	6.429 ± 0.305
EC150250	11.33 ± 0.872	0.210 ± 0.003	0.018	10.899 ± 0.192	6.843 ± 0.227
IC356072	7.00 ± 0.577	0.111 ± 0.002	0.016	9.774 ± 0.666	5.770 ± 0.255
Arun	-	-	-	10.881 ± 0.545	6.076 ± 0.120
CD value	3.303	0.028		1.236	0.814

EXTERNALY FUNDED PROJECT:

Project Title: Identification and characterization of Nodule-specific Cysteine Rich (NCR) peptides in chickpea

(Funding Agency: DBT; Project Period; 2016-2019) (PI: Dr. M. Senthilkumar)

Critical process in symbiotic nitrogen fixation (SNF), a signature feature of legumes is differentiation of free living rhizobial cells into different morphotypes (E-Elongated/S-Spherical/U-Unmodified) of nitrogen fixing bacteroids. Plant derived nodule specific cysteine

rich (NCR) peptides mediate the cell differentiation process and determine the bacteroid morphotype and nitrogen fixing efficiency. E/S morphotype bacteroids possess higher symbiotic efficiency compared to U-morphotype. In the present investigation, 64 putative CaNCR peptides from *Cicer arietinum* and 32 CrNCR peptides from *Cicer reticulatum* were identified. Of which, 16 CaNCR peptides and 8 CrNCR peptides are unique to this study and not yet reported by any other research group globally.

Genome localization: The CaNCR-peptide genes were found to be distributed uniformly across *Cicer arietinum* genome emphasizing dispersed mode of existence. Except chromosome 8, all other chromosomes including scaffold showed the presence of NCR peptide genes. Similarly, CrNCR genes are localized in linkage groups of *C. reticulatum* LG-1 to LG-6 while LG-7 and LG-8 do not possess any such NCR peptide coding genes. The phylogenetic analysis revealed that CaNCR and CrNCRs generated two main clusters.

Gene structure and motif analysis: NCR peptides of chickpea possess 0-2 introns. Introns were not observed in IIPR CaNCR56, IIPR CaNCR58 and IIPR CaNCR60, while coding region of 78% of IIPR CaNCR genes possess single introns. Eleven of the IIPR CaNCR genes were reported with two introns. A total of eight motifs were identified in IIPR CaNCR peptides and the length ranges from 8-29 amino acid residues. The motifs via MAKTLKFFYTM, RPCKSDIDCJTYEC PJYARGYCI NGSCRC and WSVFLAFVVSGVSAGTEV PCEEDRDCIYJ belong to late-nodulin domain. IIPR CaNCR peptides possess 2 to 4 motifs in which at least one belongs to late-nodulin domain. The motif MAKTLKFFYTM of late-nodulin domain is present in all IIPR CaNCR peptides. Each sequences posses at least one conserved late-nodulin domain. Seven putative NCR peptides of *Cicer arietinum* contain two motifs, 41 sequences had three motifs and remaining 16 NCR peptide sequences had 4 motifs.

Tissue specific expression and qPCR validation: Transcriptome analysis of root and nodule tissues of *Cicer arietinum* was carried out. The reads of RSG888 was mapped on CDC Frontier genome assembly following Bowtie2 and Tophat. It resulted in identification of 4378, 4702 and 199 DEGs in Root vs Small nodule, Root vs large nodule, and Small vs large nodule, respectively at corrected P value of <0.05 with down and up regulation range of -7.53 to 10.38 fold. Tissue specific expression of CaNCRs was studied with transcriptome data of nodule stage-1, nodule stage-2 as well as root tissues of *Cicer* species. Heat map developed through transcriptome as well as *in silico* analysis evidenced the tissue specific expression of CaNCR peptides. CCA and GTA genes were used as an internal control or reference gene and relative or comparative estimation was carried out with Ct value of target and reference genes following 2- ΔΔCT method. qPCR based expression profile indicated that many of the CaNCR peptides are expressed only in nodule tissues of chickpea. Further we are aiming to assign biological functions for key NCR peptides in chickpea. Deep insights on structural and functional diversity of NCR peptides will help to improve symbiotic nitrogen fixing efficiency in chickpea.



Fig. 6: Genome localization of NCR peptides from *Cicer arietinum* and *C. reticulatum*

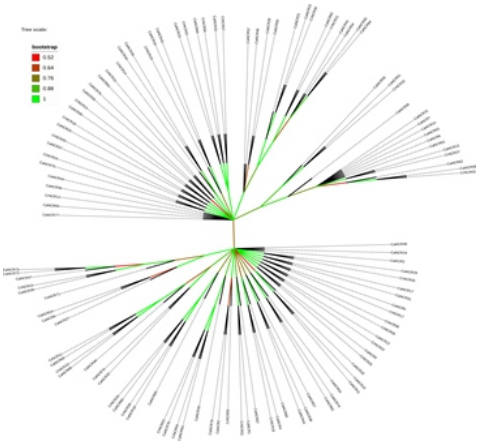


Fig. 7: Phylogenetic relationship among Cicer NCR peptides



Social Science

Institute funded project

Development of model pulses village through integrated technological interventions for livelihood and nutritional security in selected agro-ecological regions

This project has been implemented in the Maraunda Suchit village, Unnao district of Uttar Pradesh with a purpose to demonstrate the different crop and livestock technologies in an integrated mode. The major focus has been given on pulse based interventions during this year 2020 although 11 technologies have been demonstrated at the 108 farmers' field. The average yield of Mungbean variety IPM 02-3 was 9.3 q/ha and net return ₹ 41033/h. and urdbean (IPU-2-43) 7.95 q/ha and net return ₹ 23070/ha. The average yield of PB 1 variety of paddy was 46.80 q/ha and net return ₹ 53,930/ha and maize 47.60 q/ha and net return ₹ 50,330/ ha. This project has also been implemented in two villages *viz.*, Padli and Khamliya under Block and district Sehore at IIPR Regional Station, Phanda, Bhopal. Two meetings have been conducted in each village regarding seed production and seed replacement and for a green and clean village programme. Conducted six demonstrations (new and popular varieties of gram and lentil) in village Padli and five demonstrations in village Khamliya in *rabi* season. Data on socio-economic status of farmers was also collected accordingly we are giving technical guidance as per their requirements and about the schemes of the government.

The details of result are given below

Sl. no.	Crop	Farmers	No. of demons-tration	Average yield (q/ha)	Cost (₹/ha)	Gross income (₹/ha)	Net return (₹/ha)	B:C ratio
1	Mungbean (IPM 2-3)	37	37	9.30	25,890	66,926	41,033	1.58
2	Urdbean (IPU 2-43)	10	10	7.95	21,960	45,030	23,070	1.05
3	Paddy (PB 1)	13	13	46.80	32,650	86,580	53,930	1.65
4	Maize (DKC 9108)	08	08	47.60	30,590	80,920	50,330	1.64
5	Okra (Kashi kranti)	09	09	64.60	48,300	96,900	48,600	1.00

Development and validation of digital platforms for dissemination of information on pulse production technologies Website (hindi) for knowledge sharing with farmers and other stakeholders

The user friendly hindi website "www.dalhangyanmanch.res.in" developed and maintained. Efforts were made to popularize the website. Total 60, 104 users have accessed the website since its release.

Developed website (English) for knowledge sharing with farmers and other stakeholders

The website "e knowledge platform on pulse crops" was developed for sharing of knowledge resources with different stakeholders. Knowledge modules (in English) related to six pulse crops (chickpea, pigeonpea, fieldpea, lentil, mungbean, urdbean) prepared and validated for use in digital platform www.dalhangyanmanch. res.in (english). Content developed and uploaded for varietal information system of pulses, disease and pest information system, weed management system of pulses for the website.

i. Andorid mobile app *Chanamitra* upgraded in five languages

Android app *Chanamitra* upgraded from bilingual to five languages (Kannada, Marathi, Telugu, English and Hindi) for wider reach among chickpea growers across India. Innovative platforms like e market, seed calculator and Chickpea Varietal Information System (CVIS) integrated in the application.

ii. Voice SMS based advisories service *"Dalhan Sandesh"* extended

A total of 89,452 crop based advisories sent through *"Dalhan Sandesh"* service to about 3500 partner farmers across seven districts of UP state. Data on response rate of *Dalhan Sandesh* advisories by

users was analyzed for ascertaining the appropriateness of timings and duration of the advisories. The analysis reflected that the response rate of *Dalhan Sandesh* advisories was significantly better when the duration of advisories was enhanced to 60 sec from 30 sec. In addition, the response rate was significantly higher when they were delivered between 5 and 9 PM.

Voice messages were sent to farmers in two time duration 30 and 60 second duration. The response rate of farmers for the two time duration was subjected to t test. It was observed that the non answered rate for calls of 30 sec and 60 sec varied significantly (7.046, $p<0.01$).

Appropriateness of duration of message and timings of voice messages

Duration of call	Category 1 (30 sec)	Category 2 (60 sec)
Total advisories	71,220	94,283
Not answered	17,751	20,075
Index	21.49	12.37
t statistic (p>0.01)		**7.046**

The data on non response of farmers to voice advisories was categorized in different time zones and their mean were compared. The mean non response rate to voice messages was observed to vary significantly ($p<0.01$) for 6 time zones ($F=10.35$). Post hoc comparisons using the Tukey HSD test indicated that the mean score for the non response of message sent during 5-7 PM and 7-9 PM was not significantly different. However, the response rate during 5-7 PM and 7-9 PM varied significantly with non response rate in all other time zones.

Response rate to voice SMS in different time zones Appropriateness of duration of message and timings of voice messages

Time categories	No. of events	Mean
9-11 AM	9	20.052^{ab}
11-1 PM	11	26.30^{bc}
1-3 PM	9	25.73^{bc}
3-5 PM	11	30.65^{d}
5-7 PM	11	15.88^{a}
7-9 PM	10	11.90^{a}
F (p>0.01) 10.359		

Knowledge modules (in English) related to six pulse crops (chickpea, pigeonpea, fieldpea, lentil, mungbean, urdbean) prepared and validated for use in digital platform www.dalhangyanmanch.res.in (english). Content developed and uploaded for Varietal Information system of pulses, Disease and Pest Information system, weed management system of pulses for the website. Android app-*Chanamitra* has been upgraded from bilingual to five languages (Kannada, Marathi, Telugu, English and Hindi) for wider reach among chickpea growers across India. Innovative platforms like e market, seed calculator and Chickpea Varietal Information System (CVIS) integrated in the application.

Evaluation of digital platforms

Survey was conducted of stakeholders on evaluation of the digital platforms based on content, presentation, ease in accessing, functionality etc of the digital platforms. A digital form was prepared for collecting the response from stakeholders. The response was gathered on a five point continuum scale on comprehensiveness of coverage, precision, presentation, accessibility, information flow and overall effectiveness of the digital platforms. The overall response on hindi and english website was assessed as 4.7 and 4.6, respectively. In case of *chanamitra* app, the overall assessment was assessed to be 4.6 with the highest score (4.7) on intractability aspect.

Development and evaluation of elearning platform for pulse production technologies (*eLeaP-Pulse*)

The recent technological advances have paved way for creating innovative and flexible learning environments for learners and educators. The e-learning offer low cost, flexible and personalized learning experience to learners. These technological advances in communication technologies may be harnessed for strengthening the agricultural advisory services by training farmers and extension personnel with technological advancements in agriculture. The e-learning can improve the effectiveness and efficiency of training in extension services and may dramatically increase the numbers of farmers reached by single training programme.



Farm-retail price behaviour and transmission in Indian pulses market

Data on farm prices were collected from Directorate of Marketing and Inspection, Ministry of Agriculture and Farmers Welfare, Government of India for major *mandis*/APMC markets. Data on retail prices of major pulses were collected from Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi. Trends, seasonal indices and variability were estimated. Margin and interrelationship between wholesale and retail prices were worked out.

The Consumer Price Indices and Wholesale Price Indices for Pulses, Food and General Items in India were plotted (Jan-2013 to Mar-2020) in Fig. 1. This shows that both CPI pulses and WPI pulses were increasing marginally during recent months. During 2016, both these indices were at their peak. Analysis of Whole sale Price Index (WPI) revealed that overall WPI based inflation was one per cent as on March-2020, inflation in food articles declined from 13.31 per cent during Dec-2019 to 4.91 per cent during March-2020.

In case of pulses, inflation in prices declined from 16.67 per cent during November 2019 to 12.12 per cent during March 2020. Overall Retail inflation, during March-2020 was 6.09% in rural areas and 5.66% in urban areas with 5.91% in India (rural and urban combined). Compared to Feb-2020, overall retail inflation declined.

Food Retail inflation, during March-2020 was 8.88% in rural areas and 8.59% in urban areas with 8.76% in India (rural and urban combined). Compared to Feb-2020, food retail inflation declined. Retail inflation in pulses and products during March-2020 was 15.94% in rural areas and 15.74% in urban areas with 15.85% in India (rural and urban combined).

Inflation (%) based on Consumer Price Indices and Whole sale Price Indices for Pulses, Food and General Items in India (Jan-2014 to Mar-2020) were computed and depicted in Fig. 2. The graph indicated that after the peak during 2015 and 2016, inflation in pulses as measured according to both WPI and CPI were in the negative territory till recent months. During recent months, inflation in pulses were gradually increasing and was positive.

Farm prices as percentages of retail prices were estimated for pulses: it was 51% in case of *arhar* split in India (Jan-2018 to May-2020) (Fig 3).

Farm prices as percentages of retail prices were estimated for pulses: in the case of gram whole, it was 66% gram whole, 61% in gram split, farm prices as percentage of retail prices was 53% of retail prices of *besan* (Jan-2018 to May-2020) (Fig. 4).

Farm prices as percentages of retail prices were estimated for pulses: it was 57% in case of moong split in India (Jan-2018 to May-2020) (Fig 5).

Farm prices as percentages of retail prices were estimated for pulses: it was 56% in case of *urd* split in India (Jan-2018 to May-2020) (Fig. 7).

Farm prices as percentages of retail prices were estimated for pulses: it was 60% in case of *masur* split in India (Jan-2018 to May-2020) (Fig. 8).

Arrivals of pulses to APMC markets in India during last four years were compiled and analysed to understand the reduction in arrivals during the COVID-19 period in India. Results revealed that in lentil 21%, in chickpea 70% and in redgram 57% of reduction in arrivals were observed during the period March 22 to May 28, 2020 when compared to the same period during last three years (Fig. 8 to 10).

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.



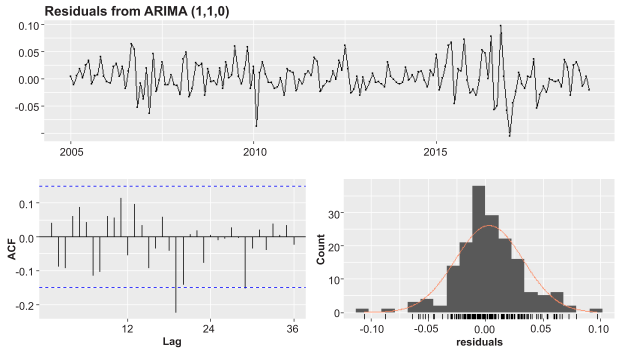


Fig. 1: Residuals from model 3 (ARIMA (1,1,0) with log transformation)

Table 1: Performance comparison of time series models using time series cross validation

Models	Mean squared error (h=1)	Mean squared error (h=2)	Mean squared error (h=3)	Overall Mean squared error
Model 1	89.59	321.01	608.92	339.84
Model2	94.78	337.65	590.03	340.82
Model 3	85.08	311.23	590.03	328.78

Out of 192 ARIMA models fitted, ARIMA (1,1,0) model fitted on log transformed price indices performed better on corrected Akaike information criterion, residual diagnostic tests and time series cross validation (Fig. 11).

Impact analysis of project "Creation of seed hubs for increasing indigenous production of pulses in India" (01-04-2019 to 31-03-2020)

An online questionnaire was developed to collect increase in incomes due to use of quality seed in pulses from seed hub centres for estimating the potential benefits of seed hub project from the centres. Data on quality seed produced were compiled. Using seed rate, increased income levels due to quality seed, annual potential benefits were estimated.

Potential area covered by quality seed under farmers' field has been shown in the Fig. 12.

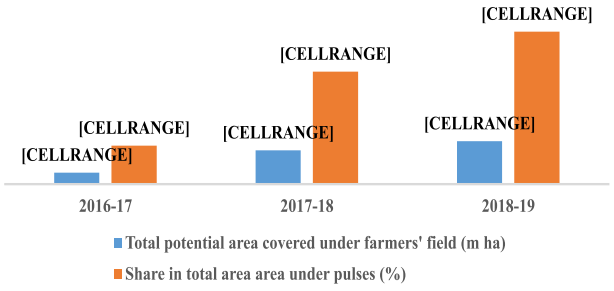


Fig. 2: Potential area covered by quality seed under farmers' field

The Fig. 13 depicts the total foundation and certified seed produced under seed hubs (2016-17 to 2018-19) in India.

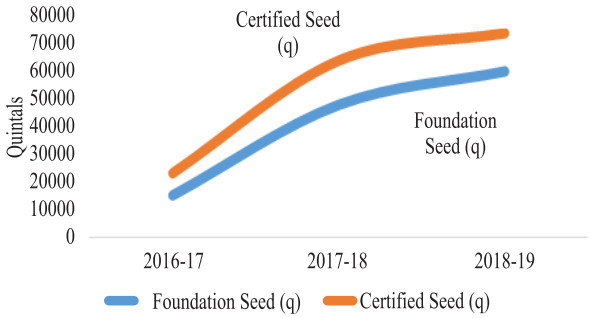


Fig. 3: Total foundation and certified seed produced under seed hubs (2016-17 to 2018-19)

Exponential growth rates (%) were estimated in case of foundation and certified seed produced under seed hubs (2016-17 to 2018-19). The results are presented in the Table 1 and in most of the cases, growth rates were positive.

Table 2: Exponential growth rates (%) in foundation and certified seed produced under seed hubs (2016-17 to 2018-19)

Pulse Crop	Exponential growth rates (%)	
	Foundation Seed	Certified Seed
Mungbean	160.43	69.51
Urdbean	127.78	135.75
Pigeonpea	63.07	57.64
Chickpea	94.25	69.56
Fieldpea	116.74	127.57
Lentil	86.69	64.66
Cowpea	33.6	-21.4
Horsegram	330.64	243.89
Mothbean	-	-6.09
Rajmash	-75.01	40.57
Lathyrus	-28.37	316.67
Total	98.06	78.01

To arrive at the potential benefits (or the impact) of the seed hubs, following assumptions were made (Table 2). Increase in farmers' net income due to use of only the quality seed were computed from the responses from the seed centres. Apart from this, seed multiplication ratio, seed rates in pulses were also assumed as shown in the following Table 2. As per the analysis of responses from 51 centres across India, average increase in net income due to use of quality seed only was estimated. In case of pigeonpea, average increase in net income due to use of quality seed only, was ₹ 7,100/ha. Average



increase in net income due to only the use of quality seed, was ₹ 8,300/ha in case of chickpea, in case of greengram, it was ₹ 5,900/ha, in case of blackgram, it was ₹ 5,900/ha, in case of lentil, it was ₹ 6,200/, in case of fieldpea, it was ₹ 7,800/ha, in case of mothbean, it was ₹ 4,800/ha and in cowpea, average increase in net income due to use of quality seed only was ₹ 6,500/ha.

Using these assumptions, the estimated annual potential increase in pulses farmers' income due to seed hubs during 2016-17 was ₹ 1,037.60 crore, during 2017-18, it was ₹ 2,994.26 crores and during 2018-19, it was ₹ 3,816.59 crore.

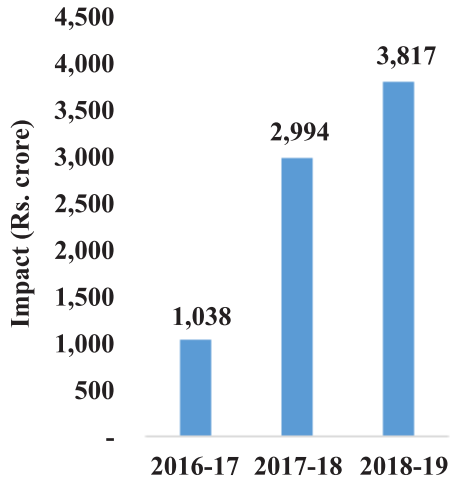


Fig. 4: Impact of seed hub - Potential increase in farmers' income due to seed hubs (₹ crore)

Development of a procedure for promotion of AICRP crop performance trials

Genotype-environment interaction (GEI) occurs in both short-term and long-term crop performance trials. It continues to be a challenging issue among plant breeders, geneticists, and production agronomists who conduct crop performance trials across diverse environments. GEI can reduce progress from selection. Researchers usually ignore GE interaction encountered, especially in short-term trials, and base genotype selection solely on mean performance across environments. A universally acceptable selection criterion that takes GEI into consideration does not exist. Whenever an interaction is significant, the use of main effects, *e.g.* overall genotypes means across environments, is questionable. Researchers need a practical selection method that would use or exploit GE interaction. Hence, stability of performance should be considered as an important aspect of yield trials. Researchers need a statistic that provides a reliable measure of stability or consistency of performance across a range of environments, particularly one that reflects the contribution of each genotype to the total 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, an stability index is proposed to rank the genotypes. The indices are proposed by taking two combination weight of yield (75% and 50%) and stability (25% and 50%), so that total weight should be 100%.

Estimation of acreage and production of pulses in Bundelkhand region of Uttar Pradesh using remotely sensed data and geo-spatial technologies

The methodology essentially consisted of selection of the datasets, processing of the satellite data, incorporation of ground information, analysis of the satellite data and generation of the output products. Single-date Resourcesat-2 (LISS-III, Spatial Resolution 23.5m), Sentinel-2 (MSI, Spatial Resolution 10m) or Landsat-8 (OLI, Spatial Resolution 30m) data were used for acreage estimation. Dates of satellite data acquisition were in between 5th December and 6th February 2020, which is the peak duration of crop vegetative phase. However, other month's data were also taken as reference during classification. A combination of Supervised (maximum likelihood) and Unsupervised (ISODATA algorithm) approach was followed for image classification, using ground truth (GT) sites collected by Remote Sensing Centres, Lucknow. Yield was estimated using two different approaches: i) Correlation weighted Agro-meteorological regression models (developed by IMD) and, ii) Remote sensing indices (NDVI and NDWI) based empirical models. *Rabi* pulses acreage for Bundelkhand region and state as a whole was estimated to be 663.2 thousand ha and 1387.3 thousand ha, respectively.

Externally funded

Value chain analysis of pulse crops in Bundelkhand region of Uttar Pradesh

The data collection schedule prepared for data collection from farmers, aggregators, wholesalers and input dealers. Data collection from 420 farmers from 12 villages of 6 blocks of 3 districts (Jalaun, Banda and Lalitpur) was carried out during October to December 2020. In addition, 24 wholesalers, 24 aggregators, 18 input and fertilizer dealers were interviewed to gather requisite information under the project. The gathered data is being tabulated and analyzed .

Establishment of Agri-business Incubation Centre at ICAR –IIPR, Kanpur

The ABI unit has been established and made functional. Two webinars on "Prospects of Entrepreneurship Development in Processing and Value Addition of Pulses" and "Business Opportunities in Seed production of Pulses" were conducted on November 26, 2020 and November 28, 2020, respectively for potential entrepreneurs. A total of 187 participants joined the webinars through zoom platform. First call for applications for incubation support in the identified focus area related to pulse crops given in month of Nov. 2020 and four applications received.

Development of farmer mobile-based applications for pulses on mKRISHI Platform

Under the collaborative project with Tata Consultancy Services (TCS), mobile app services for Farmers (farmer self registration, advisory services, ask query, best practices, disease/insect pest identification, weather forecast, alert inbox *etc.*) and web console services for experts has been designed and customized on mKRISHI platform for Farmer Management, Knowledge Management, Advisory Management, Information Management and Support Services. Contents related to the diseases and insect-pests 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. A android-based mobile application (PulsExpert) has been developed for the farmers of four major pulse producing states *viz.*, Uttar Pradesh, Madhya Pradesh, Maharashtra and Karnataka for identification and control of diseases/insect-pests for pulse crops. Application can be downloaded from Google play store using the following link: **https://play.google.com/store/apps/details?id=com.tcs.mkrishidfi.farmer.iipr**

A Mobile App (PulsExpert) was inaugurated by DDG (CS) during International Conference Feb. 10-12 , 20202 at Bhopal

Farmer FIRST Project

Integrated Approaches for Food, Nutrition and Livelihood Security of Rural Households in Fatehpur District of Uttar Pradesh

The Farmer FIRST project has been implemented in village namely Karchalpur, Khadra, Kharouli and Mirai of Devmai block of Fatehpur district during the period January 1 to December 31, 2020. Different interventions related to pulses, cereal, horticulture and livestock implemented in participatory mode in project area to enhance the productivity, production, income and over all development of farming community. The results are presented intervention wise below:

Promotion of pulses based interventions for nutritional security and income

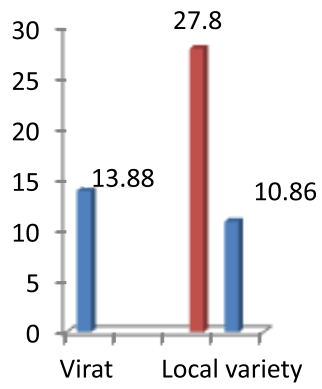
Demonstration of summer mungbean for higher income and employment generation: Summer mungbean interventions were implemented in project area by covering 47 farmers in 10.00 ha area with Virat variety of mungbean for additional income and to generate additional employment during the season in village itself. The average yield of mungbean recorded was 13.88 q/ha in compared to local variety 10.86 q/ha. The yield increase in compared to local 27.80 percentage and additional income gain by ₹ 74,766/ha in comparison with local variety ₹ 55,809 and employment generation of 2-3 hours per day (60-90 hours/month). The B: C ratio is increased to 2.97 to 2.49 in comparison with local variety.

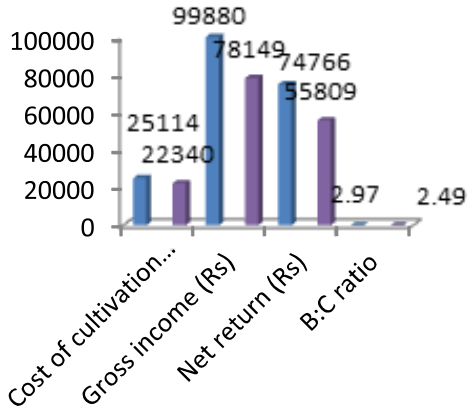




Table 3: Economics of mungbean:

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Mungbean	Virat	13.88	27.80	25,114	99,880	74,766	2.97
	Local variety	10.86		22,340	78,149	55,809	2.49

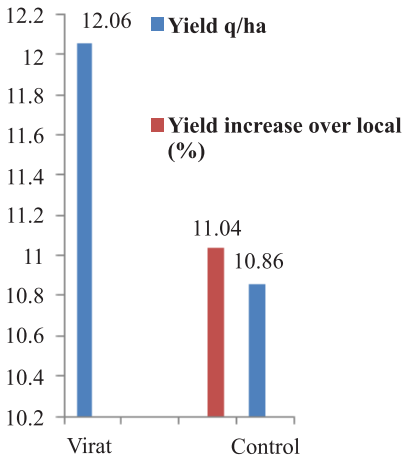


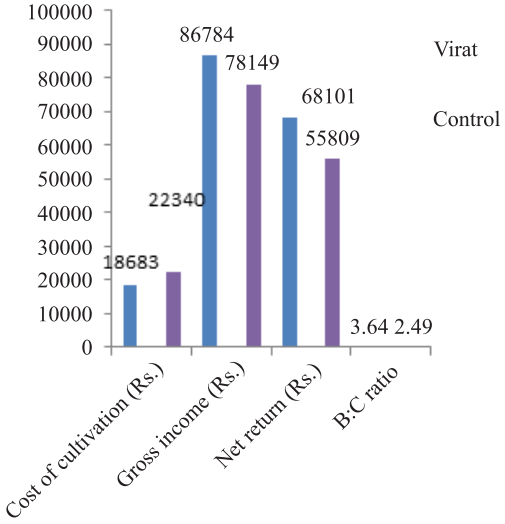


Demonstration of zero tillage practices: Introduced new technique of zero tillage for cultivation of mungbean in project area. Five demonstrations new conducted by covering one acre area. The main aim is to reduce the cost of cultivation. The average yield of zero till mungbean recorded was 12.06 q/ha in compared to control 10.86 q/ha. The yield increase in compared to control was 11.04 percentage and additional income gained in comparison with control was ₹ 55,809 and employment generation of 2-3 hours per day (60-90 hours/month) was also achived. The B: C ratio is increased to 3.64 to 2.49 in comparison to control.

Table 4: Economics of zero till mungbean

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Mungbean	Virat	12.06	11.04	18,683	86,784	68,101	3.64
	Control	10.86		22,340	78,149	55,809	2.49





Farmers Participatory demonstration on chickpea (JG 14): Farmers were provided with critical inputs to conduct the demonstration on chickpea (JG 14) to enhance yield and nutritional security. Total of 38 demonstrations were conducted on chickpea (JG 14) by covering 5.55 ha area. The average yield recorded in case of JG 14 variety was 05.30 q/ha, compared to local variety which yielded 3.10 q/ha. The yield was affected due to heavy rainfall during entire crop period along with occurrence of hailstorm mostly damaging the crops at flowering and pod formation stage.



JG 14 variety of chickpea under Farmer FIRST Project

Cereal based intervention

Demonstration of scented variety of paddy for higher income

Demonstrations on scented variety (Pusa Basmati 1509) of paddy for enhancing income were conducted in project area by covering 51 farmers in 16.66 ha area for higher return of farmers. The average yield of 57.60 q/ha in Pusa Basmati 1509 variety was recorded as compared to local variety of paddy (50.78 q/ha). The net return gained by the farmers was Rs 47610/ha in comparison to local variety ₹ 37695/ha and the B: C ratio has increased from 0.97 to 1.22 with the adoption of new variety in comparison to local practices

Promotion of bio-fortified variety (Zn & Fe) of wheat for nutritional security

Farmers were provided critical inputs to conduct the demonstration on wheat to enhance yield and nutritional security through Zn and Fe rich varieties K 1006. The variety K 1006 is rich in Zn and Fe content which is beneficial for children and old age people. A total of 10 farmers were covered with 05.00 ha area of K 1006 variety of wheat which is a timely sown variety suitable for this area. The average yield

Table 5: Economic of paddy

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Paddy	Pusa Basmati -1509	57.60	17.90	38,790	86,400	47,610	1.22
	Local variety	50.78		38,475	76,170	37,695	0.97

of 48.27 q/ha in K-1006 variety was recorded as compared to local variety of wheat (42.10 q/ha). The net return gained by the farmers was ₹ 47,090/ha in comparison to local variety ₹ 35,653/ha and the B: C ratio has increased from 1.78 to 2.02 with the adoption of new variety in comparison to local practices.

Table 6: Economics of wheat intervention

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Wheat	K-1006	48.27	14.65	45,830	92,920	47,090	2.02
	Local variety	42.10		45,390	81,043	35,653	1.78

Summer maize for additional income

Farmers were provided with critical input to conduct the demonstration on summer maize for better utilization of fallow land and additional income in the project area. A total of 16 farmers were covered in 08.00 ha area under hybrid DKC 9108 variety of summer maize. The average yield recorded was 47.14 q/ha as compared to local variety which yield 39.98 q/ha. The net return earned by farmers was ₹ 54447.00/ha as compared to local variety (₹ 40843.00/ha). The B: C ratio 1.66 in compared to local variety 1.27. Mr. Sunil Kumar S/o Shri Rajaram, a farmers of Karchalpur village cultivated the summer maize 0.66 ha area under Farmers FIRST Project and sold his crop for Rs 40000.00 during the July month and got Rs 30000/ha net return.

Table 7: Economic of summer maize

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Summer maize	DKC 9108	47.14	17.90	32,762	87,209	54,447	1.66
	Local variety	39.98		33,120	73,963	40,843	1.27

Participatory demonstration on mustard for higher production and return

Farmers were provided critical input to conduct the demonstration on mustard to enhance yield through high yielding varieties of mustard (Kanti). A total of 18 farmers were covered in 03.00 ha area under Kanti variety of mustard. The average yield recorded was 13.97 q/ha as compared to local variety which yielded 11.60 q/ha. The net return earned by farmers was ₹ 23,348.00/ha, compared to local variety ₹ 15,722.00/ha. The B: C ratio is increased to 1.95 from 1.65.



Mustard crop (Kanti) under Farmer FIRST Project

Table 8: Economics of mustard crop

Crop	Variety	Yield (q/ha)	Yield increase over local (%)	Cost of cultivation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Mustard	Kanti	13.97	21.69	24,430	47,778	**23,348**	1.95
	Local variety	11.60		23,950	39,672	**15,722**	1.65

Vegetable based module for higher return and nutrition

Demonstration of high yield variety/hybrid of summer season vegetable is utilized the fallow field for obtaining the additional income and to generate the employment of rural youth and women.

Okra: - The farmers were provided seed as critical input for conducting the demonstrations of summer okra for additional income and employment generation. Total 43 farmers and migrant labour covered with 5.80 ha area under Navya variety of okra during the COVID -19 pandemic in project villages. The average yield recorded was 72.42 q/ha compared to local variety which yielded 67.15 q/ha. The net return earned by farmers was ₹ 55,963.00 /ha, compared to local variety ₹ 49,453.00/ha. The B: C ratio is increased to 1.06 from 0.96.

Crop	Variety	Yield (q/ ha)	Cost of cultiv ation (₹)	Gross income (₹)	Net return (₹)	B:C ratio
Okra	Navya (F1)	72.42	52,667	1,08,630	55,963	1.06
	Local variety	67.15	51,272	1,00,725	49,453	0.96

Chilli: - The farmers were provided seed for conducting the demonstrations of chilli. Total 43 farmers covered by 11.00 ha area under G-4 and Divyajyoti variety of chilli. The average yield recorded was 135.4 q/ha and 170.6 q/ha compared to local variety which yielded 115.3 q/ha. The net return earned by farmers was ₹ 2,57,710.00 /ha and ₹ 3,40,850.00/ha in respect of G-4 and Divyajyoti, variety respectively compared to local variety (₹ 2,07,575.00/ha). The B: C ratio is increased to 3.18 and 3.97 from 2.57.



Chilli crop under Farmer FIRST Project

Demonstration of agri-horti model in project area

During this year, mango orchards (Dashahari, Langra) and Guava orchard (Lalit) were established for long term income and employment generation as well as nutritional security of the rural household in project area

Intercropping in guava orchard during COVID -19 Pandemic

Under Farmer FIRST Project, in Guava orchard intercropping with vegetable pea for higher income, employment generation and nutritional security of rural people. Shri Jagdish Paswan intercropped summer maize in guava orchard and obtained 19.50 q yield of summer maize in 1.20 acre the average income gained was ₹ 27,285. He also intercropped vegetable pea (Kashi Uday) in the guava orchard

Demonstration on poultry intervention for landless/women farmers for livelihood enhancement

Poultry units were continued by the farmers in project area for obtaining higher income, employment and nutritional security for rural households. They obtained income from selling of eggs to the tune of ₹ 250-300/ day in summer and in winter season they obtained ₹ 450-500 per day. Total chicks production was 997. During lockdown, a total of 375 chicks were produced and sold at the rate of ₹ 80-100/chicks. Thus farmers earned ₹ 10, 500/year by selling eggs and Rs. 12,300/ year by selling cockerel.

Impact of poultry farming

- Generated income and employment for the rural youth and woman daily (2-3 hr/day)
- Selling of poultry chicks at ₹ 80-100/chick and at ₹ 8-10/ Egg
- Obtained additional income other than farming (₹ 350-500/day)
- Better utilization of waste material from home in the form of feed for poultry

Intervention of goat for empowerment of women

Barberi breed of goat was provided to woman Self Help Groups in the project area for income and employment generation under farmer FIRST project.





Woman farmers expressed their satisfaction as earning income as well as they got milk for the consumption by family members. It helped in earning additional income by selling of milk to the range of ₹ 1500-2000/year after the implementation of project.

Sl. No.	Particulars	Before (Year round income) implemen-tation of project (₹)	After (Year round income) implemen-tation of project (₹)
1	By selling of milk	4,000	5000-6000
2	By selling of buck	6,000/buck	6000-8000/buck

Effective utilization of community ponds for job creation and income augmentation

Fish farming was introduced to utilize the community pond for income and employment generation as well as nutritional security. Altogether 50 kg (10,810 fingerlings/ fish fry) purchased from ICAR-NBFGR, Lucknow has been stocked in community ponds of villages in the project area. On an average, production of fish was 4.86 q/year (rate / kg 150). Farmers earned ₹ 38,180 and they have also consumed fish to the tune of 14.75 kg / year.

Crop cafeteria

Under farmer FIRST Project, crop cafeteria of pulses has been created at farmer's field to demonstrate high yielding varieties of different pulses crops such as Chickpea, Fieldpea, Bio-fortified variety of Lentil and *Rajmash* in Khadra village of Fatehpur District for the purpose of nutritional security and enhancement income.

Establishment of vermi-compost unit:

Farmer FIRST Project team mainly focused on organic cultivation of vegetable in project area. The participatory demonstrations vermin-compost unit were established for organic vegetable cultivation and maintaining proper level of organic matter content in soil, improving the fertility status and water holding capacity of soil.

Work done during COVID-19 pandemic

- Total 47 farmers covered under summer mungbean (Virat) were by covering 10.00 ha area during COVID -19 period
- Total 44 farmers sowed the previous year seed due to COVID-19 problem by covering 7.52 ha area under summer mungbean variety IPM 2-3. More than 52, farmers purchase the seed of mungbean other than project village.
- The average yield recorded at farmers' field was 13.88 q/ha in comparison to local variety (10.86). The average net return obtained was ₹ 74766/ha in comparison to local variety ₹ 55,809 /ha.
- Total 16 farmers covered under summer maize (DKC 9108) by covering 8.00 ha area for better utilization of fallow land and additional income during COVID-19 period. Mr. Sunil Kumar S/o Shri Rajaram, a farmer of Karchalpur village, could grow the summer maize in 0.66 ha area under Farmers FIRST Project and sold his crop for ₹ 40,000.00 during the July month and got ₹ 30,000/ha net return.
- Total 43 farmers covered under summer vegetable (OKRA variety Navya) by covering 5.80 ha for better utilization of fallow land, additional income and nutritional security during COVID-19 period. Total 37 migrant labours were covered for generation of income and employment genotype during the COVID -19 pandemic in project villages.
- Post harvest management and processing the



women make the *dal badi* for consumption during off season. They consumed after the fry in oil and in the form of vegetables. Farmers stored the garlic produced for selling in lean season at higher price (₹ 150-200 kg/ha) than the present market price (₹ 50-80/kg)

- Women Self Help Group formed for pulses based enterprises in collaboration with UPSRLM Fatehpur district.
- Intensive tillage operations deteriorate soil health and enhance cost of cultivation. Hence, zero tillage summer mungbean was promoted to reduce cost of cultivation and increase income.

Impact of Farmer FIRST Project

Farmer FIRST project has been a successful model in doubling the farmers' income through multiple components for sustainable development of the adopted villages. In this model, appropriate interventions were formulated based on baseline survey, interaction with the farmers, experts, developmental agencies *etc.* Proper implementation of such interventions has helped the farmers to earn additional income, reduced the risks associated with farming and creating of farmers' societies provided for better bargaining power of the farmers and helped the farmers to adopt scientific farming practices. The benefits and interventions are summarized below :

- Zero-tillage: in mungbean with five demonstrations in one ha.
- Bio-fortified wheat variety (Zn & Fe rich) K-1006. Yield increase over local: 14.7%.
- Scented variety of rice PB 1. Yield increase: 22.2%.
- High yielding short duration variety: Mustard Kanti, Yield increase: 21.69%.
- Poultry enterprise module for income in summer season ₹ 250-300/ day and winter season ₹ 450-500 per day.
- Agri- Horti Model has been long term income generation.
- Community pond: 08 farmers & 1.0 hectare area for fish farming.
- Line sowing practice to conserve the resource
- Twenty SHG: women groups formed
- Farmer FIRST Album published
- Documentary film was made on activities of Farmer FIRST project
- Mobile apps was developed under Farmer FIRST Project on Integrated Farming System
- Social Media Platform (Whatapps group)

Table 9: ***Mile stone established achievements***

Item	Before project	After project
Cropping intensity	210%	290%
Area under summer mungbean & no of farmers	3.5 ha & 28 farmers	178 ha & 733 farmers
Area under summer vegetables & no of farmers	2.5 ha & 25 farmers	42 ha & 241 farmers
Area under summer maize & no of farmers	1.8 ha & 10 farmers	12 ha & 123 farmers

Analysis of cropping system

Analysis of cropping system was carried out for 10 farmers to understand the effectiveness of best combination of crops and livestock. It was found that Rice–Chickpea-Okra–Poultry system has higher net returns than others.

Name of farmer	Cropping pattern before project (Net profit in ₹)	Cropping pattern after project (Net profit in ₹)	Net income (₹/ha)	
			Before project	After project
Mr. Milan	Chilli (₹ 41,232)-potato (₹ 48,760) - fallow	Rice (₹ 34,390) - wheat (₹ 41,286) -okra (₹ 39,322) -poultry (₹ 9,165)	89,992	1,24,163 (II)
Mr. Bhola	Rice (₹ 32,762) -wheat (₹ 39,725) - fallow	Rice (₹ 35,236) -chickpea (₹ 49,795)-okra (₹ 38,534) - poultry (₹ 9,852)	72,487	1,33,417 (I)
Mrs. Sudama	Rice (₹ 32,890) –wheat (₹ 41,450) – fallow	Rice (₹ 33,790) –chickpea (₹ 46,466) – okra (₹ 40,482)	74,340	1,20,738 (III)
Mrs. Vimla	Rice (₹ 33,892)-wheat (₹ 39,354) - fallow	Rice (₹ 35,268) -chickpea (₹ 51,967)-summer mungbean (₹ 21,835)	73,246	1,09,070
Mr. Jagdish	Chilli (₹ 40,125)-wheat (₹ 38,950) - fallow	Rice (₹ 35,745)-wheat (₹ 42,680)-summer mungbean (₹ 22,873)	79,075	1,01,298

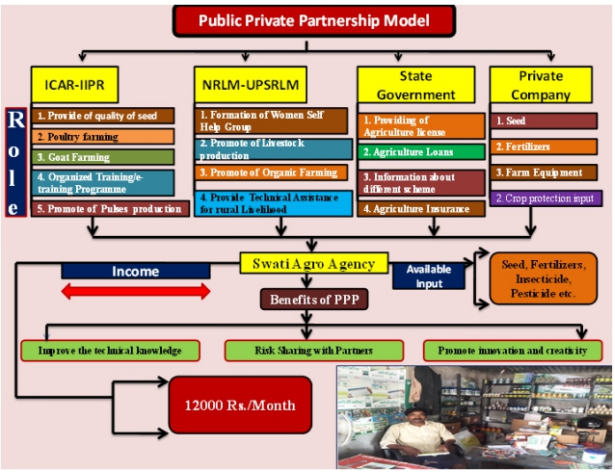
Name of farmer	Cropping pattern before project (Net profit in ₹)	Cropping pattern after project (Net profit in ₹)	Net income (₹/ha)	
			Before project	After project
Mr. Prakash	Rice (₹ 35,892) - Mustard (₹ 29,673) – Fallow	Rice (₹ 36,062) -wheat (₹ 42,763) - summer maize (₹ 23,890)- poultry (₹ 10,460)	65,565	1,13,175
Mr. Babbu	Rice (₹ 31,658)- vegetable pea (₹ 35,896)- Fallow	Rice (₹ 35,975) -wheat (₹ 43,762) - summer mungbean (₹ 22,685)	67,554	1,02,422
Mr. Kauslendra	Rice (₹ 33,762.)- mustard (₹ 28,965) – fallow	Rice (₹ 36210) -wheat (₹ 43,762) – summer mungbean (₹ 21,745)	62,727	1,01,717
Mr. Om Prakash	Chilli (₹ 40,456)-Vegetable pea (₹ 36,765) - fallow	Rice (₹ 36,460) -chickpea (₹ 49,845) - summer maize (₹ 24,765)	77,221	1,11,070
Mr. Rajjan	Rice (₹ 34,650)-Wheat (₹ 39,345)- Fallow	Rice (₹ 36,761) -wheat (₹ 41,465) – summer mungbean (₹ 23,632)	73,995	1,01,858

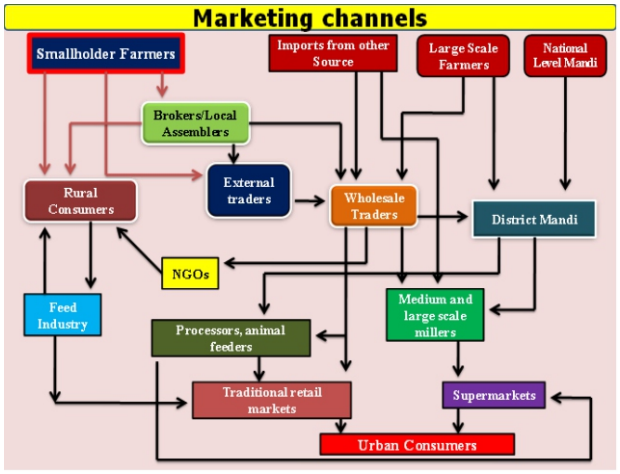
Table 10: Socio-economic impact: step towards 'Doubling Farmers Income

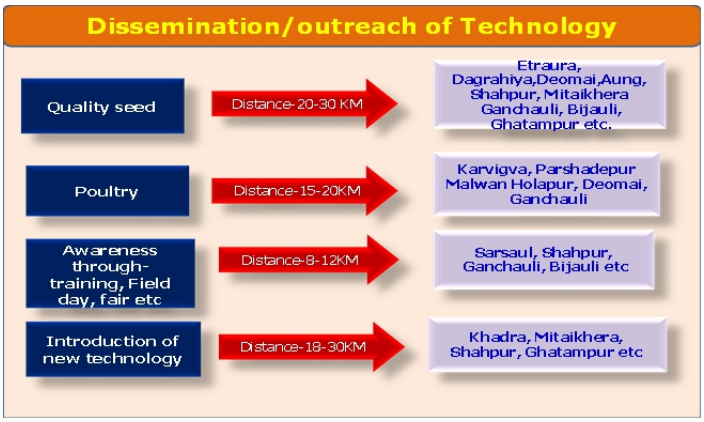
Sl. No	Interventions	2016	2020	Increase (%)
I	**Cereals based interventions**			
A	Paddy (scented variety PB 1)			
	Yield (q/ha)	48.4	65.3	35
	Net return (₹/ha)	36,910	68,949	87
B	Wheat bio-fortified variety (K-1006)	2,016	2,019	
	Yield (q/ha)	42.8	56.65	32.2
	Net return (₹/ha)	43,724	65,288	49.31
	Chapati (nutrition rich)	Normal	Good	
II	**Pulses and oil seed based interventions**			
A	Chickpea(JG 14 and JG 16)	2,016	2,019	
	Yield (q/ha)	20.9	24.7	18.2
	Net return (₹/ha)	65,208	80,134	56
B	Summer munbean (IPM-2-3 and Virat)	2,016	2,019	
	Yield (q/ha)	7.2	10.15	40.97
	Net return (₹/ha)	21,400	36,482	70.74
C	Mustard (Kanti)			
	Yield (q/ha)	10.9	13.9	28.2
	Net return (₹/ha)	15,005	23,348	55
	Oil/ protein content	Low (34%)	High (36%)	
III	Summer interventions			
A	Maize (DKC 9108)	2016	2020	
	Yield (q/ha)	40.3	47.14	17
	Net return (₹/ha)	39,890	54,447	39.49
B	Okra (Navya)	2016	2020	
	Yield (q/ha)	54.9	72.42	31.91
	Net return (₹/ha)	87,255	1,08,630	24.50



Different model under Farmer FIRST Project







Frontline demonstration:-

Coordinated 1300 demonstrations on Pigeonpea, Chickpea, Mungbean, Urdbean, Lentil, Fieldpea, Cowpea, Horsegram, Mothbean, Lathyrus, *Rajmah* and Cluster bean in different State of India. Social Science Division has conducted participatory demonstrations (10 Pigeonpea, 7 Mungbean, 10 Chickpea, 05 Fieldpea and 05 Lentil) in different districts of Uttar Pradesh for enhancing of income and nutritional security. The average yield gained under FLD given below:

Schedule Caste Sub Plan:

The SC sub plan has been implemented in different districts of Uttar Pradesh for increasing their income and nutritional security. Total 940 farmers belonging to schedule caste category have been selected and provided seed of Urdbean, Mungbean, Paddy, Cowpea, Summer Maize Okra sponge gourd, Tomato, Brinjal and Bottle gourd, chickpea and lentil for enhancing their income and nutritional security. Total 1975 kitchen garden packet distributed to 1925 Schedule Caste farmers

Tribal Sub Plan (TSP)

TSP has been implemented in 16 KVK of two States namely M.P. and Chhattisgarh for increasing their income and nutritional security. Total farmers were covered with 925 demonstrations on chickpea. The average yield of was recorded 11.08 q/ha was recorded. Total 24 training programmes organized in different KVKs covering 874 farmers and 04 Field day organized in chickpea crop in which 158 farmers participated



Table 11: KVK wise demonstrations conducted under Different KVKs

Name of KVK, centre	Name of crop	Variety	Area in ha	Number of demonstrations	Average yield (q /ha)
M.P., Dhar	**Chickpea**	**RVG-203**	**20**	**50**	**17.43**
Shahdol, M.P.	Chickpea	JG-12	30	75	17.43
Badwani, M.P.	Chickpea	RVG-202	20	50	16.50
Total			**70**	**175**	**17.12**
Kanker, Chhattisgarh	Chickpea	JAKI -9218	30	75	5.18
Ambikapur, Chhattisgarh	Chickpea	RVG-202	20	50	6.30
Korea (Chhattisgarh)	Chickpea	RVG-201	20	20	7.12
Balrampur (Chhattisgarh)	Chickpea	RVG-202	25	63	3.7
Bastar (Chhattisgarh)	**Chickpea**	**JAKI -9218**	**20**	**50**	**15.01**
Kawardha (Chhattisgarh)	Chickpea	RVG-202	20	20	13.83
Narayanpur (Chhattisgarh)	Chickpea	JAKI-9218	30	75	07.58
Jashpur		RVG-202	25	50	10.80

Mera Gaon Mera Gaurav (My Village My Pride)

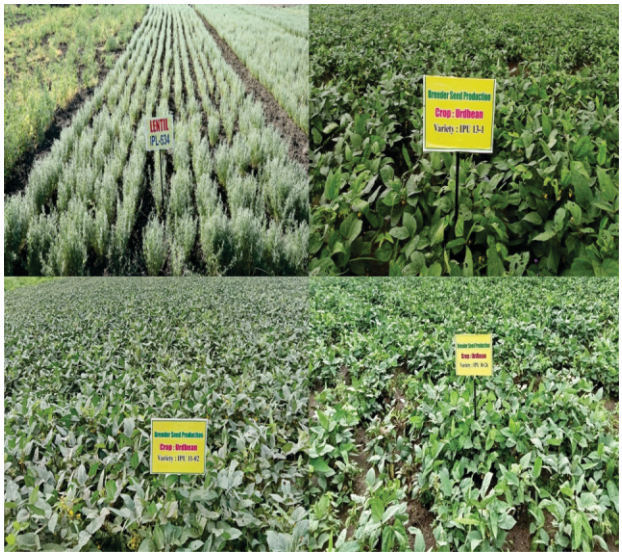
Under MGMG programme, various villages has been visited in Fatehpur, Kanpur Dehat and Kanpur Nagar districts of Uttar Pradesh. The demonstrations on Chickpea, Fieldpea, Lentil, Pigeonpea and Mungbean have been conducted for dissemination of technologies, enhancing the income and creating employment to the rural youth and women. Interactive meetings were organized with farmers, communication of pulse production technologies advisories in the form of text messages and received feedback on various aspects. Distributed extension literature, monitoring of demonstrations was done in fields. Majority of farmers have been provided Farmer FIRST Diary and other literatures. Farmers were also encouraged for adoption of summer mungbean for additional income in summer season in fallow land. 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 have been trained for seed production in pulses. Farmers were given training on crop and live stock 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 establishment of Retail input outlets of agriculture pesticides, seed and fertilizer inputs through home delivery marketing approach were carried out.



IIPR Regional Centre, Phanda, Bhopal

Research achievements:

I. **Varieties notified:** Three varieties namely, IPU 13-1, IPU 11-2 and IPU 10-26 of urdbean and a variety of lentil, IPL 534 have been 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

Fig.1: Notified varieties (Jan. 2020) from Bhopal centre for Madhya Pradesh State

II. **Entry identified:** One entry, IPU 17-1 of urdbean is identified for release in Madhya Pradesh.

III. **AICRP trials:** Entries submitted in IVT for short duration pigeonpea (02) and in lentil, large seeded (02) and abiotic stresses (04).

IV. **State Trials:** State trials were conducted on chickpea pigeonpea and urdbean.

1. Chickpea (*Cicer arietinum* L.)

A. Plant genetic resources:

(a) Chickpea germplasm: Total 908 germplasm are grown for evaluation on agro-economic lines. There is consistency in phenotypic expression of genes in unique genotypes for qualitative as well as quantitative traits viz., anthocyanin rich open flower (IC 349468), early maturity (95-106 d) (PAO 3216, IC 2717435, IC 209236 and IC 468644), flat stem (IC 424391, IC 83745 and IC 83743) Mechanical harvesting (IC 408212 100 cm plant height) and three seeds per pod (EC 55530) and a bouquet type mutant of Pusa 372 -1 from 2016-17 to 2020-21.

(b) Characterization of chickpea genetic resources for marker-assisted crop improvement: Total 2180 germplasm are grown in late sown condition to characterize for heat tolerance traits in central zone.

B. Genetics and breeding: Crosses between large seeded kabuli varieties / lines and wilt resistant / tolerant lines are being made (2020-21) to develop improved lines of kabuli chickpea for wider adaptability. Large seeded varieties namely, Kripa, JGK 5, PKV 4, Flip07-6C-S1, Flip09-346 C, Flip 09-104C, Phule Vikram, RVKG 101, KAK 2, and GOKCE, and wilt tolerant lines received from AICRP on Chickpea Pathology, RAK college of Sehore viz., DK 17-1306, DK 16-313, Phule G 16315, PG 220, RLBGK 2, IPC L19-1, RKGK 18-414, RSG 888, RVKG 151 are being used in crossing programme.



Fig. 2: Unique chickpea genotype, IC 349468 having rich anthocyanin pigmentation with open flower

C. Station trials conducted on chickpea (2019-20)

(i) IIPR Trials: (04)

(a) Kabuli timely sown (20 entries): Yield performance of entries, IPCK 18-173 (99 days), IPCK 18-185 (101 days), IPCK 18-129 (101 days), IPCK 18-170 (102 days), IPCK 18-171 (102 days), IPCK 18-177 (103 days) and IPCK 18-184 (103 days) with early maturity were evaluated as compared to checks var. KAK-2 (115 days) and Kripa (120 days). The yield of IPCK 18-177 (2138.8 kg/ha), IPCK 18-170 (2136.3 kg/ha), IPCK 19-225 (1952.3 kg/ha), IPCK 18-129 (1942.2 kg/ha) and IPCK 14-125 (1934.0 kg/ha) were superior over the checks, KAK-2 (1869.8 Kg/ha) and Kripa (1570.1 Kg/ha).

(b) Desi rainfed (27 entries**):** Yield performance of entries, IPC 19-219 (2383.6 Kg/ha) and IPC 19-229 (2357.1 kg/ha) were superior over check var. JG 16 (2249.1kg/ha), however, IPC 17-04 (2237.0 kg/ha) and IPC 19-221 (2224.0 kg/ha) were superior over check var. JAKI 9218 (1981.1kg/ha) and RSG 888 (1602.6kg/ha).

(c) Desi timely sown (18 entries): Yield performance of entries, IPC 17-162 (2073.3kg/ha), IPC 18-166 (2058.0 kg/ha), IPC 17-49 (2014.1kg/ha), IPC 17-369 (1987.3kg/ha) were superior than check var. JAKI 9218 (1979.5kg/ha). However, IPC 18-124 (96 days) is maturing earlier than check var. JAKI 9218 (107 days) and IPC 06-77 (105 days).

(d) Desi mechanical harvesting (20 entries): Yield performance of entries, IPC 16-39 (2237.0 kg/ha), IPC 15-113 (2224.8 kg/ha), IPC 15-35 (2163.3kg/ha), IPC 17-21 (2137.8 kg/ha), IPC 17-351 (2118.5 kg/ha), IPC 17-245 (2049.5 kg/ha) were superior to the check var. NBEG 47 (1742.1 kg/ha), HC 5 (1612.6 kg/ha).

(ii) **ICARDA FLRP trial on kabuli chickpea (76** entries): Performance of entries in terms of seed size (100 seed), **FLIP 09-104C (54.20 gm), FLIP 07-6 C-S1 (50.65 gm), FLIP 09-191C (48.70 gm**), FLIP 10-125C (44.20 gm), FLIP 10-247C (41.35 gm) and FLIP 07-316C-S4 (40.3 gm) were superior over the in checks. Shubhra (35.3 gm) and Kripa (40.1). However, terms of yield FLIP 09-146C-S5 (2128.5 kg/ha), XII th 77-S2 (1979.5 kg/ha) FLIP 10-237C (1940.6 kg/ha), XIIth70-S1 (1924.3 kg/ha) were superior over check var. Shubhra (1654.1 kg/ha) and Kripa (1437.5 kg/ha).

(iii) ICRISAT Trials: 03

(a) ICRISAT ICVT Kabuli Trial (20 entries**):** Yield performance of entries, ICCV 191309 (1841.8 kg/ha), ICCV 191304 (1337.9 kg/ha), ICCV 191316 (1334.7 kg/ha) and ICCV 191306 (1155.8 kg/ha) were superior over the check var. KAK 2 (705.6 kg/ha) and Kripa **(**981.6 kg/ha).

(b) ICVT DESI 01 - 2019-20 (20 entries**):** High yielding Entries ICCV 191105 (2634.3 kg/ha) and ICCV 191104 (2455.0kg/ha), were superior over JG 16 (2471.8 kg/ha) and RVG 202 **(**2427.9 g/ha).

(c) ICVT DESI MH 03 - 2019-20 (20 entries**):** ICCV 191607 (2300.8 kg/ha) were superior over NBeG 47 **(**2256.0 kg/ha) and ICCV 191603 (2175.6 kg/ha).

D. Station trials conducted on chickpea (2020-21): Entries of following 08 trials were grown and data is being recorded for their yield performance and other important traits.

(i) IIPR Trials: 02

(a) Desi (rainfed): 20 entries with 03 checks

(b) Desi (MHT): 20 entries with 03 checks

(ii) ICARDA *kabuli* chickpea international trials: 04

(a) BCIP- CIEN-MED-21: 70 entries with 02 checks

(b) BCIP- CAT – 21: 70 entries with 02 checks

(c) BCIP- CIEN- SA-21: 68 entries with 02 checks

(d) BCIP- CIF4 N: 26 entries with 02 checks

(iii) *Kabuli* station trials under ICARDA - FLRP Amlaha, Sehore, India: 02

(a) Station trial at IIPR: 05 entries with 04 checks

(b) *Kabuli* lines (selection during field day): 72 entries with 02 checks

E. Era trial under BMGF project (2019 -20 and 2020-21): 30 entries of chickpea in 2 replications in RBD are being grown to study the genetic gain during *rabi* 2019-20 and *rabi* 2020-21 and data is being recorded for yield attributing traits.

F. National Shuttle Breeding (Genomic selection) programme (2019-20 and 2020-21): A set of 310 and 480genotypes were grown in 2019-20 and 2020-21, respectively. Unique breeding lines (identified through genome selection method) with checks were grown for evaluation in Central Zone.



Fig. 3: Chickpea IIPR station trial, AICRP Genomic selection trial, ICARDA trials and Era trial (BMGF)

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

A. Plant Genetic Resources:

(i) Institute activity (*kharif 2019 &* 2020):

Total 165 genotypes of pigeonpea were characterized and evaluated under institute PGR programme during 2019-20. Promising / unique genotypes were identified for following traits:

1. **Mid-early maturity**: Genotypes, IC 0109904 (122 days), IC 0407193, IC 0109902 (125 days), IC 0407195 (126 days), IC 0407008 (126 days), IC0407196 (128 days) were superior as compared to check var. TJT-501 (181 days) and UPAS-120 (178 days).
2. **Maximum pods / cluster:** Genotypes, EC 0552882 (7.4), IC 0489678 (6.6), IC 0489696, IC 0441672 (6.2) and IC 0109902 (6.0) were superior. as compared to check var. TJT-501 (5.0) and UPAS-120 (3.6)
3. **Higher yield: Genotypes,** IC0109904 (1214.2kg/ha), IC0407195 (1242.8 kg/ha), IC0369075 (1178.4 kg/ha), IC0369074 (1098.2 kg/ha), IC0424196 (1088.3 kg/ha), IC0407209 (1077.1kg/ha) were superior as compared to check varieties TJT 501 (548.5 kg/ha) and UPAS-120 (479.2 kg/ha).
4. **Larger Pod Dimension (L x B)**: Genotypes, EC0552882 (8.0 x 0.7 cm), IC0489675 (7.0 x 0.6 cm), IC0552874 and IC0490232 (6.8 x 0.7 cm), IC0490071 and IC0490196 (6.8 x 0.6 cm), IC0552873 (4.02 x 0.8 cm) were superior as compared to check varieties TJT-501 (5.9 x 0.6 cm), UPAS-120 (5.9 x 0.7 cm).

(ii) CRP on Agro biodiversity in pigeonpea (*kharif 2019 &* 2020)

Total 1036 accessions with 4 check varieties (Pusa Arhar 16, UPAS 120, TJT 501 and Rajeshwari) were characterized (as per descriptor) and evaluated for important quantitative/qualitative traits. Promising genotypes were identified and selected for following traits:

1. **Early maturity:** Genotype, IC 523649 (118 d) were entire mainting as compared to PUSA Arhar-16 (125 days), UPAS 120 (145 days).
2. **Mid -early maturity:** The following durations were made Genotypes, IC 468256 (134 days), IC 468259, IC 468251 (137 days), IC 468258 (138 days), IC 468260 (139 days), IC 468254 (140 days), IC 468255 (141 days), IC 468257 (142 days), IC 468253 (143 days), PUSA Arhar-16 (125 days), UPAS 120 (145 days), TJT 501 (158 days), Rajeshwari (170 days).
3. **Determinate, dwarf, early maturity and higher yield:** IC 523649 (1142.0 kg/ha), PUSA Arhar-16 (230.0 kg/ha), UPAS 120 (978.0 kg/ha).
4. **High yielding type:** IC 468253 (1496.0 kg/ha), IC 468258 (1260.0 kg/ha), IC 468251 (1230.0 kg/ha), IC 468260 (1066.0 kg/ha), IC 468257 (1020.0 kg/ha), IC 468256 (1017.0 kg/ha), PUSA Arhar-16 (230.0 kg/ha), UPAS 120 (978.0 kg/ha)
5. **Extra Large seeded type:** Brown seeded genotype IC 634397 (21.0-25.8 gm/100 seed weight), and white seeded genotype IC 468496 (18.9-21.0 gm/100 seed weight), PUSA Arhar -16 (8.9 gm/100 seed weight), UPAS -120 (9.3 gm/100 seed weight) TJT 501 (8.9 gm/100 seed weight), Rajeshwari (9.5 gm/100 seed weight) . were identified from 2017-18 to 2020-21.

B. Genetics and breeding (*kharif* 2020):

1. **Crosses attempted under mid-early / medium duration Pigeopea programme:** A set of 17 high yielding pigeon pea varieties and donor genotypes (Pusa Arhar 16, Pusa 992, PA 291, UPAS 120, Rajeshwari, BDN 711, BSMR 736, JKM 189, CoRG 970, TJT 501, Manak, BSMR 853, GNP 2, Maruthi, TS 3R, Asha, Rajeev Lochan) were grown during *kahrif* 2020. Six crosses have been attempted between TJT 501 x CoRG 9701, JKM 189 x CoRG 9701, Asha x UPAS 120, BSMR 736 x UPAS 120, Rajeshwari x BDN 711 and BSMR 736 x Manak and F_1 seed were obtained in all six crosses (Table 1). Bagging was done in all 17 pigeonpea genotypes to obtain pure seed.



Fig. 4: Field view of pigeonpea germplasm & unique genotypes; early dwarf IC 523649, extra-large seeded IC 634397 & IC 468496

Table 1. Crosses attempted to develop early and mid-early duration pigeonpea

S. No.	Crossing parent	No. of crosses following Attemp-ted	Percentage of crossed pod setting seed	No. of F_1 seeds obtained
1	TJT 501 x CoRG 9701	178	6.17%	23
2	JKM 189 x CoRG 9701	142	5.63%	9
3	Asha x UPAS 120	132	14.39%	64
4	BSMR 736 x UPAS 120	169	4.73%	7
5	Rajeshwari x BDN 711	139	10.07%	32
6	BSMR 736 x Manak	156	7.69%	28

2. **Seed multiplication of advanced breeding lines:** A set of 128 advance breeding lines were grown to multiply the seed.
3. **Characterization of Pigeonpea Germplasm:** A set of 25 pigeon pea germplasm (collected from Singrauli, Sidhi and Rewa districts of M.P. in collaboration with NBPGR during March, 2020) were grown for characterization and purification of seed. Purified seed will be submitted to the NBPGR, New Delhi for conservation.
4. **Standardization of A: R ratio of hybrid pigeonpea:** Three ratio (6:1, 8:1 and 10:1) of A: R seed was planted in 3 replications for efficient seed production. Yield data is to be recorded.

C. **Station Trials on Pigeon pea (*kharif* 2020):**

(I) **IIPR Trial**: Total 13 entries of pigeonpea were grown and evaluated for yield performance. Three entries namely, IPAE 16-07 (151 days), IPAE 16-05 (158 days), IPAE 15-04 (162 days) shown early maturity as compared to check var. UPAS 120 (188 days) and PUSA 992 (193 days). Entries namely, IPAE 15-05 (447.6 kg/ha) and IPAE 15-04 (223.7 kg/ha) gave higher yield as compared to check varieties, PUSA 992 (322.2 kg/ha) and UPAS 120 (228.3 kg/ha).

(ii) **ICRISAT Trial**

(a) **Super Early, Determinate type:** Out of 12 entries, two entries namely, ICPL 20340 (104 day) and ICPL 11252 (107 day) showed early maturity over the check varieties, MN 1 (123 days), MN 5 (126 days) and MN 8 (124 days). However, three entries namely, ICPL 11252 (316.5 Kg/ ha), ICPL 11273 (213.3 Kg / ha), ICPL 11253 (201.6 Kg / ha) gave better yield as compared to check var., MN 1 (327.1 Kg/ha), MN 5 (235.5 Kg/ha) and MN 8 (198.8 Kg/ha).

(b) **Super Early, Non Determinate**: Out of 15 entries, six entires namely, ICPL 20326 (140 d), ICPL 20333 and ICPL 11242 (143 d), ICPL 11300 (145 days), ICPL 11298 (147 days), ICPL 11285 (150 days) showed early maturity as compared to check variety, **ICPL 88039 CH** (170 days). However, ICPL 11252 (316.5 kg/ha), ICPL 11273 (213.3 kg/ha), ICPL 11253 (201.6 kg/ha) gave better yield as compared to check varieties, MN 1 CH (327.1 kg/ha), MN 5 CH (235.5 kg/ha) and MN 8 CH (198.8 kg/ha).

(c) **Short Duration, Non Determinate Trial**: Out of 12 Entries, five entries namely, ICPL 161 (1329.5 Kg /ha), ICPL 2433 (1060.5 Kg/ha), ICPL 2447 (958.8 Kg/ha) and ICPL 2364 (875.5 Kg/ha) were found high yielding as compared to check variety ICPL 2429 (838.8 Kg/ha). However, three entries viz., ICPL 2429 (162 day), ICPL 2447 and ICPL 2364 (163 days) showed early maturity as compared to check variety ICPL 2441 (165 days).

(d) **Medium Early Varietal Trial:** Out of 16 entries, ICPL 15062 (4867.1 Kg/ha), ICPL 15006 (4821.1 Kg/ha), ICPL 15010 (4671.1 Kg/ha), ICPL 15079 (4295.0 Kg/ha), ICPL 15063 (4283.3 Kg/ha), ICPL 15060 (4243.3 Kg/ha), ICPL 15028 (4237.8 Kg/ha) and ICPL 15057 (4170.5 Kg/ha) exhibited higher yield as compared to check variety Maruthi (3955.0 Kg/ha) and Asha (2376.1 Kg/ha). However, four entries viz., ICPL 15062 (186 day), ICPL 15014 (189 days), ICPL 15023 (197 days), ICPL 15060 (198 days) were early maturing types as compared to check varieties, Maruthi (212 days) and Asha (211 days).

D. **National Shuttle breeding programme in Pigeonpea (*kharif* 2020)**: Total 10 breeding lines from S.K. Nagar, Gujarat (03); Gulberga, Karnataka (03) and Badnapur, Maharashtra (04) evaluated during kharif 2019 and data supplied to Pigeonpea Co-ordinator.

3. Grasspea (*Lathyrus sativus* L.)

A. **Plant Genetic Resources (*rabi* 2019-20):** 393 genotypes were purified and evaluated and these are under purification and ODAP estimation during 2020-21. High yielding, white

and large seeded genotype, IC 296745 (15 gm / 100 seed), and green seeded genotype, RLK 195 identified. Landraces, IPLa 24 (0.05 %) is at par with check var. Mahateora (0.05 %) followed by were identified promining IPLa 28 (0.06 %), IPLa 30, (0.06 %), IPLa 20 (0.06 %), IPLa 27 (0.07 %), and IPLa 29 (0.09 %) for ODAP estimation. ODAP estimation and validation is required at germination, growth, reproduction and mature seed stages to analyse the level of ODAP in grasspea genotypes at various growth and developmental stages.

B. Genetics and breeding (*Rabi* 2019-20): Inter-specific crosses between Mahateora var. of *L. sativus* and *L. cicera* was attempted. Seeds were grown to raise F_1 progeny but due to abnormal germination plant could not survived. Further, mutants of M5 generation are grown for seed multiplication, selection and identification of unique lines that are subjected to ODAP analysis during *rabi* 2020-21.

C. Station Trials:

(i) ICARDA Trials (*Rabi* 2019-20):

(a) FLRP Grasspea trial (Low ODAP): 28 entries with two checks were evaluated and six high yielding entries (kg/ha.) namely, IFLA 123 (817.2 kg), BANG-249 (709.8 kg), Bio 520 (595.6 kg), IFLA 220 (593.8 kg), BANG-310 (574.7 kg) and IFLA 3001 (563.2 kg) were identified against the check varieties, Mahateora (466.7 kg) and Ratan (176.0 kg).

(b) FLRP Grasspea trial (Early): Total 33 with three checks were evaluated and BK-15-4 entries (104 days) was found at par with Mahateora (104 days), BANG-224 (107 days), BANG-297, BANG-308, IFLA 1795, BK-14-8, (108 days), IFLA 276, IFLA 2736, BANG291, IFLA 274, BANG-211, BANG-198 (108 days) matures earlier / at par with check var. Ratan (108 days) and Prateek (110 days).

(c) FLRP Grasspea trial (High Biomass): Total 34 entries with two checks were evaluated for dry matter yield (DMY/ha) and BK-10-1 (9.01 t), BK-39-1 (5.36 t), IFLA144 (5.31 t), IFLA1522 (5.10 t), BK-30-1, BK-54-1 (5.0 t) were superior over the check var. Mahateora (3.85 t) and Prateek (4.64 t).

(ii) ICARDA Trials (*Rabi* 2020-21) under evaluation:

(a) BCIP-GYIT-HB-21 (High biomass): 48 entries with two check

(b) BCIP-GYIT-LO-21 (Low ODAP): 48 entries with two check

(c) BCIP-GYIT-E-21(Earliness): 48 entries with two check

(d) BCIP-GISPN-F7-21 (Breeding line): 5 entries with one check

4. Lentil (*Lens culinaris* L.)

A. Plant Genetic Resources (*Rabi* 2019-20): 800 germplasm were grown for characterization and few unique plants in genotype IC 428472 identified for large number of pods per peduncle (07 pods) and genotypes were (IC 560291, IC 428139, IC 428216 and IC 428210) identified for earliness (103-105d), whereas IC 428255 (4.0 g), IC 428252 (3.9 g), IC 428357 (3.9 g) for large seed size (100 seed wt.) were identified from *Rabi* 2017-18 to 2020. Besides 109 germplasm lines are grown and being characterized during *rabi* 2020-21.

B. Station trials (*rabi* 2019-20):

(i) IIPR Station Trials (2019-20): 03

(a) Out of 13 entries, IPL 121802 (13.01 q/ha), IPL 131210 (12.17 q/ha), IPL 181618 (11.97 q/ha), IPL 14977 (11.71 q/ha), IPL 181662 (922.2 gm), IPL 171423 (900.2 gm) were found superior over the check DPL 62 (9.87 q/ha) but these could not performe as IPL 316 (13.41 q/ha).

(b) Out of 15 entries grown for yield potential in Central region, IPL-161435 gave highest yield (15.47 q /ha) followed by IPL-161441 (13.57 q /

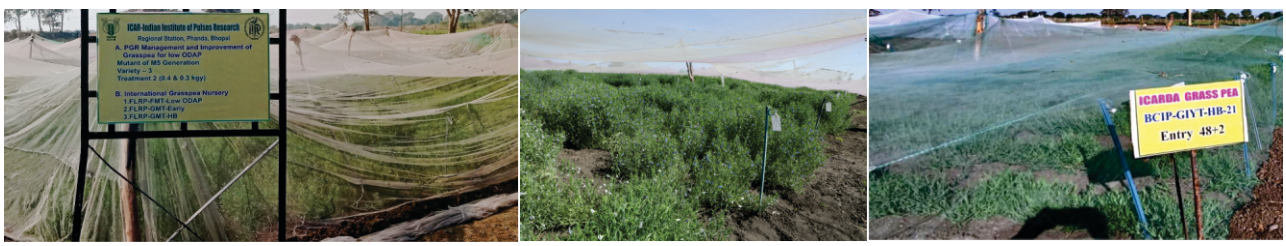


Fig. 5: Grasspea germplasm purification and evaluation of station trials under controlled conditions.

ha) and IPL- 11718 (13.11 q/ ha) against the best check IPL 316 (9.71 q/ ha).

(ii) IIPR Station Trials (2020-21): 03

(a) Total 15 entries are grown to evaluate yield attributes and earliness.

(iii) ICARDA trials:

(a) ICARDA FLRP trial (2019-20): 02

(i) Large seeded

(ii) Small seeded

(b) ICARDA global trial (2020-21):02

(i) BCIP SA-21: 70 + 02

(ii) BCIP LIEN-GLOBAL-21: 70+2



Fig. 6: Field view of lentil germplasm, IIPR lentil trial, and 7- pods/peduncle (IC 428472)

5. Urdbean (*Vigna mungo* L.)

State Trial on Urdbean (*kharif* 2020): Five entries with two checks were evaluated at five centres namely, Raisen, Ichhawar, Chitrakoot, Burhanpur, and IIPR, Bhopal in Madhya Pradesh State and IPU 17-1 (1557.1 kg/ha) was identified for release.

6. Pre-breeding and wild genera/species

Vigna: 18 wild accessions maintenance of 09 species are being maintained in wild pulse garden.

Pigeonpea: 128 accessions of 11 species belonging to genera *Cajanus* and *Rhyncosia*, are maintained.

Chickpea: 96 accessions of 8 annual *Cicer* species were grown in wild pulses wild garden.

Grasspea: 02 accessions of *Lathyrus cicera*, maintained.



Fig. 7: Wild pulses and pre-breeding garden at IIPR, RC, Bhopal

7. Breeder Seed Production at Bhopal station:

Table 2: Breeder seed production during *rabi* and summer 2019-20 and *kharif* 2020 at IIPR, RC, Bhopal

Crop	Variety	Production (qtl)
Chickpea	RVG 203	19.20
Fieldpea	IPFD 10-12	51.20
	IPFD 11-05	52.80
	IPFD 12-2	35.20
Lentil	IPL 316	40.00
Total rabi crops 2019-20		**163.40**
Summer Mung bean	Virat	4.15
	Shikha	6.41
	Samrat	2.43
Total mung bean 2020		**12.99**
Pigeonpea	Rajeshwari	27.0
Urdbean	IPU 13-1	0.50
	IPU 11-02	1.00
	IPU 10-26	0.30
	Uttra	6.00
	IPU 2-43	14.0
Total kharif crops 2020		**48.80**
Grand Total		**225.19**



Fig. 8: Field view of breeder seed production plots of *rabi* crops at IIPR RC, Bhopal

8. Seed Hub :

Seed business license is renewed 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 which is continuously monitored by DAC, Govt. of India.

9. Pulse Pathology:

(i) Wilt sick plot is under development for following crops:

(a) Chickpea wilt sick plot: Second year of development

Table 3: Quality Seed Production under seed hub at IIPR, Regional Station, Bhopal

Crop	Varieties	Production (qtl.)
Mung bean	Virat, Shikha	150.00
Urdbean	Uttara, IPU 2-43	240.00
Pigeonpea	UPAS-120, Pusa Arhar-16, Rajiv Lochan, Rajeshwari	100 .00
Chickpea	RVG 202, RVG 203, JG16, Shubhra	350.00
Lentil	IPL 316	80.00
Fieldpea	IPFD 10-12, IPFD 12-2	220.00
Total		1140.00



Fig. 9: Foundation seed monitoring for pigeonpea, urdbean, chickpea and lentil at farmer's field

(b) Pigeonpea wilt sick plot: First year of development

(c) Lentil wilt sickplot: Second year of development

(ii) NBRI Trial conducted: Efficacy of biocontrol agents developed by NBRI (CSIR), Lucknow

10. Crop Production:

The field experiment was conducted during *kharif* 2020 to improve soil health, nutrient dynamics, productivity, profitability and sustainability of pulses-based production system through efficient nutrient and water management treatments while assessing nutrient and water use efficiencies in central India. For this, pigeon pea–wheat and soybean–chickpea cropping system was followed. Pigeon pea and soybean was raised during the *kharif* 2020 while wheat and chickpea crops are presently standing in the field. The observation on yield and yield parameters of *kharif* crops have been recorded and nutrient and moisture data collection/analysis is under process.

11. Extension activities:

A. IIPR Model Pulses village programme: Two villages, namely Padli and Khamliya were adopted to develop as a model pulses village in Sehore district. Farmers of these villages are already in practice of growing pulse crops. They use to grow chickpea and lentil in *rabi*, and pigeonpea and urdbean in *kharif*. Few farmers use to grow summer mungbean as per availability of irrigation facility. They also participate under seed hub programme to produce quality seed at IIPR. Six demonstrations of new varieties of chickpea and lentil are conducted to popularize and promote the new technologies of pulses among farmers.

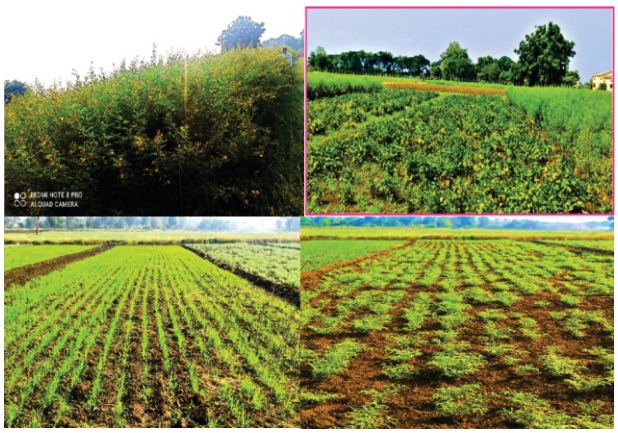


Fig. 10: Experimantal view of crops growth at reproductive stage *kharif* 2020 & at vegetative growth *rabi* 2021

B.(i) FLD conducted in *rabi* 2019-20 and *kharif* 2020 at IIPR, RC, Bhopal

Table 4: An outline of Front line demonstrations

Crop (no. of FLD)	Village	Name of Farmer	Variety	Production (qtl.) (range)	C:B Ratio range
Chickpea (10)	Jahangeerpura, Mogaraful, Chaudi, Barwai, Basoda, Jamani, Shaistakhedi, Dhamanda, Basoda, Bhad	Praveen Shrivastava, Laal Mohammad,Mahesh Mewada, Durgaprasad Dhakad, Dewabai/ Surendrasingh, Ramlal / Ratansingh, Devendra Tyagi, Ghanshyam/ Motilal, Dharusingh/ Dinansingh, Urmila Tripathi	RVG 202	14- 20.0	1:2-1:2.9
Lentil (05)	Talen, Dist. Rajgarh, Chaudi, Dist. Sehore, Barwai, Dist. Vidisha, Nayakheda, Dist. Sehore, Dhamanda, Dist. Sehore	Chandar singh/ Shankarlal, Sanjay Mewada, Sandip/ Durgaprasad, Kanchanbai/Omprakash, Kuntabai/Ghanshyam,	IPL 316	8.2 -14.0	1:1.2-1:2.4
Field pea (03)	Mundara, Gadla, Syari in district Vidisha	Dimansingh/Babulal	IPFD 10-12	18.0-22.0	1:1.4-1:1.6
Pigeonpea (05)	Islam Nagar, Raipur Nayakheda (03), Khokari veera,	Smt. Rajani w/o Kailash, Shri Rahul s/o Veerbhan, Shri Sanjeev Kalra s/o Kailash, Shri Kripal singh s/o Bhagwat singh, Shri Devsingh s/o Rajmal	Rajeshwari, Rajiv Lochan, Rajeshwari, TJT 501	12.3-16.0	1:2.2-1:2.9

(iii) FLD conducted in *rabi* 2020-21 at IIPR, RS, Bhopal

(a) Chickpea: 15 FLD in 15 villages of Sehore, Vidisha, and Bhopal districts with RVG 202 and RVG 203 varieties.

(b) Lentil: 10 FLD in 10 villages of Sehore, Vidisha and Bhopal districts with variety IPL 316.

(c) Field pea: 10 FLD in 10 villages of Vidisha and Bhopal districts with varieties IPFD 10-12 and IPFD12-2.

C. Farmers visit

D. Seed distribution under SC sub plan: Seed distribution programme under SC Sub Plan of Govt. of India was organized on 22 October, 2020 and 229 farmers were benefitted with the scheme.

Table 5: Farmers visited under various organization/scheme of Govt. of M.P.

S.N	Place	No. of farmer's	Organization	Date
1	Bhopal	30	CARD, MANAGE	30/01/2020
2	Kalapipal	16	Mapwa Yojna Mahila Kisan	26/02/2020
3	Kalapipal	15	Mukhyamantri khet tirth yojana	28/02/2020
4	Ichhawar	20	Krishi Vigyan Kendra	29/02/2020
5	Shujalpur	09	Krishi avm Kisan Kalyan Vibhag	19/11/2020
6	Vidisha	39	Krishi avam Kisan Kalyan Vibhag	06/01/2021



Fig. 11: Extension activities performed (Seed distribution, model village prog., and FLD on pigeonpea)

World Pulses day celebrated with the farmers' on 10.02.2020
***Vishwa dalhan diwas* celebrated**



Fig. 12: Glimpses of celebration of World Pulses Day during February 10, 2020.

12. Officer's visits:

1. DDG (crop Sciences) visited on 10.02.2020.
2. GM, NABARD visited on 10.02.2020
3. Director, IIPR visited 16.11.2020 to monitor research and CPWD activities at station.
4. Addl. Director (Agril.), Bhopal, Govt.of Madhya Pradesh visited on 10.02.2020.
5. Ex. Er., CPWD along the officer's visited station and monitored the developmental works
6. Dr. Neeta Singh, Principal Scientist, NBPGR, New Delhi visited to monitor CRP on Agro-biodiversity in Pigeonpea project activities.
7. Mahindra & Mahindra (CSR fund for watershed Dev.) team visited to developed ponds at Station.
8. Seed monitoring team including RM, NSC, RM, Beej Nigam (M.P.) and Seed inspection officers, MPSSCA, Bhopal. Visited research station to monitor the breeder seed programme.
9. Scientist from National Institute of Hydrology, Bhopal visited for monitoring of weather station.

13. Developmental activities:

(i) Farm implements (06 nos.) delivered and installed.

(ii) Plantations have been enhanced at the station.

(iii) Drainage channels (kachcha) to channelize the rain water is developed.

(iv) Extension of seed drying shed is under construction.

(v) Widening and extension of existing CC approach road is under process.

(vi) Main gate at Toll Plaza is under construction.

(vii) Retaining cum boundary wall is under construction.

(viii) Pond under development



Main gate at Phanda Toll Plaza Widening of existing RCC road and Retaining wall of ponds (under construction)



Extension of seed drying shed and pond under development

Fig. 13: Status of developmental activities under works category



Fig. 14: Farm implements purchased during 2019-20 to strengthen farm machinery at station.



Fig. 15: Independence Day and Parthenium Eradication week celebrated with all Covid 19 safety measures

IIPR-Regional Station *cum* Off-Season Nursery Dharwad, Karnataka

Crop Improvement

Plant genetic resources management and its utilization through pre-breeding

Cowpea

Total 200 accessions of cowpea germplasm were rejuvenated and evaluated for different morphological traits during spring-summer. Wide range of variations was observed for different morphological traits. The entries such as PL-4 (76 days), EC-724284 (79 days) and EC-738194 (80 days) were identified as early maturing genotypes of cowpea. The genotypes EC-528457, IC-19786 and EC-390277 were having more number of pods per plant.

Horsegram

Total 227 accessions of horsegram germplasm were maintained and characterized for different morphological traits during *rabi*. Wide range of variations was observed for different morphological traits. The entries such as TCR-1675, TCR-1493 and IC-68595 were found to be early maturing types. The entries such as IC 19446, IC 347177, IC 342684, IC-139450 and IC 145297 were having more number of pods per plant (>80). The entries such as VLG-15, KBHG-01, TCR-1489, GPM-49 and PHG-62 showed resistance reaction to powdery mildew disease under natural field conditions during *rabi*.



Cowpea and horsegram germplasm evaluation



Fig. 1: Variations for seed colour and size in horsegram and cowpea germplasm

Mungbean

Two hundred Ninety six accessions of mungbean-mini-core received from World Vegetable Centre, Hyderabad were rejuvenated and characterized for qualitative and quantitative traits during *kharif*/ summer 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.



Fig. 2: Mungbean mini-core evaluation during summer

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).

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) were rejuvenated and evaluated for different traits during *rabi* season.



Fig. 3: Maintenance of wild *Vigna* species in cement pots

Genetic enhancement of pulse crops for yield, stability and quality

Evaluation of advance breeding lines of pulses

Mungbean

Total 25 advance breeding lines of mungbean were evaluated during summer. The entries such as, IPM-

205-7 (63 days), IPM-1603-9 (66 days) and IPM 312-379-2 (66 days) were identified as early maturing genotypes. The genotypes such as IPM-14-35 (1364 kg/ha), IPM-14-9 (1295 kg/ha) and IPM-312-394-1 (1254 kg/ha) were recorded higher grain yield (kg/ha) compared to check, IPM-2-14 (1087 kg/ha).

Chickpea

Two station trials of chickpea were evaluated during *rabi*-season-2019-20. In station trial-I (30 entries), the genotypes such as IPC-17-20 (93 days) and IPC-17-35 (93 days) were the earliest to mature, while the genotypes, IPC-17-377 (117 days) and IPC-17-16 (114 days) took more number of days to mature. The genotypes, IPC-19-226 (2450 kg/ha), IPC-17-53 (2356 Kg/ha) and IPC-17-369 (2193 kg/ha) were found to be promising for grain yield when compared to JG-11 (1890 kg/ha). In station trial-II (22 entries), the genotypes such as IPC-17-364 (90 days) and IPC-17-49 (90 days) were found early to mature. The genotypes such as IPC-17-49 (2523 kg/ha) and IPC-18-166 (2470 kg/ha) were recorded higher grain yield (kg/ha) when compared to check varieties (JG-11 (2130 kg/ha) and BGD-111-1 (1814 kg/ha).

AICRP Chickpea trials:

Total 30 entries of chickpea were evaluated under genetic gain trial and 16 entries of chickpea were evaluated for drought tolerance under rain out shelter during *rabi*. Total 310 entries were evaluated under genomic selection trial during *rabi.*

Entries in state MLT:

Promising entries of mungbean (IPM 14-28) and urdbean (IPU 12-30) were put to state multi-location trial (MLT) to assess their suitability for cultivation in different agro-climatic zones of Karnataka.

Generation of breeding material in pulses

Cowpea

Fifteen new crosses were generated in cowpea involving donor lines for earliness, plant type, large seed size and resistance to YMV disease (Goa Cowpea-3 x RC-101, RC-101 x PL-4, PL-3 x EC-472250, CO-2 x GC-3, DC-47-1 x GP-40, GC-4 x C-152, PL-4 x RC-101, CO-7 x Goa Cowpea-3, KM-5 x EC-170604, GP-40 x GC-4, DC-15 x KBC-2, EC-458403 x RC-19, RC-19 x GC-4, CO-7 x NB-4 and CO-2 x MP-2). Total eighteen crosses from different segregating generations were advanced during *rabi* season. Individual plant selections were made based on their superiority for grain yield and disease resistance traits.

Horsegram

Nine new crosses were generated in horsegram (AK-22 x CRHG-09, CRHG-05 x CRHG-09, VLG-44 x KBHG-01, VLG-15 x BHG-14-1, KBHG-01 x CRHG-09, BHG-13-16 x Baster Kulthi-15, TCR-1799 x CRHG-22, BHG-14-1 x BHG-13-16, CG-KULTHI-2 x BHG-14-1) involving donor lines with earliness, high biomass and resistance to powdery mildew disease . Total nineteen crosses from different segregation generations were advanced during *rabi*. Individual plant selections were made based on their superiority for seed yield and resistance to powdery mildew disease.

Off-season generation advancement of pulses Chickpea and lentil

Breeding materials for generation advancement were received from AICRP centres 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 IIPR, Kanpur. The generation advancement was performed during the *Kharif* and advanced breeding materials were sent to the respective centers. During the year 2020-21, breeding materials (F_1/F_2) were received from AICRP chickpea centres of Hisar (17 lines) and Bijapur (14 lines) and segregating materials (F_2/F_3) / mapping populations of chickpea and lentil from IIPR, Kanpur were advanced during *kharif*-2020. More than 30 new crosses were developed in chickpea during the off-season.

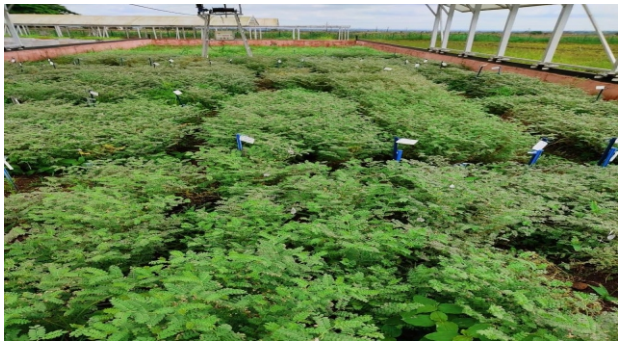


Fig. 4: Off-season generation advancement of chickpea

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

Screening and characterization of mungbean genotypes for their drought and heat tolerance

Mungbean germplasm (n=104) were screened for drought and heat tolerance including checks (IPM 2-14, IPM 02-3, LGG460 and ML5) during summer

season. Mungbean genotypes were categorized based on their physiological parameters under different treatments *viz*., Unstressed control {T1, (Timely sown, fully irrigated)}, Drought stress {T2, (Timely sown, one irrigation after 20 DAS then withheld irrigation during flowering) and Heat stress {T3, (Late sown, fully irrigated)}. Under T_1 treatment, genotypes IPM 03-1, MH 421, IPM 06-5, PUSA BOLD 2, IPM 2-16, IPM 2-14 and IPM 02-3-2 exhibited >4.5 gm of 100-seed weight, genotypes ML 1464, MH 421, IPM 02-3-2 and IPM 2-16 showed good NDVI values and genotypes IPM 2-17, EC 520024, IPM 02-3-2, IPM 5-2-8, BDYR -2 for SPAD values. In T_2 treatment genotypes ML1464, PUSA 672, IPM02-3-2, UPM 02-18, PUSA BOLD 2 and BIG-0068-1 showed >4.5 gm of 100-seed weight. Indore Mung, Asha Mung, BIG-0068-1 exhibited higher NDVI indices and genotypes ML 682, AKM 96-1 and ML 1059 showed higher SCMR values indicating better adaptiveness to drought stress.

In T_3 treatment, genotypes IPM 06-5, PAU 911, MH 03-18, PDM 191 showed >4.5 gm of 100-seed weight and genotypes IPM 03-1, IPM 02-3-2, PM 3, IPM 99-125, ML 2037 exhibited higher NDVI values and genotypes SML 191, OMG 1045, IPM 5-2-8, C 3, BIG-0068-1 showed higher SCMR values indicating better adaptiveness to heat stress.

Based on Chlorophyll fluorescence images of quantum yield (Fv/Fm), the genotypes IPM 2-14, IPM 2k-14-5, IPM 205-7 and OUM 11-5 were better adopted under stress condition, whereas genotypes LGG 460, IPM 40-9-4, HW421 and ML 1059 were poorly adopted to stress condition. Light response of Chlorophyll fluorescence derived photosynthetic electron transport (ETR) in the chloroplasts revealed higher electron transport rate in MH 421, PDM 288, EC520014 and IPM 9901-10 indicating they are better adopted to stress condition and genotypes PM 3, IPM 2-17, SML 191 and IPM 06-5 which showed low ETR indicating their poor adoptability to stress condition.

Cowpea

Evaluation of cowpea (n=240) germplasm lines for multiple stress resistance is being carried out. Advancement of breeding lines from F_2 generation is in progress. Crossing programme and generation of fresh breeding material involving following parental lines, DC-15 X GC-3, KBC-9 X RC-19, DC-15 X PL 1/PL2, DC-15 X RC 101, DC-47-1 X RC-19 and DC-15 X EC 47252 were done.

Urdbean

Generation advancement of different crosses of Urdbean was carried out at *Kharif* 2020 at Technology Block of RC Dharwad.F_2 to F_3 (21 lines), Multiparent crosses (09 lines). Advancement of crosses from F_3 to F_4, photo-thermo insensitivity (10 lines), heat tolerance (6 lines) and drought tolerance (15 lines) were carried out.

Lentil

Advanced lentil lines (n=23) received from PC MuLLARP were used in conducting special trial on lentil for abiotic stress (drought stress) screening in Rainout Shelter at RC Dharwad. Following observations are being recorded in the experiment: Plant Stand (%), 50% Flowering (Days), Maturity (Days), Plant height (cm), No. of branches/Plant No. of Pods /plant, Seed yield (kg/ha) and 100-Seed weight (g)

Germplasm exploration

Seed multiplication and evaluation of germplasm (41) collected from Germplasm exploration trip, French bean (*Phaseolus vulgaris*) (15), Lima bean (*Phaseolus lunatus*) (2), Runner bean (*Phaseolus coccineus*) (1), Cowpea (*Vigna unguiculata*) (1), *Cajanus heynei* (1), *Cajanus grandifloras* (1), *Vigna vexillata* (1) was done.

Breeder/TL Seed Production

Total 800 kg of breeder seed of mungbean *cv.* IPM 2-14 and urdbean *cv.* IPU-2-43 were produced during summer/*kharif*. TL seed production of chickpea variety-JG-11 was done during *rabi* and produced seed yield of about 300 kg. In horsegram, of seed variety-CRIDA-18 was produced (250 kg) during *rabi*.



Fig. 5: Breeder seed production during *Kharif*

Crop Production

Effect of pigeonpea based intercropping systems on productivity and soil properties.

A field experiment was conducted at IIPR RRC, Dharwad during *kharif* season (2020-21) on effect of pigeonpea based intercropping systems on productivity and soil properties. Treatments

composed of three intercropping systems *viz;* 1) Pigeonpea+ Mungbean 2) Pigeonpea + *kharif* sorghum 3) Pigeonpea sole. The four subplot (fertilizer treatments) comprised of 1) 100% to main+ 100% to intercrop (100-100) 2), 100% main+ 75% to intercrop (100-75) 3) 100% to main +50% to intercrop (100-50) and 4) control. The results revealed that highest *kharif* sorghum yield of 25.87 q/ha was recorded in R_1(100-100) treatment. Mungbean yield of 6.47 q/ha was recorded in R3 (100-75) treatment and the lowest yields of sorghum and mungbean were recorded in R_1 (control) & R_2 (100-50) treatments. The estimation of pigeonpea equivalent yield and soil properties will be done after harvest of pigeonpea.

Phosphorus use efficiency in Mungbean genotypes.

A pot experiment was conducted at IIPR-RRC, Dharwad during *Kharif* season of 2020 to evaluate 15 genotypes of mungbean for phosphorus use efficiency in Alfisol. There were two P levels *viz.,* 0 and 50 kg P_2O_5/ha and 15 genotypes of mungbean *viz.*, 1) IPM 2-14 2) IPM 99-125 3) IPM 2-3 4) DCGV 2 5) PDM 139 6) IPM 205-7 7) IPM 14-35 8) IPM 14-9 9) IPM 9901-6-1 10) IPM 302-2 11) IPM 14-10 12) IPM 312-394-1 13) TARM-1 14) DGGS-4 15) IPM 101-102-1. Results revealed that highest plant height at maturity (72.16cm) in DGGS-4, dry matter yield (21.5 g/plant) in DGGS-4 and root length (40.9 cm) in IPM 14-10 were observed at P50 level. The highest yield of 204.52 g/pot or 30.53 q/ha was observed in DGGS 4 genotype at P50 level. The estimation of P content in grain and P uptake/ PUE estimation are under progress.



Crop Protection

Novel fungicides for management of chickpea rust

Five fungicides of various groups along with neem oil were evaluated against chickpea rust at IIPR, RCC, Dharwad. The results indicated that foliar spray of a combi product Tebuconozole 50% + Trifloxystrobin 25% WP @ 0.5 g/l was found the most effective and reduced rust severity to the tune of 31.23% followed by difenconozole 25% EC @ 0.75 ml/l and propinonozole 25% EC @ 0.75 ml/l with 32.57% and 36.70%, respectively. The untreated control recorded the highest severity of rust disease (90%). However, the highest grain yield of 1350.7 kg/ha, was registered in the treatment propiconozole @ 0.75 ml/l followed by Tebuconozole + Trifloxystrobin @ 0.5 g/l (1327.1 kg/ha) and Difenconozole @ 0.75 ml/l (1280.4 kg/ha). All three fungicides were at par in increasing the yield of chickpea. Whereas, neem oil 5000 ppm @ 2 ml/ l recorded 855.4 kg/ha grain yield which was at par with carbendazim 50% WP @ 1 g/l and thiophanate methy l 70% WP @ 1 g/l treatments.



Fig. 6: Field view of evaluation of new fungicides against chickpea rust

Inheritance of resistance to two isolates of sterility mosaic pathogen in pigeonpea (*Cajanus cajana*)

Phenotyping of F_1s and F_2s for SMD done in SMD Nursery developed at IIPR RC, Dharwad. Based on phenotypic data, SMD resistance in Bahar is governed by two genes which interact in non-allelic fashion (inhibitory gene interaction)



Fig. 7: Phenotyping of F1s for SMD. P1 to P6 : True F_1s derived from Maruti x Bahar; S : Maruti; R : Bahar

Evaluation of greengram germplasm lines against Yellow mosaic virus

Fifty two entries were screened against yellow mosaic disease during summer season at IIPR, RCC Dharwad. Three entries (IPM 99-125, IPM 604-1-8, and IPM 2-14) were completely free from disease and 13 entries (EC 520034-1, IPM 14-19-5, IPM 312-394-1, IPM 312-394-2, IPM 410-3, IPM 430-4, IPM 9901-6-1, IPM 207-7, VBN 3, CO 5, COGG 912, BARIMUNG 6, NR/18-85) were found resistant, which showed 0.1-10% YMV severity and incidence.



Fig.8 : Field view of greengram germplasm screening

Evaluation of greengram germplasm lines against major diseases of greengram

A total of 85 greengram germplsm lines were evaluated against *Cercospora* leaf spot, *Antracnose* leaf spot and powdery mildew disease.

***Cercospora* leaf spot:** The disease severity in the field ranged between 4.4 and 77.8 per cent. Among 85 lines screened, V1003490AG was found resistant and 3 lines namely, PDM 54, COGG 912 and VBN 3 showed resistance reaction

***Anthracnose* leaf spot:** The disease severity among 85 entries ranged between 20 and 77.8 per cent. Among which none of the entries were resistant however, Vamban and V1003958-13-BLM were found moderately resistant.

Powdery mildew: The disease severity ranged between 13.3 and 100 per cent. Among which one entry namely, TM96-2 was found moderately resistant.

Development of ecofriendly insect pest management strategies in mungbean, urdbean, cowpea and horsegram for peninsular India

New emerging insect pests of *Vigna* pulses

Outbreak of pod weevil, *Apion amplum* (Faust) (Coleoptera: Apionidae) incidence was recorded on blackgram and greengram during *kharif* season 2020. Incidence of the pest was observed during flowering stage. The grubs damage the pods by feeding on the embryo of the seed. The peak activity of the pest was observed during July to September month. Incidence of pod weevil was severe in blackgram as compared to geengram. The pod damage and seed damage in blackgram was around 60.30 % and 59.10%, respectively. In case of greengram, the pod damage and seed damage was 20.10% and 17.20%, respectively.



Adults feeding on flower buds and pods | Adults under leaf



Damaged seeds with grubs | Damaged pods with exit holes

Another emerging insect pest, pink pod borer, *Cydia ptychora* (Meyrick) (Lepidoptera: Tortricidae) was recorded on greengram and cowpea. It is known as cowpea seed moth or pink pod borer. It is a major insect pest around Dharwad area. Infestation starts at late stage of crop, when pods are at maturity. Larvae feed on seeds. In mungbean and cowpea, around 30.19 and 65.53 % pod damage was recorded, respectively, with 30 % seed damage.

Effect of different intercrops on the incidence of major insect pests in cowpea

Field experiment was conducted to study the effect of different intercrops on the incidence of major insect pests in cowpea during *Kharif* season. Cowpea was intercropped with nine different intercrops *viz.*, pigeonpea, mungbean, sorghum, maize, foxtail millet, groundnut, cotton, amaranths, okra at 3: 1 ratio. Cowpea sole crop was taken as check. The results indicated that cowpea intercropped with okra was effective followed by cowpea + sorghum and cowpea + pigeonpea in reducing the incidence of pod borer *Maruca vitrata* at pod maturity stage with per cent pod damage of 18.0 and 21%, respectively.

Evaluation of biopesticides against major insect pests of cowpea

Field experiment was conducted to evaluate the efficacy of different biopesticides against cowpea pod borer. There were seven treatments including control. Two sprays of biopesticides was applied at

50 % flowering at 10 days interval. Among different biopesticides, *Beauveria bassiana* @ 3 gm/L was found most effective followed by neem soap @ 10 g/L and recorded 61.15 % and 53.80% reduction, respectively in pod damage as compared to untreated control.

Screening of cowpea germplasms/lines against major insect pests

Nineteen cowpea lines were screened against pod borer during *Kharif* season. All the cowpea entries/lines were found susceptible to pod borer. Only one line CP 1 recorded per cent pod damage less than 10%. Twelve lines *viz.*, CP-3, CP-4, CP-6, CP-7, CP-8, CP-9, CP-10, CP-11, CP-13, CP-15, CP-16 and CP-19 recorded per cent pod damage between 11 and 20% whereas six lines *viz.*, CP-2, CP-5, CP-12, CP-14, CP-17 and CP-19 recorded per cent pod damage between 21 and 30%. Incidence of sucking insect pests like whitefly, aphid and jassids was very minimum and negligible for taking observation.

Evaluation of germplasm of mungbean and urdbean against major insect pests

During *kharif* season, out of 32 mungbean entries evaluated, 12 entries showed pod damage less than 20%. In case of urdbean, out of 49 entries, 23 entries showed pod damage less than 10 % and in rest of the entries the pod damage was less than 20 %. During *rabi* season, out of 17 mungbean entries evaluated, 3 entries (RME 19-70, RME 19-81 & RME 19-82) showed pod damage less than 20 %. In urdbean, out of 12 entries evaluated, three entries (RUE 19-86, RUE 19-87 & RUE 19-91) showed pod damage less than 10 %.

EXTENSION ACTIVITIES

FLDs and visits to farmer's fields

Total five FLDs of chickpea and eight FLDs (cowpea and horsegram) were conducted in different farmer's fields of Narendra, Amargol, Byahatti, Mulamuttal, Yettinagudda, Mangalgatti of Dharwad district during *rabi*-season and visited pulse growing farmers fields of during *kharif/rabi* and interacted with them. Visited different farmers fields of Narendra and Mulamuttal villages of Dharwad and interacted with the pulse growing farmers under MGMG programme.



Fig. 9: Pulse growing farmers field visit during *rabi*

International/National symposia attended

- Dr. PR Sabale, Revanappa SB, Kodandaram MH and Venkatesh MS attended International Conference on "Pulses as the Climate Smart Crops: Challenges and Opportunities' held at Bhopal from Feb. 10-12, 2020.
- Dr. Revanappa attended the international e Conference on Advances in Biotechnology and Crop Improvement held at COH, Bangalore during Nov. 24-27, 2020.
- Dr. Revanappa participated in the virtual India International Science Festival-Young Scientist Conference held from December 22 -25, 2020.
- Dr P.R. Sabale attended e international Conference on Multidisciplinary Approaches for Plant Disease in management in Achieving Sustainability in Agriculture from Oct. 06-09, 2020 organized by UHS Baglkot, CoH, and Bangalore.
- Dr PR Sabale attended webinar on bio-control of pest and diseases on 21st Aug. 2020 organized by NBAIR, Bangalore
- Dr Manu participated in the International E-Conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity' organized by the Department of Biotechnology and Crop Improvement, College of Horticulture, Bengaluru during 24-27th November, 2020.

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

Developmental works completed

- New sprinkler irrigation sets was purchased for use in research farm.
- Construction of seed storage buildings-cum-threshing floor was completed through CPWD.
- Construction works like CC road & drainage near new seed store building was completed by CPWD.
- C/o of damaged boundary wall at eastern side was completed.
- C/o remaining part of damaged boundary wall at eastern side is under progress by CPWD.
- C/o damaged boundary on the South side is under progress by CPWD.


Farm workers shed


Seed store and open threshing yard


Hitech Green house


Insect Proof Net House


Rainout Shelter


Cemented Ring Pots

- Strengthening of the South side boundary wall and fixing of barbed wire fence by the CPWD was completed by CPWD.
- Shed with toilet for farm workers was constructed in the RRC campus.

Infrastructural facilities created

- Established sick plots for screening facilities for soil borne diseases in pulses.
- Installed RCC cement ring pots for nutritional studies.
- Hi-Tech Green House with temperature, RH control for biotic stress screening.
- New rainout shelter for abiotic stress screening.
- Insect proof net house for biotic screening.
- Laboratory equipments like BOD incubator (1 No.), Double distillation unit (2 Nos.) were procured for laboratories.
- Furniture's and other items like sitting chair, visitor chairs, office table, conference table, chairs for conference room, office computer, printer, UPS and display kiosk were purchased for the centre.
- Farm implements like brush cutter machine, disc harrow, rotavator, bund former, multipurpose thresher, seed grader, manual seed drill, raised bed planter were purchased for use in research farm
- Construction works like CC road & drainage, new threshing & seed store building, east side damaged boundary wall, the South side boundary wall and fixing of barbed wire fence and shed for DG set were completed by the CPWD.

Other Institutional Activities/Programmes

Organised various institutional activities and programmes like *Parthenium* Awareness Week, Vigilance Awareness Week, *Swachata Pakhwara*, *Van Mahotasav* Programme *etc.*, at RRC, Dharwad.

Linkages with other Organisations

- ICAR-IIPR, Kanpur (RRC Dharwad) signed MoU with UAS, Dharwad for PG research and teaching.
- Coordination with the other scientists of AICRP on MuLLARP centre at UAS Dharwad for research and extension needs in pulse crops.
- Liaison with officials of UAS, Dharwad and State Dept. of Agriculture for various activities related to pulses.

ICAR- IIPR, Regional Centre, Bikaner

Crop improvement

Genetic enhancement in arid pulses for abiotic and biotic stresses

Mothbean

A total one hundred accessions were evaluated with three checks (RMO-40, RMO-225 and RMB-101) at ICAR-IIPR, RC, Bikaner. Out of 100 accessions evaluated in arid ecosystem, 4 erect (IC-36038, IC-415167, IC-258096, IC-120973), 8 semi-erect (IC-311396, IC-35975, IC-311423, IC-370533, IC-415150, IC-402283, IC-311425, IC-35681) and 4 (IC-39689, IC-36663, IC-121064, IC-39689) spreading type accessions were identified on the basis of yield and plant morphological characteristics.

Cowpea

Segregating material of cowpea (F_4 and F_5) were sown in *kharif* 2020 and promising selection were made for different traits under arid ecosystem. Based on plant morphological and yield observations, out of 11 crosses (nine F_4 and two F_5 generations), crosses of F_4 generation (RC-101 X DCP-30 and RC-101 X GC-4) showed earliness (46 and 48 days to flowering, respectively), semi erect growth habit, higher number of pods per plant with higher yield.



Fig. 1: Segregating materials of cowpea raised under arid ecosystem

Drought and heat tolerance in mothbean, mungbean and pigeonpea

Mothbean: Experiments were conducted to study the genotypic variation for drought stress in 21 mothbean genotypes. Leaf canopy temperature, chlorophyll content and dry biomass were recorded at vegetative stage. RMO-2251 and RMB-25 showed the least reduction in dry matter and chlorophyll content.

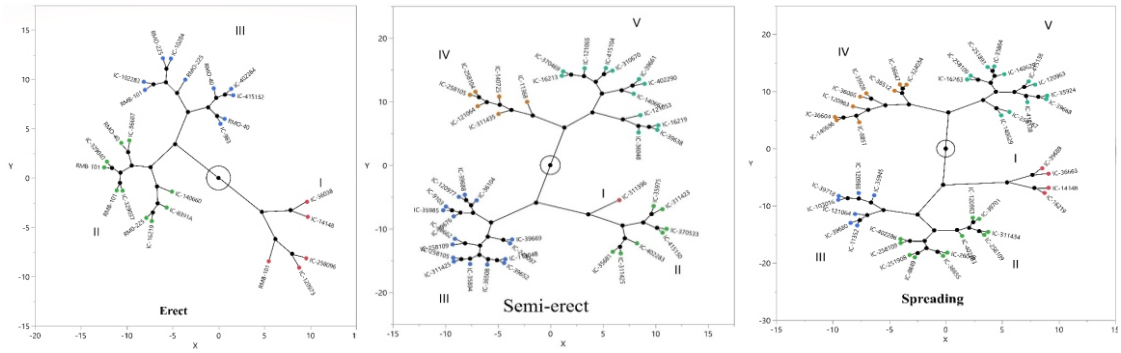


Fig. 2: Constellation plots displaying the relationships between 100 mothbean accessions. Cluster I, in erect and spreading and cluster I and II in semierect are represented by high yield, intermediate to deep lobing of leaves and higher number of leaf lobes the remaining clusters consisted of lower yield shallow leaf lob and less number of lobs per leaf.

Mungbean: To study the effect of drought on physiological traits and identification of donors for drought stress, sowing was done at ICAR-IIPR, Regional Centre, Bikaner in *kharif* season 2020-21. A field experiment was conducted with 20 mungbean genotypes under well-watered and water deficit conditions. Drastic reduction (28.9-88.9%) was found in the seed yield/plant under water deficit condition as compared to control. Comparatively less per cent reduction (28.9-37.4%) in seed yield/plant was recorded over well-watered condition in genotypes *viz.*, IPM 1103-1, IPM 410-3 and IPM 312-20 whereas, the higher reduction (80.8-88.9%) was observed in IPM 1604-1, IPM 1603-7 and IPM 1603-3.

Pigeonpea: Total 39 pigeonpea accessions were grown in rainfed conditions for identification of donors for drought tolerance. These accessions comprised of super early determinate type line (12), super early non-determinate type line (10), extra early lines (8), collected from ICRISAT and early maturity lines (9) collected from IIPR, Kanpur. Phenological traits *viz.*, date of flowering and podding and dry biomass were recorded. SEDT 08 and SEDT 06 showed better growth and performance compared to other ones.



Fig. 3: Screening of mothbean and pigeonpea genotype for drought stress

Station trial

Station trials on pigeonpea (21 genotypes), chickpea (20 genotypes) and lentil (15 genotypes) are being carried out for yield potential in arid ecosystem during *kharif* and *rabi* 2020-21.

Crop Production

Enhancing input use efficiency and productivity of pulses in arid ecosystem

***Tillage, residue and nutrient management*:** The field experiment was carried out at IIPR, Regional Centre Bikaner during *kharif* 2020 to assess/refine crop productivity and profitability along with scaling resource use efficiency involving pulses under arid ecosystems of Western plains Zone of Rajasthan. The observation on growth parameters has recorded and yield data collection is under process.



Fig. 4: Station trial on pigeonpea, chickpea and lentil

Irrigation and nitrogen management: An experiment was carried out in *Kharif* 2020 to evaluate the effect of nitrogen management and irrigation scheduling. As physical appearance of the crop/ growth data, the treatment 15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering and pod development was superior as compared to other nitrogen managements options. Further, two irrigations at branching + flowering/pod development stage was superior in comparison to single irrigation at branching stage and flowering stage/pod development stage.



Fig. 5: Experimental view: *Kharif* and *rabi* season

RCT for improving soil health and minimizing the yield gap in arid pulses

Two field studies were conducted during *kharif* 2021 on follows :

Effect of tillage and residue: A field experiment was initiated during the *rabi* season 2020-21 to study the effect of tillage and residue management on the performance and resource use efficiency of different pulse inclusive cropping systems and their consequences on soil health.

INM in pulse-based cropping systems: An experiment was conducted with the sowing of chickpea and mustard in current *Rabi* season 2020-21 in a split plot design to evaluate the effect of integrated nutrient management practices in soil health improvement and sustainability of pulse-based cropping system in arid-ecosystem.



Fig. 6: Field view of experiment during *kharif* and *rabi* season

Seed production

Seed production of mungbean in 4.0 ha area (var. Virat and Shikha) were undertaken in *kharif* season and in chickpea (IPC-11-112 and IPC-5-62) and lentil (IPL 316 and IPL 220) seed production programmme were undertaken in 7.0 ha area during *rabi* season.



Fig. 7: Seed production block: mungbean (kharif) and chickpea (*rabi*)

Developmental activities

Infrastructure developed/equipment purchased:

- Laboratory-cum-administrative building
- Farm office and threshing floor
- Water harvesting structure (Diggi): capacity = 20 lakh litres
- Tube well (3 nos.)
- Boundary wall (200 m)
- Chain link fencing (240 m)
- Road constructed (CC Road 300 m & Bituminous road 250 m)
- 62 KVA DG Set (2 Nos.)
- Electricity connection with transformer 98 KVA
- Underground pipeline for water supply to building and research area (500 m)
- Main gate

Laboratory establishment:

A well-equipped laboratory (Dry and wet lab) has been established at the centre with following equipment facilities

1. BOD Incubator-1
2. Laminar Air Flow Cabinet (Vertical)-1
3. Hot Air Oven-2
4. LED Fluorescent Microscope with HDMI Camera-1
5. Digital Hot Plate- 1
6. Automatic Weather Station-1
7. Water Quality Multiparameter Analyzer 1
8. Shaker-1
9. All Quartz Double Distillation Unit -2
10. Microprocessor Flame Photometer-1
11. Seed Germinator-1
12. Electronical Weighing Scale (up to 300kg) -1
13. Electronical Weighing Scale -1
14. Mrida parikshak 1

Farm Implements procured:

The following equipments were purchased for agricultural operations along with office vehicle:

1. Tractor New Holland 65 hp
2. Tractor trolley
3. Thresher Multipurpose
4. Seed cum Fertilizer Drill
5. Cultivator
6. Disk Harrow
7. M.B Plough
8. Disc Plough
9. Land leveler
10. Power Weedar
11. Bund Maker
12. Rotavator
13. Power Sprayer
14. Lawn mower
15. Sprinkler system
16. Water tanker



Laboratory-cum-Administrative building



Farm Office & Threshing Floor



Laboratory



Conference Room

Events, visits and activities



Independence Day Celebration



Director, ICAR-IIPR along with Directors, Heads and staff of ICAR institutions. (Bikaner)

All India Co-ordinated Research Projects
Chickpea

Varieties Developed

CG Lochan Chana (RG 2015-08): The *desi* chickpea variety was developed from cross PDE 90-2E x JG 67 is suitable for cultivation under timely sown irrigated condition of East Central Zone. It has attractive seed size of 25.46 g/100 seeds. It has an average yield potential of 2228 kg/ha and matures in 106 days. The variety has been released for cultivation in the East Central Zone comprising of Chhattisgarh and Eastern Madhya Pradesh.

Raj Vijay Gram 204 (RVSSG 8102): 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 and has attractive brown coloured seed of size 23.8 g/100 seeds. It has an average yield potential of 2250 kg/ha and matures in 110 days. The variety has been released for cultivation in Central Zone comprising of Maharashtra, Gujarat, Madhya Pradesh, southern Rajasthan and Bundelkhand region of Uttar Pradesh.

NBeG 810: The large seeded *kabuli* chickpea variety developed from cross ICCV 95311 × ICCV 95333 is suitable for timely sown irrigated condition of West Central Zone and North West Plain Zone. It has attractive beige-coloured bold seeds weighing more than 40 g/100 seeds and has average yield potential of 1836 kg/ha. Its maturity duration is 145-150 days in NWPZ and 110-115 days in WCZ. The variety has been identified for release in North West Plain Zone comprising of Punjab, Haryana, western UP, Delhi, North Rajasthan, Jammu and Kashmir and plains of Uttarakhand and West Central Zone comprising of Gujarat, Maharashtra, western Madhya Pradesh and Budelkhand region of Uttar Pradesh.

Kota Kabuli Channa 2 (RKGK 13-499): The large seeded *kabuli* chickpea variety developed from cross Phule G 517 X MPJGK-6 is suitable for timely sown irrigated condition of North West Plain Zone. It has attractive beige-coloured large seeds weighing more than 40 g/100 seeds. The variety showed average yield potential of 1734 kg/ha and matures in 143 days. The variety has been released for cultivation in North West Plain Zone comprising of Punjab, Haryana, western UP, Delhi, North Rajasthan, Jammu and Kashmir.

Raj Vijay Kabuli Gram 2020 (RVSSG 63): The *kabuli* chickpea variety developed from cross JSC 52 x RVKG 100 is suitable for timely sown irrigated condition of North West Plain Zone. It has attractive beige-coloured large seeds. The variety showed average yield potential of 1658 kg/ha and matures in 143 days. The variety has been released for cultivation in North West Plain Zone comprising of Punjab, Haryana, western UP, Delhi, North Rajasthan, Jammu and Kashmir.

Jawahar Gram *Kabuli* 6 (JGK 2017-32): The large seeded *kabuli* chickpea variety developed from cross JGK 2 x ICCV 95333 is suitable for timely sown irrigated condition of North West Plain Zone. It has attractive beige-coloured seeds weighing more than 40 g/100 seeds. The variety showed average yield potential of 1698 kg/ha and matures in 143 days. The variety has been released for cultivation in North West Plain Zone comprising of Punjab, Haryana, western UP, Delhi, North Rajasthan, Jammu and Kashmir.

RLBGK 1: The *kabuli* chickpea variety developed from cross JGK 1xICCV 95333 is suitable for timely sown irrigated condition of South Zone. It has attractive beige-coloured seeds weighing 36 g/100 seeds. The variety showed average yield potential of 1549 kg/ha and matures in 100 days. The variety has been identified for release in South Zone comprising of Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and parts of Odisha.

Pusa Chickpea 20211 (BG 20211): It is a *fusarium* wilt resistant introgression line of *desi* chickpea variety Pusa 391 developed through introgression of "QTL region" for wilt resistance on LG 2 having QTLs 1, 3, 4 and 5 from WR 315. It has an excellent grain colour, size and shape with average 100-seed weight of 19.5 g. The variety has an average yield potential of 2290 kg/ha and matures in 108 days. The variety has been released for cultivation in Central Zone comprising of Gujarat, Maharashtra and Madhya Pradesh.



Research Highlights

GERMPLASM AND SEED

- Thirteen Thousands Seven Hundreds Fourteen germplasm accessions were maintained at 21 centres. These accessions were evaluated for morphological traits and are being maintained.
- Total 12287.15 q of breeder seed of 69 chickpea varieties was produced against DAC indent of 10678.64 q including the carry over seed of indented varieties available with seed producing centres.

Crop Production

Agronomy

- On a strategic season-long weed control programme involving combination of pre- and post- emergence broad spectrum herbicides, the study revealed that pendimethalin 38.7 CS (0.75-1.0 kg/ha) PE + one hoeing at 30-35 DAS was optimum under Badnapur, while at Durgapura, pendimethalin + one HW at 30 DAS was optimum. At Imphal, pendimethalin 1.0 kg ai/ha alone as pre-emergence was optimum.
- Biofortification of Zn and Fe in chickpea through agronomic intervention could be possible as at both Sriganganagar and Dholi, combined application of RDF along with Zn and Fe (0.5% Zn+ 0.1% Fe) as foliar sprays at critical stages (pre-flower and pod formation) was found to be effective. However, RDF + Soil application of $ZnSO_4$ @ 25 kg/ha was the better option at Junagadh.
- 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 at Durgapura, Kota, Junagadh, Raipur and Kalaburagi, CFG 1 (with NPKSZnMo based on 100% recommendation) was optimum (with higher grain yield and economics) over rest of the treatments. This treatment was superior (to both RDF-NPK and RDF-NPKSZnBMo), thereby indicating saving of precious nutrients through CFG by chickpea crop.
- To scale up crop productivity and profitability in a tactical chickpea based intercropping system, it revealed that chickpea + linseed (6:2) at Durgapura, Samba, Shillongani and Raipur, chickpea + mustard (6:2) at Kota and Ranchi, and chickpea + sorghum (6:2) at Kalaburagi were the best.
- For enhancing crop and water productivity with supplementary irrigation through sprinklers in chickpea, the study showed sprinkler irrigation at both branch and pod (at par with flood irrigation at branch + pod) at Durgapura, Sehore and Kalaburagi was optimum. At Kalaburagi, zero tillage (ZT) to chickpea was better over conventional tillage (CT), while at Dholi and Sehore, crop response to CT was observed.
- 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 Durgapura and Raipur only with economic benefits. In most of the locations, salicyclic acid 100 ppm (or thiourea 500 ppm) applied at flower initiation and pod development was beneficial (at par with NPK::19:19:19 at 0.5 %).

Plant Physiology

- Higher NIR reflectance under water-limiting situation represented less water content while reverse for more leaf water content. Some of the drought tolerant chickpea genotypes such as Digvijay, PG 96006, Pusa 212,GG 2, GNG 1581 had shown to have moisture conservation mechanism to sustain normal metabolic activities under drought.
- The pigment anthocyanin expressed in some chickpea genotypes such as ICC 4958, Annegiri, PDG 4, Vaibhav, BG 1006, PG 5, PG 96006 BDG 75, GNG 663 and GG2 when water stressed was imposed which protect plant from oxidative stress. This pigment confers resistance to abiotic stresses
- The foliar application of Jasmonic acid @ 50 µmol twice at flowering stage increased yield by more than 15% and this was found to be effective in mitigating the adverse effects of drought.
- High internode length was associated with cold tolerance along with high numbers of branches at initial growth states. The chickpea genotypes PG 5, JG 74, PG 96006 and ICCV 92944 showed consistently higher yield under low temperature as compared to best known cold tolerant checks ICCV 88505 and ICCV 88506. Pollen fertility and fluorescence imaging of quantum yield as a measure of photosynthetic activity confirmed the cold tolerance of these genotypes
- Common mechanisms of tolerance to temperature extremities such as heat and cold

stress as well as drought were identified in chickpea which involved membrane stability, expression of antioxidant activity and modified photosynthetic responses. The precise physiological studies revealed that ICCV 92944 is aunique genotype having combined tolerance to multiple abiotic stresses.

Microbiology

- Two Mesorhizobium isolates FRW2 and FRW3 were found promising with the production of IAA, ACC-deaminase and P-solubilization. Out of 26 endophytes, 3 (flower) and 2 (seed) bacterial isolates were selected based on high production of phytohormones (IAA), P-solubilization, ACC-deaminase and siderophores
- Multilocation testing of 8 elite Mesorhizobium strains at 5 different centres showed that strain CR-53 (Pantnagar) out yielded all other strains by registering an increase in grain yield of 18.5% and was followed by RFC-117 & KBR-16-18(Kanpur) by 18.2%, and 17.3%, respectively over the control. However, none of the strain out yielded in comparison to 20 kg N/ha treatment.
- Three microbial consortia developed at IIPR, Kanpur for alleviating moisture stress were evaluated for their performance at 5 locations *viz*., Ludhiana, Kalaburagi, Durgapura Kanpur and Sehore. Pooled mean of different locations indicated highest grain yield of 20.2% with consortia II, followed by consortia III 19.6% over control. Enhancement in yield due to consortia II was 2.2% over 20 kg N/ha whereas, it was 8.8% and 14.8% over Mesorhizobium CR-13 (IIPR) and Mesorhizobium CH1233, respectively. The three consortia inoculants gave 15.9 to 20.2% more mean grain yield than the control across the locations. In general, Consortia II was found better than others at Ludhiana, Kanpur, and Durgapura except at Sehore where Consortia III was better than others in grain yield. Consortia II and consortia III microbes will be registered with ICAR-NBAIM, Mau.

Crop Protection

Plant Pathology

- In Advance Varietal Trial 2 + AVT 1 (*Desi*, irrigated timely sown),thirteen chickpea entries *viz.* DC 17-1111, RKG 18-1, Phule G 16109, RG 2015-08, JG 2018-52, NBeG 857, NBeG 798, DC 17-1115, RVSSG 67, PG 216, BG 4001, BDNG 2017-1 and CSJ 1065 were resistant or moderately resistant to wilt at 6 or more locations in different zones of India. In AVT 1 late sown, GNG 2418 was resistant or moderately resistant to wilt at 6 locations, whereas, BRC 421 at 5 locations. In AVT 1 (Rain-fed), Phule G 1010-14 and PBC 510 were resistant or moderately resistant to wilt at 7 and 8 locations, respectively.
- In AVT 2+AVT 1 (K + ELSK), 28 entries were tested against wilt. Among them, GLK 17301 (ELSK), HK 1630, GNG 2453, Phule G 16315, PG 219 (ELSK), RVSIG 63 (ELSK) (AVT 2), Phule G 16318, IPCK 13-163, RLBGK 3, NBeG 810 (ELSK) (AVT2), PG 220, and RKGK 13-499 (ELSK) (AVT2) were resistant or moderately resistant to wilt at six or more locations, whereas, in IVT, nine entries GLK 10-40, BG 4018, IPCK 2014-98, Phule G 171307, RSJK- 179, NBeG 1635, BUC -3, IPCK 2016-12 and HK 17-30 were resistant or moderately resistant at six or more locations.
- Three new *Trichoderma* strains obtained from IGKV, Raipur and one *Trichoderma* mutant from BARC centre were used for seed treatment and compared with chemical seed treatment for the management of wilt and dry root rot diseases of chickpea. *Trichoderma harzianum* T6 + Propineb (@ 10g + 1.5g/kg seed) were most effective in minimizing wilt/DRR incidence at six centres *viz.* Sehore, Shillongani, Dholi, Vijyapur and Junagadh.

Entomology

- The moth catch of *H. armigera* and *S. exigua* with pheromone traps were corelated with weather parameters and revealed that there was positive correlation with mean temperature (°C), sun-shine (hrs) and wind speed and negatively correlated with mean relative humidity (%) and rainfall (mm) in NWPZ. However, it had showed significant negative correlations with evening relative humidity in CZ and significant negative correlation with maximum temperature (r = -0.50), wind velocity (r = -0.48) and bright sunshine hours (r = -0.38) in SZ.
- In compatability experiment, the insecticides Chlorantraniliprole 18.5 % SC and Emamectin benzoate 5 % SG and foliar nutrients Urea, DAP and KNO_3 alone and their combinations did not show any phytotoxic effect on the crop when they were mixed together. They were compatible with each other. The foliar nutrients Urea, DAP and KNO_3 in combination with Chlorantraniliprole 18.5% SC and Emamectin benzoate 5% SG were statistically effective in terms of higher larval reduction and lower pod



damage and ultimately higher yield.

- In Evaluation of ecofriendly approaches for the management of gram pod borer, H. armigera experiment the treatment Chlorantraniliprole 18.5 SC % @ 0.25 ml/litre, HaNPV (2 x10^9PoBs) @ 250 LE/ha and Mahastra 0.5% Bt @ 4g/litre water were statistically effective in terms of lower pod damage, less larval population and higher grain yield of chickpea crop.

Frontline Demonstrations

- Three hundred demonstrations were conducted on package technology. On an average, 1656 kg/ha of yield was obtained through package technology against 1325 kg/ha by farmer's practice with an increase in grain yield by 25.0 per cent.
- Fifty demonstrations were conducted on package technology in rice fallow. The overall mean grain yield of package technology in rice fallow was 1214 kg/ha and mean yield of local practice was 976 kg/ha. The per cent increase in grain yield was 24.3%.
- Five demonstrations were conducted on Insect Pest management technology. The overall mean grain yield through IPM was 1668 kg/ha and mean yield of local practice was 1401 kg/ha. The per cent increase in grain yield was 19.1.
- Five hundred and twenty demonstrations were conducted in tribal areas under Tribal Sub Plan which gave an average yield of 1354 kg/ha which was 25.1% higher than yield obtained through traditional practices and varieties (1082 kg/ha).



All India Co-ordinated Research Projects
Pigeonpea

Crop Improvement

Varieties notified for commercial cultivation

Early duration

IPH 09-5: It is a CGMS based hybrid derived from CMS PA 163A × AK 261322R. The hybrid IPH 09-5 was notified for cultivation in North West Plain Zone (NWPZ). It is an early duration (151 days) high yielding (1822 kg/ha) hybrid exhibited an average of 43.5% yield superiority over the best checks. IPH 09-5 exhibited tolerant reaction to *Phytophthora* blight, sterility mosaic disease and moderately resistant reaction to *Fusarium* wilt. It has also shown very less damage due to pod fly and borer complex at field conditions. Hence, the hybrid IPH 09-5 has been identified for NWPZ comprising of Punjab, Delhi, Haryana and Western U.P. under early duration.

Mid early duration

WRGE 121: The variety WRG 121 was notified for South Zone (SZ) cultivation. It was developed by crossing WRGE-14 × ICP 825406 parents. It belongs to mid-early duration (151-165 days) and has exhibited high yield (1700 kg/ha) and yield superiority of 22% over the best checks. It has shown moderately resistant reaction to *Fusarium* wilt and it's at par in resistance to resistant check for sterility mosaic disease. Hence, was identified the variety WRG 121 was identified for South Zone comprising of Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha under mid early maturity group.

Medium duration

LRG 133-33 (Sowbhagya): The varieties LRG 133-33 (Sowbhagya) was notified and released for cultivation in South Zone (SZ). It was developed by crossing LRG 30 and ICP 8863 parents. It is medium duration (166-185 days) and has exhibited 14.61, 19 and 17.58 per cent yield superiority over ICP 8863, WRP 1 and Co 6, respectively. The variety LRG 133-33 (Sowbhagya) is moderately resistant to Fusarium wilt and sterility mosaic disease. Thus, the varieties LRG 133-33 (Sowbhagya) has been identified for South Zone comprising of Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Odisha under medium maturity group.

Long duration

IPA 15-2 (Sharada): The varieties IPA 15-2 (Sharada) has been notified for cultivation in North East Plain Zone (NEPZ). It was developed by crossing NA 1 and MAL 13 parents. It matures in 240-255 days with an average yield of 2266 kg/ha. Nevertheless, the potential recorded yield is up to 2998 kg/ha under favourable conditions. IPA 15-2 recorded 23.47, 19.24, 21.36 and 34.38 per cent superiority in yield over Bahar (1847 kg/ha), NDA 1 (1904 kg/ha), MA 6 (1882 kg/ha) and IPA 203 (1868 kg/ha), respectively. The variety IPA 15-2 is resistant to *Fusarium* wilt, sterility mosaic disease and moderately resistant to *Phytophthora* stem blight. Thus, the variety IPA 15-2 (Sharada) has been identified for North East Plain Zone comprising of Uttar Pradesh, Bihar and Jharkhand under late maturity group.

Pigeonpea entries promoted to advanced trials of *Kharif* 2020

Trial	Zone	Test Entries	Grain yield (kg/ha)		Days to 50% flowering	Days to maturity	100 seed wt.(g)
			Zonal mean	% increase over check			
IVT (E:131-150 days)	CZ	CRG 16-12	2037	26.75	108	158	9.23
AVT-1(E:131-150 days)	CZ	IPA 15-06	1791	11.44	96	151	10.63
AVT-1(E:131-150 days)	NWPZ	Pusa 2018-4	1630	17.60	91	143	8.84
AVT-2(E:131-150 days)	NWPZ	RKPV 413-02	1549	11.76	102	152	9.09
IVT(ME:151-165 days)	CZ	RVSA 28-1-1	2088	8.01	113	164	10.76
		PT 10-1-1-2	2157	11.58	124	169	1. 82
		BDN 2013-2	2 146	11.01	121	167	12.30
		WRGE 128	2285	18.21	118	170	10.73
		PT 11-4-4-1	2239	15.83	120	170	11.47
	SZ	WRGE 128	1362	5.01	113	168	10.30
		PT 11-4-4-1	1438	10.87	113	167	11.86

AVT-2 (ME:151-165 days)	SZ	WRGE 121	1712	10.8	114	161	10.26
	CZ	KRG 33	2360	14.48	107	162	10.91
IVT (M:166-185 days)	CZ	AKTM 1637	1941	7.59	120	178	11.10
		AKTM 1644	1971	9.25	119	176	11.23
AVT-1 (M:166-185 days)	SZ	TDRG 59	1733	13.49	124	175	11.86
AVT-2 (M:166-185 days)	SZ	PT 0723-1-2-3	1689	10.6	123	172	11.58
IVT (L:>200days)	NEPZ	BAUPP 17-41	1805	8.34	144	253	11.15
		Pusa 194	2008	20.52	154	249	11.29
		DA 19-1	1755	5.34	148	249	11.22
		MAL 52	2208	32.53	156	254	11.13
		IPA 15-21	1875	12.54	155	254	10.56
		KA 18-2	2484	49.09	143	251	11.09
AVT-1 (L: >200 days)	NEPZ	KA 17-2	2207	10.35	161	232	12.07
AVT-2 (L:>200 days)	NEPZ	KA 16-1	2231	10.06	157	236	12.51
		IPA15-2	2324	14.65	158	239	11.61

Pigeonpea hybrids promoted to advanced trials of *Kharif* 2020

The IHT (Early, North) comprised of eight hybrids (IPH 18-01, IPH 18-02, IPH 18-04, IPH 18-09, PHP 150, PHP 151, PAH 9 and PAH 10) while IPH 17-01, PAH 5 and IPH 09-5 were evaluated under AHT 1 and AHT 2, respectively. Three checks (Pusa 992, PAU 881 and ICPL 88039) were used in IHT + AHT 1+ AHT 2 (Early, North). In a similar manner, IHT (Early, South and Central) comprised of six hybrids (IPH 17-08, IPH 18-02, IPH 18-05, ICPH 2441, ICPH 3310, SKNPH 1504), while two entries SKNPH 1214 and SKNPCH 1411 were evaluated under AHT 1. Three checks (Rajeswari, CORG 9701 and GTH 1) were used for evaluation in this trial.

In IHT (Medium) (Central & South), four hybrids (ICPH 4200, ICPH 3881, ICPH 3762, ICPH 3933) were evaluated. The hybrid BDNPH 12-01 was evaluated in AHT 1. Both IHT and AHT1 were combined and three checks ICPH 2671, ICPH 2740 and Asha were used for evaluation. A total of thirteen locations were selected (Kanpur, Delhi, Ludhiana, Pantnagar, Akola, Badnapur, Gulbarga, Rahuri, Sehore, SK Nagar, Navsari, Bangalore, and Warangal).

Genetic resources evaluation and management under AICRP on Pigeonpea

- AICRP on pigeonpea coordinating centers has a pool of 1170 crosses and 8381 breeding lines derived from different crosses. During *Kharif* 2019 a total of 504 fixed lines were evaluated under preliminary yield trials and/or their respective station trials by different centers. Ten centres has more than 50 number of diverse crosses in which SK Nagar has the highest number (184) of crosses followed by Raipur (106), Khargone (96), Warangal (86), Ludhiana (86), Coimbatore (80), Rahuri (74) and Pantnagar (68).
- Pantnagar centre has advanced 2089 single plant selections (SPS) and evaluated 23 fixed lines under station trials for yield and yield attributing traits. Similarly, Warangal centre has advanced 1217 SPS and 21 fixed lines which were evaluated for yield and yield attributes. Two centres namely, Kanpur-CSAUA&T and Tripura did not evaluate any fixed lines. This is due to less number of crosses (7 each) with these centers and the breeding lines are still in segregating generations.
- AICRP on Pigeonpea has the total of 7534 germplasm collections with its 24 differerent coordinating centres. Of the total collections, 155 accessions are of wild type belonging to 10 different species.
- The maximum germplasm holdings are with Badnapur (1308) followed by Coimbatore (1147), Kalaburgi (547), Ludhiana (440), Kanpur,

CSAUA&T (390), Lam (345), Warangal (344) and Khargone (300).

- Badnapur centre has 30 wild pigeonpea accessions belonging to 9 different species followed by Ludhiana having 39 accessions belonging to four different species.
- During *kharif* 2019, a total of 2008 pigeonepa germplasms were evaluated for different traits namely, yield and yield attributes, biotic and abiotic stress resistance/tolerance, vegetable type, maturity *etc.*
- An average of 3.80 per cent germplasm utilization was recorded by different pigenpea coordinating centers. The highest per cent utilization was reported by Rahuri (17.60%) followed by Bangalore (13.28%), Viringipuram (12.30%), Medziphema (9.09%), Berhampur (9.04%), Warangal (6.67%), Junagadh (5.88%) and Khargone (3.00%)
- During *Kharif* 2019, a total of 137 new germplasm collecitons were added by different AICRP on Pigeonpea centers *viz.,* Warangal (58), Rahuri (25), Coimbatore (15), Medziphema (15), Viranjipuram (9), Ranchi (5), Berhampur (3), Tripura (3), Akola (2) and Kalaburgi (2).
- Four different centre's namely Badnapur from Central Zone, Kalaburgi from South Zone, Dholi from North Eastern Plain Zone and Ludhiana form North Western Plain Zone were identified as pre-breeding hubs for pigoenpea improvement. Except Dholi, others have reported their pre-breeding activities undertaken during *Kharif* 2019.
- Presently a total of 155 accessions belonging to 10 different species are being maintained however, six species namely *C. cajanifolius, C. scarabaeoides, C. platycarpus, C. Acutifolius, C. Sericeus and C. Albicans* were used for widening the genetic base in pigoenpea.

Breeder Seed Production

A total of 301.14 quintals of breeder seed was planned to be produced against the consolidated indent of 240.84 quintals for 45 varieties and four hybrid parental lines received from Department of Agriculture and Co-operation (DAC), Ministry of Agriculture, Govt. of India for *Kharif* 2019. On the basis of BSP IV received from various AICRP (Pigeonpea) centres which were involved in the breeder seed production of early, medium and late maturing pigeonpea varieties produced a total of 845.95 q breeder seed during *Kharif* 2019.

Of the total 45 indented varieties, nine (UPAS 120, BDN 2, Manak, Bahar, ICPL 87 (Pragati), Maruti (ICP 8863), ICPL 87119 (Asha), BSMR 736 and NDA 1) were released before 1997 and 14 varieties in between 2001 to 2009 while, 22 varieties were released after 2010.

Because of the old of varieties age and non lifting of breeder seed, two centres namely NDUA&T, Faizabad and JNKVV, Jabalpur did not taken up the BSP for the variety NDA 1 and ICPL 87119 (Asha), respectively. Except for five varieties namely TJT 501 (-2.4 q), JKM 189 (-4.2 q), VLA 1 (-1.75 q), BDN 2 (-0.1 q) and ICPH 2671 (A&B lines) (-3 q & -0.05 q) surplus quaintly (**605.11 q)** of Briding Seed was produced for other varieties. The four centres namely RVSKVV, Gwalior; ZARS, Sehore (RVSKVV, Gwalior); VPKAS, Almora and ARS, Badnapur met with deficit in BSP to their respective indented varieties.

Crop Production

Agronomy

Cropping system

- Pigeonpea + Soybean (1:4) and Pigeonpea + Urdbean (1:2 ratios) intercropping produced significantly higher pigeonpea grain equivalent yield than pigeonpea alone.
- Mechanized cultivation of pigeonpea under raised bed system with intercropping of green gram and black gram has registered significantly higher pigeonpea grain equivalent yield

Irrigation Management

- The pooled data of three years (2017 to 2020) indicated that irrigation scheduled at 75% CPE through drip recorded significantly higher pigeonpea grain yield (2509 kg/ha) and the spacing 120 x 60 cm (2494 kg/ha) significantly recorded higher grain yield. Further giving supplemental irrigation resulted in higher grain yield (1518 kg/ha) of pigeonpea as compared to rain fed pigeonpea (1075 kg/ha).



Nutrient and Pest management

- Application of recommended dose of fertilizers + Multi-micronutrient spray @ 2 ml/ litre water at 50% flowering +Indoxacarb at flowering + Dimethoate (30 EC) @ 0.03% at 15 days after first spray recorded better economic yield.

Effect of nipping and spacing

- Nipping of pigeonpea at 45 days after sowing (DAS) with the spacing of 90 x 30 cm recorded significantly higher pigeonpea grain yield, GMR, NMR, B:C ratio and Rain water use efficiency.

Enhancing production through foliar nutrition

- Application of recommended dose of fertilizer plus pulse magic 1% sprayed at flowering stage recorded significantly higher pigeonpea grain yield.
- The pooled data of two years indicated that RDF + 19:19:19 @ 0.5% spray at flowering recorded significantly higher grain yield.
- Application of RDF+$ZnSO_4$@0.5%+ $FeSO_4$@0.5% at flowering stage recorded significantly higher pigeonpea grain yield, gross returns, net returns and B:C ratio.
- Application of RDF and 0.5 % Borax spray at 50% flowering recorded higher yield.

Use of Gibberelic acid for enhancing productivity of pigeonpea

- Application of GA_3 @ 25 to 75 ppm at flower and pod initiation stages recorded significantly higher pigeonpea grain yield, gross and net monetary returns, and B: C ratio.

Evaluation of post emergence herbicide in pigeonpea

- Application of Imazethapry + Imazamox on 25 DAS as post emergence and one intercultural operation on 50 DAS recorded higher grain yield (1228 kg /ha), net income of ₹36,240 and BCR of 1.81.
- Application of Propaquizalop 2.5% + Imazethapyr 3.75% w/w @ 50 + 75 =125g a.i./ha at 20-25 DAS found superior.
- The herbicides Chlorimuron ethyl 9 g + Quizalofop ethyl 50 g ai/ha at 20-25 DAS recorded the yield of 1655 kg/ha.
- Combined application of Chlorimuron ethy 9 g + Fenoxaprop ethyl 70 g at 20 DAS together recorded the lowest weed count and weed dry biomass and the highest weed control efficiency and higher yield

Yield maximization

- Overall Zonal mean analysis showed that adoption of all the management practices *in toto* (INM +IWM +IPM) has registered higher pigeonpea grain yield in both the zones of CZ and NWPZ.
- Weeds were found to be the most important yield limiting factor at various centres so weed management is crucial in pigeonpea.
- In case of economics, adoption of combined practices of INM + IWM + IPM has registered higher benefit cost ratio.

Drought mitigation

- Higher average grain yield was obtained with application of pusa hydrogel with organic residue mulching in Central Zone. Where as in case of southern zone, application of FYM and Pusa Hydrogel followed by foliar spray of KH_2PO_4 and KNO_3 has registered higher average grain yield.

Compatibility of insecticides with plant growth regulator

- Tank mix application of Rynaxipyr + NAA at flowering and Indoxacarb at 15 days later has recorded higher grain yield of pigeonpea.
- Tank mix application of Indoxacarb and TNAU pulse wonder followed by Rrynaxipyr application at 15 days later has yielded higher grain yield in South Zone.

Effect of nipping and spacing in pigeonpea under North Eastern Hilly Zone

- At Tripura and Rakh Dhiansar of Jammu, nipping @ 45 DAS recorded significantly higher pigeonpea grain yield. Whereas the spacing of 75 x 30 cm found better at Tripura and 45 x 30 cm at Jammu.

Response of pigeonpea to tillage and mulching under NEHZ

- At Nagaland and Tripura, conventional tillage (One ploughing + One harrowing) recorded significantly higher yield which was at par with Zero tillage + Spraying of contact non-selective herbicide (paraquat) whereas as the Polythene mulch recorded significantly higher growth and yield.



Microbiology

- Diversity of native *Rhizobium* strains like AKPR-02, BPR-03, KRR-19-8, KRR-19-13, RA-19-04 and RA-19-08 were identified as potential candidates for evaluation.
- Performance of native rhizobial strains *viz.*, GAKPR-16 at Akola, KRR-18-5 at Kalaburagi and RA-18-16 at Varanasi are better than alien strains including national check at concerned testing centres.
- Effect of Pulse Magic Spray (PMS) on nodulation and grain yield of pigeonpea indicated that the highest grain yield was obtained with the inoculation of *Rhizobium* along with pulses magic spray (10 g/l of water) at 25th & 40th days after sowing.
- Co-inoculation effect of PGPR-18-14 enhanced the yield of pigeonpea through nodulation.

Crop Protection

Plant Pathology

I. **Host Plant resistance:** In screening trials against major diseases, an average per cent disease incidence cum scales were considered for evaluating pigeonpea entries and highlights of screening of pigeonpea entries for major diseases are mentioned below.

A. **Wilt:**

Wilt resistant entries *viz.*, BDN 13-41, BRG 16-1, GRG 152, GRG 177, ICPL 15084, ICPL15028, ICPL 15036, LRG 133-33, IPA 16F, IPA 20-121, KPL 43, KPL 44, MAL 45, MAL 46, MAL 47, TDRG 58, TDRG 60, IPA 203, BSMR 553, MAL 13, ICPWS 1904, ICPWS 1921, ICPWS 1942, IBTDRG 1, IBTDRG 2, IBTDRG 3, PT 0723-1-2-3, GRG 152, MAL 45, CORG 93, TDRG 58, MPV 106, LRG 223, KRG 33, BDN 2014, BDN 2014-1, TRG 87, GJP 1606,TDRG 59, MAL 13, MAL 49, IPA 2014-4A, BRG 5, BSMR 736, BSMR 853, KPL 44, IPA 8F, CRG 2015 and BDN 711

Wilt moderately resistant entries *viz.*, IPAE 15-02, BDN 2013-2, BDN 711, ICPL 17116, LRG 393, AKTE 12-04, KRG 33, WRGE 122, AKTM 1644, BAUPP 16-01, BDN 2013-5, BDN 716, GJP 1606, GJP 1801, IBTDRG 8, IPA 14-4A, BDN 2013-1, PT 0723-1-2-3, TDRG 59, IPA 18-8, MA 6, MAL 52, MAL 50, IPH 09-05, BSMR 1, BSMR 26, BSMR 65, BSMR 74, BSMR 79, BSMR 243, BSMR 316, BSMR 553, BSMR 736, BSMR 853, BWR 153, BWR 164, BWR 254, IPA 203, IPA 9F, ICPWS 1602, ICPWS 1603, ICPWS 1605, ICPWS 1607, ICPWS 1608, ICPWS 16, ICPWS 1613, ICPWS 1615- ICPWS 1618, ICPWS 1622- ICPWS 1627

B. **Sterility mosaic disease**:

SMD resistant entries *viz.*, BDN 13-41, BDN 711, BRG 16-1, BRG 16-2, IPA 9F, ICPL 15028, KPL 43, MA 6, MAL 13, PUSA 151 , PT 711-1-1-2, TDRG 60, ICPWS 1617, ICPWS 1618, ICPWS 1622 IPAE 15-02, BDN 711, IBTDRG 8, IBTDRG 10, IPA 7-2, IPA 14-4A, IPA 15-19, IPA 16 F, BDN 2013-1, Bahar, IPA 203, IPA 18-8, MA 6, MAL 52, DA 19-1, MAL 50, NDA 1, BRG 4, BSMR 1, BWR 153, IPA 203, IPA 9F, KPL 43, KPL 44, MAL13 and sixteen ICRISAT 's ICPWS.

SMD moderately resistant entries *viz.*, BDN 2013-2, ICPL 17116, IPAE 17-03, LRG 393, PT 0012, PT 10-1-1-2, PT 11-4-4-1, RVKT 322 and WRGE 128, WRGE 121, WRGE 122, BDN 2013-5, BDN 716, CRG 16-11,GJP 1606, GJP 1801, IPA 18-4, IPA 18-33, JKM 189, LRG 275, PT 0723-1-2-3, TDRG 59, BAUPP 17-41, IPA 16-18, KA 17- 02, MAL 51, DA 15-1, KA 16-1, KA 16-5, IPH 09-05, IPH 15-03, PAH 5, PAH 9, PAH10, BSMR 26, BSMR 65, BSMR 74, BSMR 79, BSMR 243, BSMR 316, BSMR 553, BSMR 736, BSMR 853, BWR 164, BWR 254, IPA 15F and WRG 65.

C. ***Phytophthora* stem blight:**

Entries *viz,* PA 421, CRG 2012-25, IBTDRG 2, PT 0704-1-2, BDN 2014-1BDN 2008-7, PAH 5 were found resistant against *Phytophthora* stem blight disease.

PSB moderately resistant entries *viz.*, IPAE 17-03, AKTE 12-04, IPA 18-4, RPS 2007-106-1, IPA 18-8, DA 15-1, IPH 09-05, BSMR 736, BWR 164, WRG 65. ICPPBN 1909, NTL 30, GJP 15028 and PT 711-1-1-2

D. ***Macrophomina* stem blight (MSB):**

MSB resistant entries *viz.*, BDN 2, RVSA 16-1, GJP 1606, WRG 122, BAUPP 15-21, PT 0704-1-2, IPA 2014-2 AKTE 12-02, IPA 9F, IPA 16F, KPL 43, KPL 44

MSB moderately resistant entries *viz.*, AL 1965, CRG 16-12, IPA 15-06, IPAE 15-02, IPAE 16-07, PA 574, PA 582, Pusa 992, IPA 15-03, BDN 2013-2, BDN 711, ICPL 17116, IPAE 17-03, LRG 393, PT 10-1-1-2, SKNP 1608, TJT 501, PT 0918-1-1, KRG 33, AKTM 1644, BDN 2013-5, BDN 716, CRG 16-11, GJP 1606, IBTDRG 8, IPA 7-2, IPA 13-1, IPA 15-19, IPA 18-4, IPA 18-33, PT 0904-1-1-2, WRG 327, WRG 369, BDN 2013-1, PT 0723-1-2-3, TDRG 59,



IPA 15-21, IPA 203, MA 6, MAL 52, IPA 16-18, KA 17-02, MAL 50, KA 16-5, BSMR 553, MAL 13, BSMR 1, BSMR 26, BSMR 65, BSMR 74, BSMR 79, BSMR 243, BSMR 316, BSMR 553, BSMR 736, BSMR 853, BWR 153, BWR 164, BWR 254, IPA 203 and IPA 9F.

E. *Alternaria* Leaf spot (ALS)

ALS resistant entries *viz.*, KPL 44, IPA 2014-2, KA 16-5, IBTDRG 1, IPA 17B-10, BDN 711, KRG 33, TDRG 58, PUSA 153, BDN 2, BDN 711, CRG 2013-12, IPA 9F, IPA 16F, LRG 133-33, MA 6, NTL 30, VRG O6-003

ALS moderately resistant entries *viz.*, PAU 881, Pusa 2019-1, CRG 16-12, PA 291, Pusa 992, PA 536, BDN 711, PA 592, GJP 1801, GJP 1820, BRG 4 and BSMR 1 were found moderately resistant against *Alternaria* leaf spot disease during *Kharif* 2019.

II. Epidemiology

A. Epidemiology of sterility mosaic

The incidence of pigeonpea sterility mosaic disease was observed at Dholi, Varanasi, Junagadh and Warangal. Dholi centre had very low incidence of sterility mosaic disease and Junagadh centre recorded absence of the sterility mosaic disease. However, Varanasi and Warangal reported that sterility mosaic disease was positively correlated with wind speed and vector population but changing in sowing dates did not show any significant difference in appearance of disease.

B. Epidemiology of *Phytophthora* stem blight:

Two centres *viz.*, Nagaland and Tripura reported that *Phytophthora* stem blight disease was positively correlated with rainfall. The correlation study in relation with average rainfall and disease incidence revealed that with decrease in average rainfall during the crop growth period, disease incidence also decreased.

III. Monitoring of race of *Fusarium udum*: The reaction of pigeonpea host differentials in wilt sick plot at 11 locations over the years across different zones indicated the possibility of presence of variability in *Fusarium udum* population across centres. Test entries have shown variation in reaction to wilt disease.

IV. Variability study in pigeonpea sterility mosaic virus: On the basis of pigeonpea host differential reaction against virus at Dholi, Varanasi, Badnapur, Rahuri, Bengaluru, Coimbatore, Dharwad, ICRISAT and Warangal, it was concluded that presence of variability exists in the pigeonpea sterility mosaic virus pathogen (PPSMV) at these centres. Particularly, Bengaluru centre had higher incidence of sterility mosaic disease as compared to other centres.

V. Survey and surveillance: Over the years, various farmers' and research fields of different cantres indicated the incidence of major diseases viz., wilt, sterility mosaic, *Phytophthora* blight, *Macrophomina* blight and *Alternaria leaf* spot. The Central Zone as well as South Zone recorded high incidences of wilt ranging 0 to100 per cent. However, the sterility mosaic disease incidence was recorded low at Dholi and Coimbatore *i.e.* in the range of 0 to 15 per cent and high at the Bengaluru up to hundred per cent. Varanasi centre recorded *Phytophthora* blight incidence from 17.35 to 71.87 per cent in research field. *Macrophomina* blight incidence was high (67.32%) when dry condition occurred in the research field of Badnapur center. *Alternaria* leaf spot disease severity on pigeonpea crop was high at Warangal and Nagaland center in scale 3 and 5, respectively.

Entomology

Host plant resistance

- Tolerant to gram pod borer and pod fly was low in IPA 16-18, MAL 51, WRGE 121 AKTE 12-04, PT 0918-1-1, WRGE 127. WRGE 122, AKTE 12-04, KRG 33, KA 16-5, DA 15-1. GRPH 3477, ICPH 7933, ICPH 2671, PHP 145, IPH 15-03, Pusa 163, MAL 45, Pusa 151, Pusa 153, DA 15-1, RKPV 403-02, KA 16-5 and MA 6
- The pod damage due to pod borer complex was low in IPH 15-03, IPH 09-05, AL 1992, WRGE 122, AKTE 12-04, GJP 1606, RPS 2008-5, PADT 16 and IPH 18-2
- Tolerance to *Maruca* and pod fly was found to be low in RKPV 413-02 (AVT 2) and IPA 15-06.

Insect pest management

- Flubendiamide 480 SC @ 0.2 ml/l; Thiamethoxam 25 WP @ 0.4 g/l ; Dinetofuron 20 SG @ 0.3 g/l; Diafenthiuron 50 WP @ 1.0 g/l Deltamethrin 2.8 EC @ 0.9 ml/l reduced pod fly incidence, pod and seed damage with high grain yield.
- Spraying of chlorantraniliprole 18.5 SC @ 30 g a.i/ha (0.3 ml/l), followed by flubendiamide 480

SC @ 30 g a.i/ha (0.2 ml/l) and dimethoate 30 EC @ 300 g a.i/ha (2.0 ml/l) at 10 days interval starting from flower bud initiation stage was very effective against pod borers and sucking pest.

- Lambda-Cyhalothrin 5 EC @ 25 g a.i / ha (1.0 ml/l) was found very effective against blister beetles, with higher no. of pods/plant and grain yield.
- Acephate 75 SP @ 750 g a.i/ha (2.0 g/l), fipronil 80 WG @ 50 g a.i/ha (0.125 g/l) and deltamethrin 2.8 EC @ 12.5 g a.i/ha (0.9 ml/l) performed well against pod sucking bugs, and the results are to be further confirmed
- Fipronil was found to be effective against pod bug; Profenophos 50 EC @ 2.5 ml/l; Deltamethrin 2.8 EC @ 0.9 ml/l; Acephate 75 SP @ 750 g a.i./ha have recorded less seed damage due to pod bugs.
- Insecticidal schedule consisting of chlorantraniliprole 18.5 SC @ 0.3 ml/l, fby flubendiamide 480 SC @ 0.2 ml/l was proved to be highly effective in recording less pod damage with significantly higher grain yield in all the centres.
- Experimental results on monitoring of major insect pests on pigeonpea revealed that in CZ, 42 to 50 SMW, in SZ, 37 - 52 SMW, in NEPZ, 9th & 10th SMW, in NWPZ, 40 - 47 SMW and in NEHZ, 43 - 47 SMW were crucial for different stages of *H. armigera* and *M. vitrata* which corresponds to active vegetative to pod development stage.

Survey and surveillance

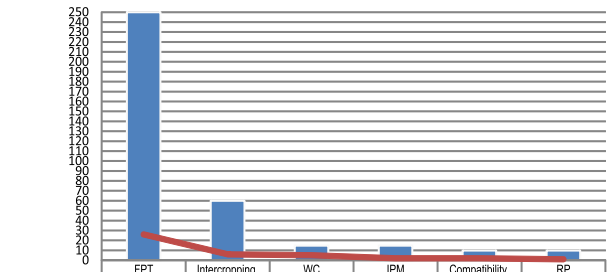
- Farmer's field surveys carried out during 2019-20 revealed that in CZ, the pod damage due to gram pod borer and pod fly ranged between 6.0 and 21.0% and 2.0 and 15.0%, respectively. In SZ, the pod damage due to gram pod borer, spotted pod borer and pod fly ranged between 0.2 and 16.4%, 0.6 and 60.0% and 10.0 and 60.0%, respectively with the highest being in Coimbatore. In NEHZ, the infestation of *M. vitrata* and *A. clavipes* ranged from 1.6 to 4.4 webs/plant and 2.4 to 5.4/plant, respectively. In NEPZ, the pod damage due to gram pod borer and pod fly and seed damage due to pod bugs ranged between 7.0 and 12.0, 21.1 and 32.1 & 5.3 and 7.6%, respectively. In NWPZ, *Maruca* and pod fly were the predominant pod borer pests whereas; pod bug was the major sucking pest of pigeonpea.

(iii) Nematology

- Entries moderately resistant to *Meloidogyne jaavanica*: WRGE 121 and AKTE-12-04, AKTM 1012, CRG -2012-25, GRG-177 and PA 414
- Entries moderately resistant reactions against *M. incognita*: RPCAU, Pusa and NDUAT, CO6 and CRG -2012-25
- Moderately resistant against *Heterodera cajani*: WRGE 121, AKTE-12-04, KRG-33, DA 15-1 and KPL 43.

Frontline demonstrations

- During *Kharif* 2019, a total of 360 pigeonpea Frontline Demonstrations (FLDs) was targeted and 304 demonstrations were conducted on six different components *viz.*, Full package technology (250 No.), Intercropping with soybean/other crops (60 No.), Weed control-pre and post emergence (15 No.), Integrated Pest Management (IPM) to manage pod borer complex (15 No.), Compatibility of growth promoter and insecticides (10 No.) and Ridge planting (10 No.) at 26 coordinating centers spread across the pigeonpea growing areas of the country (Fig 1).



	FPT	Intercropping	WC	IPM	Compatibility	RP
No. of FLDs	250	60	15	15	10	10
No of centers	26	6	5	2	2	1

Fig. 1: Component wise number of FLDs and total number of centres assigned to each components

- All together results 304 demonstrations conducted on six different components were reported.
- Full package technology increased grain yield by 29.64 % and 38.60 % over farmers practice and district average yield, respectively. Further, the high cost to benefit ratio (2.1) was recorded in 238 improved full package demonstrations.
- Intercropping of pigeonpea with soybean was more remunerative (42.75 %) than sole soybean crop.
- Demonstrations on pre and post emergence weed management recorded 36.74 % more grain yield with 1.67 costs to benefit ratio over farmers

practice.

- Insect pest management was found more beneficial and recorded 15.14 % higher grain yields with 2.54 cost to benefit ratio in 15 demonstrations conducted at Lam and Kalaburgi centers.
- Compatibility of growth promoter and insecticide (Effect of combined application of insecticide with growth regulator on yield) by applying this 36.4% more grain yield was obtained than the local practice with 48.48% higher net return.
- Planting on ridges recorded 19.71% higher grain yield as compared to flat sowing in demonstrations conducted by Dholi centre.
- Central zone has allotted the highest number (168) of FLDs across four different components

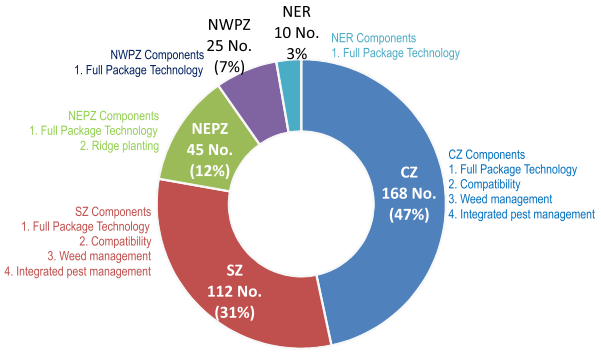


Fig. 2: FLD area allocated to different zones of pigeonpea cultivation

namely, full package technology, Intercropping with soybean, Compatibility of insecticide and growth regulators and weed management demonstrations. South Zone has 31 per cent of the total FLDs in five different components *viz.*, full package technology, intercropping with soybean, Compatibility of insecticide and growth regulators, weed management and integrated pest management (Fig 2).

DUS on Pigeonpea

During *Kharif* 2020, only one new farmer variety was received for DUS characterization. A set of 87 reference varieties namely 24 early, 38 medium and 25 long duration varieties were planted for rejuvenation.

TSP and NEH scheme under AICRP on Pigeonpea

Under NEH, 11 entries in IVT early and about 110 germplasm and breeding lines have been evaluated in Medziphema (Nagaland) and Agertala (Tripura) centres, Five acres each of FLD was also demonstrated 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 pigoenpea production technology. Under this scheme pigeonpea growing farmers/beneficiaries were trained on various aspects of pigeonpea production technologies.

All India Co-ordinated Research Projects
MULLaRP

Crop Improvement

Crop varieties released and notified

S. No.	Crop	Variety	Area of adoption	Salient features
1.	Mungbean	IPM 512-1 (Soorya)	NEPZ comprising states of eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal for spring season.	The variety is resistant to MYMV, Cercosphora leaf spot and Anthracnose. Maturity : 60-65 days Average yield : 12-13 q/ha
2	Mungbean	MH 1142	NEPZ (Eastern U.P., Bihar, Jharkhand, West Bengal, Assam) and NWPZ (Punjab, Haryana, Rajasthan, Uttarakhand and Delhi)	This variety has shown moderately resistance to Anthracnose and powdery mildew and resistance to MYMV. Maturity : 60-65 days Average yield: 11-12 q/ha
3.	Mungbean	KM 2342 (Azad Mung 1):	Uttar Pradesh during *Kharif* season	Moderate resistance to MYMV. Maturity : 65-70 days Average yield: 8-10 q/ha
4.	Mungbean	IPM 312-20 (Vashudha)	Uttar Pradesh during spring season	Synchronous in maturity and has shown moderately resistance to Anthracnose and powdery mildew and resistance to MYMV. Maturity : 70-75 days Average yield: 10-11 q/ha
5.	Mungbean	IPM 409-4 (Heera)	Uttar Pradesh during spring, summer season	Resistance to MYMV. Maturity : 65-70 days Average yield: 8-10 q/ha
6.	Urdbean	KPU 12-1735 (Kota Urd 4)	NEPZ comprising states of eastern Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal for spring season.	Moderately resistance to MYMV and *Cercospora* leaf spot Maturity : 77 days.
7.	Urdbean	VBN 9 (VBG 12-111)	Suitable for rice fallow cultivation in SZ comprising states of Andhra Pradesh, Tamil Nadu, Karnataka and Odisha	Moderately resistance to MYMV, leaf crinkle, leaf curl and powdery mildew. Maturity : 70-75 days Average yield: 12-13 q/ha
8.	Urdbean	VBN 10 (VBG 12-034)	SZ comprising states of Andhra Pradesh, Tamil Nadu, Karnataka and Odisha	Resistance to MYMV, ULCV and LC disease Suitable for *Rabi* season Average yield : 12-13 q/ha Maturity: 74 days.
9	Urdbean	VBN 11 (VBG 12-062)	Tamil Nadu	Moderately resistance reaction to MYMV, leaf spot and anthracnose. Average yield : 12-13 q/ha Maturity: 70-75 days.
10	Urdbean	OBG 33 (Shashi)	Odisha during Irrigated uplands, rice fallows of *Rabi* season &*Kharif* rainfed uplands of Odisha	Moderately resistance reaction to MYMV. Average yield : 11-12 q/ha Maturity: 70-75 days.



S. No.	Crop	Variety	Area of adoption	Salient features
11	Urdbean	KPU 524-65 (Kota Urd 3)	Rajasthan	Moderately resistant to MYMV, leaf spot and anthracnose Average yield : 10-12 q/ha Maturity: 68-74 days.
12	Lentil	L-4729	Central Zone comprising states of Madhya Pradesh parts of Uttar Pradesh and Rajasthan and Chhattisgarh	It mature in 103 days with average grain yield 0f 1747 kg/ha. It is moderately resistant to wilt and low incidence of major pests.
13	Lentil	Kota Masoor-3 (RKL605-03)	Central Zone (CZ) comprising sates of Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Uttar Pradesh and Rajasthan	It is moderately resistant to wilt, pod borer and aphids.
14	Lentil	LL 1373	North West Plain Zone (NWPZ) comprising states of Punjab, Haryana, Western Uttar Pradesh, Rajasthan, Himachal Pradesh and Uttarakhand	It is moderately resistant to wilt and rust.
15	Lentil	VL Masoor 148	Northern Hill Zone (NHZ) comprising states of Uttarakhand, Himachal Pradesh, Jammu & Kashmir and North Eastern hills.	It is moderately resistant to wilt and rust disease with average grain yield of 1148 kg/ha.
16	Lentil	IPL 534	Madhya Pradesh	This is extra early maturing variety having maturity 100-107 days with yield potential 16-18 q/ha. This variety showed resistance to *Fusarium* wilt and rust, which are the most important diseases of lentil.
17	Lentil	Chhattisgarh Masoor-1 (RL 3-5)	Rainfed and semi-irrigated conditions of Chhattisgarh	It is moderately resistant to wilt, rust, stemphyllium and powdery mildew. It is early maturing type (88-95 days) with average yield of 1008 kg/ha.
18	Fieldpea	IPF 16-13	North Eastern Plain Zone (NEPZ) comprised of eastern and central Uttar Pradesh, Bihar, Jharkhand, Assam and West Bengal	It is tall, leafy type variety with grain yield potential of 18-20 q/ha. It matures in 116 days with 19.0g of 100-seed wt. It is moderately resistant to powdery mildew, rust disease and moderately resistant to pod borer, aphid and leaf miner.
19	Fieldpea	IPFD 12-8	Uttar Pradesh	It is resistant to powdery mildew and tolerant to rust disease. It has medium seed size with round, smooth and creamish white colour and yellow cotyledons.
20	Fieldpea	IPFD 13-2	Uttar Pradesh	It is a dwarf and leafy type variety with average grain yield of 15-17 q/ha. It is resistant to powdery & downey mildew and tolerant to rust disease. It has medium seed size with round, smooth and white colour seed coat and yellow cotyledon
21	Fieldpea	Kota Matar (KPF 101)	Rajasthan	It is resistant to powdery mildew, downey mildew and root knot nematodes. It matures in 113 days with average grain.
22	Fieldpea	VL Matar 61	Uttarakhand	It is moderately resistant to wilt and powdery mildew. It is nutritionally rich with 28.6% protein content and average grain yield of 1130 kg/ha.





MH 1142 of mungbean



VBN 9 of urdbean for suitable rice fallow

Seed Production

- In mungbean, the total breeder seed production was 560.37 q against the indent of 523.66 q for 58 indented varieties. A total of 160 q breeder seed production programme has been taken as compensatory seed production and seed production of summer varieties during summer/spring 2020.
- In urdbean, the breeder seed production was 434.49 q against the indent of 348.72 q for 48 indented varieties. A total of 102.50 q breeder seed production programme has been taken as compensatory seed production and seed production of summer varieties during summer/spring 2020.
- In lentil, the total breeder seed production was 675.93 q against the indent of 475.66 q for 32 indented varieties.
- In fieldpea, the total breeder seed production was 717.93 q against the indent of 460.57 q for 25 indented varieties.

Crop Management

- Foliar spray of 0.5% $ZnSO_4$ + 0.5 % $FeSO_4$ at flower and pod initiation was found better for higher grain yield and economic return (net return ₹ 36,544/ha and B:C ratio 2.02) of mungbean.
- Application of Pendimethalin 30% EC @ 1.0 kg/ha PE fb fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS was found effective for controlling weeds and produced mean higher grain yield of urdbean, net return (₹ 25,812/ha), B:C ratio (1.86) and maximum weed control efficiency at 30 and 45 DAS over weedy check (81.6 and 82.3 per cent).
- Foliar application of 0.5% NPK 19:19:19 along with 0.5 % $ZnSO_4$ twice at pre flowering and pod initiation was found effective for enhancing grain yield under relay cropping in rice.
- Application of 50% recommended phosphorus dose along with basal application of 12.5 kg/ha $ZnSO_4$ + seed inoculation with biophos + biozinc @ 5 ml/kg seed was found effective for enhancing grain yield of fieldpea.
- Application of recommended dose of fertilizer (RDF) 20:17:16:20 – N:P:K:S kg/ha along with either soil application of 15 - 20 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 of lathyrus.

Crop Protection

- Seed treatment with imidacloprid 5 g/kg seed followed by foliar spray of Tebuconazole 50%+ Trifloxystrobin 25% wg @0.75 g/l at appearance of disease was highly effective against foliar fungal diseases in mungbean and urdbean.
- Fungicides propiconazole and tebuconazole were effective for lowering the disease severity of rust and increasing the yield in lentil. Whereas the fungicide Amistar was highly effective against stemphylium blight.

- The seed treatment with imidacloprid 600 FS @ 5 ml/kg seed followed by foliar application of pyriproxyfen 10 EC @ 100 gm *a.i*/ha was found the most effective on occurrence of sucking pests in mungbean and urdbean.
- The IPM modules comprises seed treatment with Carbendazim @ 2.0 g/kg,Thiamethoxam 35 FS @ 5.0 g/kg and *Rhizobium*, growing of millet crop in one rows around the field as barrier crop, monitoring with yellow sticky trap @ 50 number per ha, monotioring of *Helicoverpa* from flowering inititation stage with pheromone traps @ 10 number/ha, Spraying of neem based insecticide at 30days after sowing, and need based application of insecticides in rotation at 10 days intervals Flonicamid 50 WP @ 75 g a.i./ha, Chlorantarniliprole 18.5 SC @20 g a.i./ha were conducted over local farmers practices. The IPM modules found effective in reducing insect-pests incidence and giving more yield and net return in mungbean.
- Evaluation of some eco-friendly management practices against major insect pests of fieldpea indicated that the seed treatment with Imidacloprid 600 FS @ 3 ml/kg of seed + *Baccillus thuringiensis kurstaki* 127 SC @ 3 ml/l found effective treatments in fieldpea.

Frontline Demonstrations

- Package technology in *kharif* mungbean witnessed 22.5 per cent higher grain yield and 34.70 per cent increment in net returns over local farmers practices.
- Package technology showed 23 per cent grain yield increase over the farmer's practices with 26 per cent monetary benefits in terms of net return in lentil.



Arid Legumes

Plant Breeding

Varieties Identified

BSP 17-3 (Sabri Kulthi): This variety has been developed through selection from landrace collected from Bilaspur district and identified for northern part of the country. Plant is semi-determinate and seed coat colour is light brown. It matures in 100-103 days. 100 seed weight is 3.0 gram. Protein content is 24.4%. It is resistant to dry root rot.

BSP 17-1 (**Alakh Kulthi**): This variety has been developed through selection from landrace collected from Bilaspur district and identified for northern part of the country. Plant is semi-determinate and seed coat colour is light brown. It matures in 105-106 days. 100 seed weight is 3.1 gram. Protein content is 26.1%. It is resistant to dry root rot.

ATPHG-11 (**Anantha Vulava**): This variety has been developed through selection from local germplasm ATP-1 and identified for northern part of the country. Plants are having green foliage with medium sized leafs and seed coat colour is greyish brown. It matures in 105-110 days. 100 seed weight is 2.9 gram. Protein content is 24.1%. It is resistant to dry root rot and moderately resistant to YMD.

Promising Entries

Based on 2019-20 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	North	PCP 1124-1 (869), PGCP -70(780), KBC 11 (769) & PL-3 (ch) (730)
2	Cowpea	AVT-I+ IVT	South	MC 17-2 (KBC-12)(1400), DC 15 (ch) (1281)
3.	Cowpea (Summer)	AVT-I	-	GC-1601(1192), GC -1602(1170), RC-101 (1084)
		IVT	-	PGCP-71 (1164), GC 01802 (1075), RC-101 (1068)
4.	*Guar*	AVT-I+IVT	N+S	RGr 18-1(1099), CAZG 16-12 (1074), RGr 19-2 (1050), RGC 1033 (ch) (1049)
5.	Horsegram	AVT-II	North	BSP 17-3 (868), BSP 17-1 (865), BSP 17-2 (730), ATPHG 11 (821), AK 42 (ch) (725)
		IVT	North	CRHG 31 (892), BSP 19-3 (880), BSP 119-2 (880) SHG 007 (843), VLG 15 (ch) (813)

Breeder Seed Production

In case of four Arid Legume Crops, BS indent of 229.28 q was received. Total of 256.38 q of breeder seed was produced against the allocation target of 256.80q.

In case of *Guar*, 185.10 q of breeder seed was produced against the DAC indent of 178.53 q of 19 varieties. In case of cowpea, an indent of 20.05 q of 7 varieties was received and 26.17 q of breeder seed was produced. In case of moth bean, DAC indent of 18.90 q of 4 varieties was received and 20.00 q of breeder seed was produced. In case of Horse gram, indent of 11.80 q of 9 varieties was received. Total 28.11 q of Breeder seed was produced.

Agronomy

The trial "Agronomic evaluation of promising genotypes of cowpea" was conducted at two locations. At Bengaluru, no significant difference was observed between the two varieties, spacing and nutrient doses. However, among the spacing 45 x 10 cm (1338 kg/ha) has recorded higher yield and among the nutrient dose, application of 125% RDF (1476 kg/ha) has recorded higher yield.

At PRSS Samba, variety PL 1 (1156 kg/ha) recorded significantly higher seed yield as compared to the PL-3 variety (992 kg/ha). Among the spacing, the 45x10 cm recorded higher seed yield of 1163 kg/ha whereas the nutrient application of 125% recorded higher seed yield of 1149 kg/ha as compared to 100% RDF (999 kg/ha).

The trial "Effect of foliar application of nutrients to enhance productivity through combating the dry spell effect in cluster bean" was conducted at four locations on the basis of mean yield of the 4 locations, treatment T_5 *i.e.* folior spray of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stage was the best. This treatment gave an average yield of 1299 kg/ha followed by Treatment T_8 Foliar spray of soluble KNO_3 @ 0.5% at flower initiation & pod formation stage.



At Gwalior, foliar application of soluble NPK (19:19:19) 1% at flower initiation & pod formation stages gave significantly higher seed yield (1627 kg/ha) of cluster bean, net monetary return (₹ 46447/ha) and B:C ratio (3.14) over all the treatments.

At Durgapura, foliar spray of soluble NPK (19:19:19) @1% at flower initiation & pod formation stage spray resulted in seed yield (1389 kg/ha), Stover yield (2315 kg/ha) which was statistically significantly superior over T_1, T_2,T_6, T_7 and at par with T_3 , T_8 and T_4treatments of foliar spray, nutrient management.

At Hisar, highest seed and straw yield were recorded with treatment T_5 ie Foliar spray of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stage. However, maximum net returns (₹ 13619 /ha) and B:C ratio (1.51) was recorded with T_3.

At Bhilwara, application of 100% RDF+Spray of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stage gave significantly higher clusterbean seed yield (1353 kg/ha), net monetary return (₹ 749,75/ha) and B:C ratio (3.91) .

The trial "Effect of foliar application of nutrients to enhance productivity through combating the dry spell effect in horsegram" was conducted at Ananthapur. The results revealed that application of 100% RDF+spray of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stages gave significantly higher horsegram grain (1168 kg/ha) and straw yield (2594 kg/ha).

The trial "Effect of foliar application of nutrients to enhance productivity through combating the dry spell effect in cowpea" was conducted at Bengaluru and results revealed that Foliar application of soluble NPK (19:19:19) @1% at flower initiation & pod formation stage recorded significantly higher seed yield (1738 kg/ha) of cowpea and higher B: C ratio (1.91) as compared to all other treatments.

The trial "Effect of different spacing and fertility levels in cowpea" was conducted at two locations at Gwalior. Results showed that significantly highest cowpea seed yield (1395 kg/ha), net return (₹ 68,187 /ha) and B:C ratio (4.71) were obtained with spacing 45X10 cm (S_2)/ whereas fertility levels, the higher cowpea seed yield (1408 kg/ha), net return (₹ 69,000/ha) and B:C ratio (4.75) were recorded with the application of 100% RDF.

At S.K. Nagar, there was no significant difference was observed among the spacing and fertility levels. However, among the spacing 30 x 10 cm (1568 kg/ha) has recorded higher yield and among the fertility levels, application of 75% RDF (1614 kg/ha) obtained higher yield.

The Trial "effect of crop establishment method and weed control practices in clusterbean" was conducted at three locations. The highest mean yield of 1160 kg/ha was obtained with broad bed sowing method. Weed control practice, pendimethalin 30% + imazethapyr 2% @1,000 g/ha PE gave the highest yield of 1229 kg/ha.

At Gwalior, significantly higher clusterbean seed yield (1627 kg/ha), net return (₹ 50811 /ha) and B:C ratio (3.76) were obtained with broad bed sowing method. Amongst weed control practices, the higher clusterbean seed yield (1662 kg/ha), net return (₹ 52875 /ha) and B:C ratio (3.97) were recorded with the application of pendimethalin 30 % + imazethapyr 2% @ 1,000 g/ha as PE.

At Durgapura, significantly higher seed yield (1015 kg/ha), stover yield (2453 kg/ha) of clusterbean and B:C ratio 2.76 were achieved under broad bed sowing. In case of weed control treatments, the highest seed yield, Stover yield and B: C ratio 2.76 was found under pre-emergence application of pendimethalin 30% + imazethapyr 2% @ (velor) 1,000 g/ha.

At Hisar, results showed that among different crop establishment methods, significantly highest seed and straw yield were recorded with broad bed sowing (744.0 and 3431.7 q/ha, respectively). Among weed control practices, highest seed and straw yield were recorded with weed free check which were on a par with Pendimethalin 30%+ imezethapyr 2% @ 1,000 g/ha PRE.

The trial "Integrated nutrient management in clusterbean" was conducted at three locations. On the basis of mean yield, treatment (T_5) 100% RDF + seed treatment with *rizobium* + PSB + 2% urea spray gave highest yield of 1471 kg/ha.

At Gwalior, application of 100% RDF + seed treatment with *rizobium* + PSB + 1% 19:19:19 spray produced significantly higher seed yield (1724 kg/ha), stover yield (3755 kg/ha) of clusterbean and gave more net monitory returns (₹ 52,637/ha) and B:C ratio (3.62) over other treatments of nutrient management.

At Durgapura, based on two years mean data, 100% RDF + seed treatment with *rizobium* + PSB + 1% 19:19:19 spray resulted in the highest seed yield (1287 kg/ha), Stover yield (2556 kg/ha) of clusterbean with maximum B: C ratio 3.33.

At Bhilwara, application of 100% RDF seed treatment with *Rhizobium*+ PSB + 1% NPK (19:19:19) spray gave significantly higher clusterbean seed yield (1375 kg/ha), net monetary return (₹ 78969/ha) and B:C ratio (4.67) over all of the treatments.

The trial "Integrated nutrient management in cowpea" was conducted at Bengaluru and results showed that application of 100% RDF with *Rhizobium* and PSB seed treatment also along with foliar spray of WSF 19:19:19 @ 1% at vegetative stage has recorded significantly higher yield (1688 kg/ha), net returns (₹ 23022) and B:C ratio (1.83).

The trial "Effect of foliar nutrition on productivity of spring/summer cowpea" was conducted at four locations. The highest mean yield of 1049 kg/ha was obtained when Complex NPK (19:19:19) 2% spray at flower initiation and pod initiation was applied. In treatment T6 *i.e.* Salycilic acid, 100 ppm spray at flower initiation and pod initiation, recorded higher yield. The lowest mean yield (747 kg/ha) was recorded in absolute control (No spray).

The trial "Efficacy of post emergence herbicide to manage weeds for higher productivity of spring/summer cowpea" was conducted at four locations. The highest mean yield of (789 kg/ha) obtained under hand weeding once 25-30 DAS followed by treatment T5 *i.e.* Quizalofop ethyl, 5 EC @ 50 g/ha + imazethapyr 10% SL @ 75 g/ha (Tank mix) at 15-20 DAS (769 kg/ha). The lowest mean yield (446 kg/ha) was recorded in weedy check.

Plant Pathology

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

Clusterbean

At Bikaner, two entries *viz;* RGr 18-1 (AVT-I) and CAZG 17-16 were found free from bacterial blight disease. Rest all the entries were found highly resistant against bacterial blight. Eight entries *i.e.* RGC 1033 (ch), RGr 18-1 (AVT-I), RGr 19-2, CAZG 17-16, CAZG 17-24,RGr 19-10,RGr 19-14 and RGr 19-15were found free from root rot. At S.K. Nagar, all IVT entries were found highly resistant against BLB except RGr 19-7.

At ARS, Mandor, eight entries *viz;* HG 2-20 (ch), RGC 1033 (ch), RGr 18-1 (AVT-I), CAZG 16-12 (AVT-I),RGr 19-7, CAZG 17-24, GAUG 1507 and CAZG 16-21 were found resistant against BLB.Five entries *i.e.* HG 2-20 (ch), RGC 1033 (ch), RGr 18-1 (AVT-I), CAZG 16-21 and RGr 19-15 were found highly resistant against root rot.

At RARI Durgapura, one entry *i.e.* CAZG 16-12 (AVT-I) was found resistant. Eleven entries *viz;* RGC 1033 (ch), RGr 18-1 (AVT-I), CAZG 16-12 (AVT-I),RGr 19-2, CAZG 15-5-8,RGr 19-5, CAZG 17-16, CAZG 17-24,RGr19-10, GAUG 1507 and RGr 19-14 were found highly resistant against root rot disease.

Cowpea

At Bikaner, two entries *viz;* RC 101 (ch) and KBC-9 (ch) were found free from root rot. However, seven entries *i.e.* GC-3 (ch), TPTC-29 (ch), Pant Lobia-3 (ch), DC-15 (ch), Pant Lobia-4 (ch), PCP-0306 (ch) and MC 17-2 (KBC-12) (AVT-I)were found highly resistant against root rot disease.

At S.K. Nagar, two entries *i.e.* PGCP-69 and PCP 1124-1 were found free from *Cercospora* leaf spot disease and three entries *viz;* TPTC-29 (ch),PCP 1124-1 and KBC-11 were found free from yellow mosaic disease (YMD).

Mothbean

At Bikaner, five entries *viz;* CZMO 17-1, MBS -0845, MBS-821, MBS 084-5 and RMO 4-1 were found free from leaf crinkle. Four entries (CZMO 17-1, MBS -0845, MBS-821 and MBS 084-5) were found free from root rot disease. However, five entries *viz;* CZM-2 (ch), RMO-2251 (ch), RMO-257 (ch), CZMO 17-2 and RMO 4-1 were found highly resistant against root rot.

At S.K. Nagar, two entries *viz;* MBS -0845 and MBS-821 were found free from MYMV and two entries *i.e.* CZM-2(ch) and MBS 084-5 showed resistance reaction. At ARS Mandor, six entries *viz;* RMO-257(ch), CZMO 17-1, MBS-0845, MBS-821, MBS 084-5 and RMO 3-5 showed highly resistance reaction against MYMV disease.

Horsegram

At S.K. Nagar, three entries *i.e.* ATPHG-11 (AVT-II), BSP 17-2 (AVT-II) and BSP 17-3 (AVT-II) were found highly resistant against root rot disease. In IVT two entries *viz;* IPH 18-5 and CRHG-31 were found free from the *Cercospora* leaf spot disease.

At Pattambi, in AVT-II four entries *viz;* (AK-42 (ch), VLG-15 (ch), ATPHG-11 (AVT-II) and BSP 17-2 (AVT-II) were found free from dry root rot. In IVT twelve entries *i.e.* VLG-15 (ch), Bilasa Kulthi (ch) ,CRIDA 1-18-R (ch), Ch. Kutlhi-3, CRHG-22 (ch), BSP 19-1, SHG -07, VLG-50, IPH 18-5, CRHG-31, OHG-142 and BSP 19-3 were found free from dry root rot.

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

At Gwalior, it was observed that dry root rot



incidence range from 5.00 to 47.50 %. None of the entry was found free from dry root rot. However, one entry *i.e.* Pant Lobia-4 was found highly resistant and two entries *viz*; Pant Lobia-3 and MC 17-2 (KBC-12) (AVT-I) were found resistant against dry root rot. Eight entries *viz*; GC-3 (ch), TPTC-29 (ch), RC 101 (ch), KBC-9 (ch), CPD-313, PGCP-69, GC-1602 and PGCP-70 were found moderately resistant against root rot disease. The maximum disease incidence of root rot was observed in entry CPD-311 (47.50 %).

At Pattambi, only two entries *viz*; GC-3 (ch) and KBC-13 were found free from dry root rot. However, only one entry Pant Lobia-4 (ch) was found resistant and three entries MC 17-2 (KBC-12) (AVT-I), PGCP-69 and PGCP-70 were found moderately resistant. As far as collar rot is concerned, ten entries *viz*; GC-3 (ch), RC 101 (ch), KBC-9 (ch), Pant Lobia-4 (ch), PCP-0306 (ch), CPD-313, PGCP-69, TC-1901, GC-1712 and PGCP-70 were found free from disease. However, four entries i.e. MC 17-2 (KBC-12) (AVT-I), CPD-311, KBC-13 and KBC-11 were found highly resistant against disease.

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

At ARS Bikaner, 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. The results pertaining to grain yield of clusterbean revealed that the maximum grain yield 15.67 q/ha was recorded in the same treatment.

It is recommended to treat the seeds with a combination of *T. harzianum*+ *P. fluorescens* (4+4 g/kg seed) and apply *T. harzianum*+ *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) which mange the root rot incidence and increase grain yield.

At RARI, Durgapura, treatment combination *T. harzianum*+ *P. fluorescens* seed treatment (4g + 4g /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 (4.96%) was recorded. Maximum grain yield (8.71q/ha) was also recorded in the same treatment.

Management of Alternaria blight of clusterbean

At Gwalior centre, treatment T_3 *i.e.* foliar spray with Tebuconazole 250 EC @ 0.1 % was found, most effective at initiation of flowering and at pod stage among all the treatments tested with minimum disease severity (9.87 and 12.00%). Maximum seed yield and straw yield (2077 and 3994 kg/ha, respectively) was also recorded in the treatment $T_3$with the highest B:C ratio of 4.55 over all the other treatments.

At S.K. Nagar, minimum alternaria blight was recorded 0.33 in treatment T_6 *i.e.* foliar spray with Trifloxystrobin 50% WG @ 0.1% followed by treatment T_7 *i. e.* foliar spray with Zineb 68% + Hexaconazole 4 % W P @ 0.2 % (0.50). Maximum grain yield 610.00 kg/ha was recorded, in the treatment foliar spray with Trifloxystrobin 50 % WG @ 0.1 % (T_6).

At RARI, Durgapura, minimum Alternaria blight (4.60%) was recorded in treatment T_4 i.e. foliar spray with Propiconazole 25 EC @ 0.1 % followed by treatment T_3: foliar spray with Tebuconazole 250 EC @ 0.1 %. Maximum grain yield (8.9 q/ha) was also recorded in T_4 treatment.

Evaluation of seed dressing fungicides against charcoal rot of cowpea

At ARS, Bikaner, minimum charcoal rot incidence (2.60 %) was recorded in treatment T_5i.e. seed treatment with Tebuconazole 2 DS @1.5 g/kg seed + soil application of *T. harzianum* 2.5 kg in 500 kg FYM/ha followed by treatment T_4: seed treatment with Carboxin 37.5% + Thiram 37.5%WP @ 2g/kg seed + soil application of *Trichoderma harzianum* 2.5 kg in 500 kg FYM/ha (3.66 %). Maximum grain yield (547.32 kg/ha) was also recorded in treatment T_5..

At RARI, Durgapura, minimum charcoal rot incidence (5.00 %) was recorded in treatment T_7 i.e. seed treatment with Tebuconazole 50% + Trifloxystrobin 25%WG @ 1.5 g/kg seed + soil application of *T. harzianum* (2.5 kg in 500 kg FYM/ha) with the highest grain yield of 6 q/ha.

Entomology

Evaluation of genotypes in coordinated varietal trials

Cowpea

At Bikaner, the minimum incidence of leaf hopper was observed in PCP- 0306 (1.4 leaf hopper/leaf), however, in case of whitefly, it was minimum in PGCP-69 (1.0 whitefly/leaf).

At S.K. Nagar, the incidence of leaf hopper was minimum in TPTC-29 (ch) and PCP-0306 (ch) (0.50 leafhopper/trifoliate), whereas pod borer damage was minimum KBC-13 and PCP 1124-1 (4.5%).

At Durgapura, minimum population of whitefly, jassid and aphid was observed in DC-15, CPD-311 and PCP-0306. Whereas at Dharwad, minimum pod damage was recorded in PGCP- 69 (27.8%).

At Pattambi, GC-3 (ch), TPTC-29 (ch), KBC-9 (ch), Pant Lobia-3 (ch), PCP-0306 (ch), MC 17-2 (KBC-12) (AVT-I), CPD-311, KBC-13, PGCP-69, PCP 1124-1, KBC-11, GC-1602, GC-1712 were found free from aphid infestation.

Clusterbean

At Bikaner, data revealed that the leafhopper population was minimum in HG 2-20(1.5 leafhopper/leaf). However, the whitefly population was minimum in HG 2-20 (0.8 whitefly/leaf). At S.K. Nagar, the minimum population of leafhopper was observed in RGr 19-15 (1.50 leaf hopper/leaf), However, whitefly was minimum in HG 2-20 (5.0 whitefly/leaf) and root beetle damage was minimum in CAZG 16-21 (3.69%). At Durgapura, minimum population of whitefly, jassid and aphid was observed in HG 2-20, KBC-13, CPD 313, PCP 1124-1 and KBC-11.

Mothbean

At Bikaner, data revealed that the leafhopper population was minimum in CZM-2 (1.5 leafhopper/leaf). However, the whitefly population was minimum in RMO-2251 (1.0 whitefly/leaf). At S.K. Nagar, the minimum population of leafhopper was observed in CZMO 17-2 (0.77 leaf hopper/leaf). However, whitefly population was minimum in MBS084-5 (0.33 whitefly/leaf).

Horse gram

At S.K. Nagar, in IVT the entry BSP 19-2 had minimum incidence of leaf hopper (0.78/leaf), However in AVT-II, the minimum incidence of leaf hopper was observed in BSP 17-2 (0.58/leaf).

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

At S.K. Nagar, this experiment was conducted for three years. Pooled results indicated the foliar spray with Chlorantraniliprole 18.5 SC @ 0.3 ml/ litre (T2) water was found significantly superior (5.99%) in reducing the pod borer damage in cowpea which was at par with treatments T_1 and T_3. Significantly maximum (971 kg/ha) yield was also recorded in T_2 treatment. This treatment also gave maximum net return (₹ 14,067.50/ha) and incremental cost benefit ratio (1:1.32).

At Dharwad, the results indicated that among different insecticides, rynaxpyre @0.3ml/L was the most effective followed by Emamectin benzoate @ 0.50 g/L and recorded, least % pod damage of 13.77 and 22.47%, respectively. Rynaxpyre treated plots recorded 73.73%, reduction in pod damage as compared to untreated control, whereas Emamectin benzoate recorded 57.14% reduction.

Management of sucking pests of cluster bean

At Bikaner, the minimum population of whitefly (2.19/leaf) and leafhopper (3.92) 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 2.49 and 4.11/leaf, respectively at 3 DAS. At 7 DAS, minimum population of whitefly (1.82/leaf) and leafhopper (2.51) was recorded in the treatment of T_2: NSKE 5% @ 50 g /lit followed by T_5: *Azadirachtin* 1500 ppm@ 4g/lit in which the whitefly and leaf hopper population was 1.96 and 2.79/leaf respectively. However, at 10 DAS, minimum population of whitefly (195/leaf) and leafhopper (2.54) was recorded in the treatment of T_6: *Beauveria bassiana* @ 4g/lit.. The maximum grain yield was recorded in the treatment of NSKE5% @ 50 g/lit.(1192 Kg/ha) followed by *Beauveria bassiana* @ 4 g/lit.in which the grain yield was 1094 Kg/ha.

At S.K. Nagar, the bioefficacy of biorationals revealed that 3 days after spray (DAS), the foliar spray with *Beauveria bassiana* (T_6) was significantly superior (0.42/leaf) in reducing the whitefly population and was at par with NSKE 5% (T_2) *Lantana camera* 10% (T_4) and Azadiractin 1500ppm (T_5). Whereas, 7 DAS only T_6 maintained its significant effect (0.99/leaf) and was at par with T_2. Ten DAS, only T_6 was significantly effective (1.01/leaf) as compared to rest of the treatments in reducing the whitefly population. At 3 DAS the leafhopper population, significantly lower (0.11 /leaf) in T_6 and was at par with T_5. At seven DAS, also T_6 (0.44/leaf) was found to be significantly better than rest of treatments and was at par with T_5. Treatment 6 maintained its significant lead (0.87/leaf) even after 10 DAS and was at par with T_5. Significantly maximum (656.30 kg/ha) yield was also recorded again in T_6 and par with T_5 and T_2.

At Durgapura, treatment no. 5 *i.e. Azadirachtin* 1500 ppm@ 4 gm/lit and treatment no 2 *i.e.* NSKE 5%



@ 50 g /lit. was found superior as compared to other treatments.

Evaluation of biopesticides against major insect pests of cowpea

At Bikaner, the variety used was Bidoli local. Among these treatments, Azadirachtin 1500 ppm @ 4ml/lit had minimum population of Jassid and whitefly at 3 and 7 DAS in cowpea and this treatment also gave maximum grain yield.

At Durgapura, in this experiment, the variety RC 101was sown and treatment no. 4 *i.e.* Azadiractin 1500 ppm @4 ml/lit and treatment no.3 *i.e. Bacillus thuringiensis* (NBAIR strain) @ 20 ml/lit found superior.

At Dharwad, among different biopesticides evaluated *Beauveria bassiana* @ 5 gm/L was found most effective followed by neem soap @10g/L with lowest per cent pod damage and recorded 61.15% and 53.80% reduction in pod damage, respectively as compared to untreated control.

Population dynamics of insect pests and associated natural enemies of moth bean

At Bikaner, the overall insect population remained low during the entire crop period. Whitefly population started from last week of August and continued till 3rd week of September, the peak was observed in 2nd week of September. Whereas leaf hopper incidence was started during 3rd week of August and remained up to 3rd week of September, the peak was observed in 1st week of September. The maximum population of spider and *Chrysoperla* was also observed during 1st week of September.

At S.K. Nagar, the overall insect population in mothbean remained low during the entire crop period. Also, the number of rainy days and rainfall were also high during the crop period which had an impact on insect population. The whitefly population started from 34th standard week (3rd week of August) and continued till 37th std. week (2nd week of September). The peak was observed during first week of September. Whereas, incidence of leafhopper started a week later during third week of August with a peak at 2nd week of September.

Quality Characters

Clusterbean

Mean Protein content was maximum in CAZG 15-5-8 (29.19%).

Mean value of carbohydrate content was maximum in the RGr 18-1(AVT-I)(44.93%).

Maximum mean endosperm content was observed in CAZG 16-12(AVT-I) (34.58%).

Maximum mean gum content was observed in HG 2-20 (31.45%).

Maximum mean viscosity was observed in RGC-1033 (3773cp).

Cowpea

Mean value of protein content was maximum in the GC-3(ch)(25.78%).

Trypsin inhibitor activity was minimum in Pant Lobia-3(ch) (2028TUI/g).

Minimum tannin content was observed in the Pant Lobia-4(ch)(0.380 mg/g).

Phytic acid content was minimum in GC-3 (ch) (5.65mg/g).

Frontline demonstrations

In cowpea, total 90 frontline demonstrations were organized. Over all mean yield of high yielding varieties with improved technology was 828 kg/ha and yield of local practices was 657 kg/ha. 20.6 per cent increase in yield was recorded in demonstrations. In cluster bean, 55 demonstrations were organized and mean yield of the frontline demonstrations was 1114 kg/ha which was 21.7% higher than the yield obtained through farmers practices (872 kg/ha). In horsegram, 65 Frontline demonstrations were organized. The average yield of demonstrations with improved practices was 720 kg/ha which was 21.3% higher than the yield of farmers practices (567 kg/ha).

Tribal Sub Plan

In cowpea, 17 demonstrations were organized by two centres *i.e.* SDAU, S.K. Nagar and MPAUT, Bhilwara. The yield obtained in demonstrations plot was 974 kg/ha as against 622 kg/ha in check plots. In case of clusterbean, 65 demonstrations were organized to demonstrate the potential of high yielding varieties like RGC 1055, RGC 936, RGC 1077 and GG-2. The mean yield of high yielding varieties was 768 kg/ha which was 22.8% higher than average yield of traditional varieties (592 kg/ha). In horsegram, total 85 demonstrations were conducted by MPUA&T Bhilwara and ARS, Bilaspur by distributing the seed of varieties AK 53, AK 42, AK 21 and Chhattisgarh Kulthi-2. The average yield obtained in case of high yielding variety was 678 kg/ha. Farmer's obtained 538 kg/ha by adopting new varieties and production & Protection technologies. In mothbean, S.K. Nagar organized 19 demonstrations and in which 8 demonstrations were failed. The yield was low but 11.1% increase in average yield was observed.

Transfer of Technology

Training and extension activities organized during January 2020- December 2020

Sl. No.	*Activity*	*Duration*	*No. of participants*
1	Training Programme on Improved technologies for Pulses Production and Agricultural Management sponsored by Development Foundation New Delhi	January 14-16, 2020	22
2	Training Programme on Enhancement of Farmers Income through Improved Pulses Production Technology, Processing and Marketing Strategies	January 27-29, 2020	25
3	Training Programme on "Improved Technologies for Pulses Production" Crops sponsored by ATMA, Kanpur Dehat	February 20-22, 2020	39
4	Training Programme on "Improved Technologies for Pulses Production" crops sponsored by ATMA, Datiya M.P.	February 24-28, 2020	26
5	Training Programme on "Improved Technologies for Pulses Production" sponsored by ATMA, Fatehpur, Uttar Pradesh	March 13, 2020	34
6	Training programme on "Improved Technologies for Pulses Production" sponsored by ATMA, Ballia, Uttar Pradesh	March 16-18, 2020	27
7	Online Training Programme on "Better Livestock Management and Measures for Higher Returns"	July 31, 2020	31
8	Online Training Programme on Disease and Insect Management of *Kharif* Season Crops	August 07, 2020	34
9	Online Training Programme on "*Kisano Ki Adhiktam Aya Ke Liye Unnat Sabji Utpadan Takniki*"	August 14, 2020	36
10	Online Training Programme on Awareness on Congress Grass	August 21, 2020	38
11	Online Training Programme on "Soil and *Jal Sanrakshan Ki Adhunik Krishi Me Bhumika*"	September 09, 2020	52
12	Online Training Programme on "*Rabi Dalhani Faslo Ki Unnat kheti*"	September 10, 2020	62
13	Online Training Programme on "*Rabi Dalhani Faslo se Adhiktam Aya Hetu Unnat Prabandhan*"	September 18, 2020	48
14	Online Training Programme on *Kisano Ki Adhiktam Aya Ke Liye Tilhan* and *Gehu Ki Unnat Utpadan Takniki*	September 25, 2020	38
15	Online "*Khadya Prasansakaran* and *Mulya Sambardhit Krishi Adharit Udhyog*"	October 09, 2020	45
16	Online Training Programme on "World Soil Day" "*Fasal Utpadan Me Soil ka Mahatva*"	December 05, 2020	72
17	Training Programme on "*Dalhani Faslo Ki Unnat Kheti* and *Bagwani Ka Prabandhan*"	December 11 , 2020	28
18	Online Training Programme on World Soil Day *Ke Ausar Per Dalhan ka Mahatva* : Health and Environment	December 23, 2020	93
19	Training Programme on "*Basic Skills in Computer Operation*" for Skill Supporting Staffs of the Institute	February 28-29, 2020	22



Exposure visits of farmers and stakeholders

Sl. No.	*Participants from the Districts*	*No. of Participants*	*Date*
1	Ambedakar Nagar, U.P.	57	8/01/2020
2	Damoh, M.P.	68	09/01/2020
3	Chhatarpur, M.P.	26	18/01/2020
4	Ballia, U.P.	41	21/01/2020
5	Varanasi, U.P.	25	22/01/2020
6	Bijnour, U.P.	11	22/01/2020
7	Kasganj, U.P.	27	22/01/2020
8	Mirzapur, U.P.	15	22/01/2020
9	Damoh and Panna, M.P.	36	23/01/2020
10	Madhya Pradesh	20	26/01/2020
11	Sehore, M.P.	24	30/01/2020
12	Madhya Pradesh	37	07/02/2020
13	Shahdole, M.P.	60	07/02/2020
14	Chhatarpur, M.P.	10	07/02/2020
15	Raibareli, U.P.	11	11/02/2020
16	Raibareli, U.P.	60	13/02/2020
17	Jaloun, U.P.	60	15/02/2020
18	Kanpur, U.P	28	17/02/2020
19	Hathras, U.P	65	18/02/2020
20	Gorakhpur, U.P.	117	19/02/2020
21	Tikamgarh, M.P.	15	19/02/2020
22	Anooppur, M.P.	44	19/02/2020
23	Gorakhpur, U.P.	80	22/02/2020
24	Siddharth Nagar, U.P.	60	22/02/2020
25	Satana, M.P.	36	22/02/2020
26	Basti, U.P.	50	23/02/2020
27	Unnao, U.P.	72	24/02/2020
28	Satana, M.P.	36	26/02/2020
29	Gorakhpur, U.P	50	26/02/2020



Sl. No.	*Participants from the Districts*	*No. of Participants*	*Date*
30	Shahdole, M.P.	28	27/02/2020
31	Shivpur, M.P.	20	03/03/2020
32	ATMA, Deoria	110	04/03/2020
33	Satana, M.P.	10	04/03/2020
34	Satana, M.P.	10	04/03/2020
35	Satana, U.P.	50	04/03/2020
36	Datiya, M.P.	30	04-05/03/2020
37	Sagar, M.P.	39	05/03/2020
38	Satana, M.P.	50	06/03/2020
39	Prayagraj, U.P.	08	13/03/2020
40	Datiya, M.P.	30	04-05/03/2020
41	Sagar, M.P.	39	05/03/2020
42	Satana, M.P.	50	06/3/2020
43	Prayagraj, U.P.	08	13/3/2020
44	Rewa, M.P.	39	16/03/2020
45	Bhind, M.P.	09	23/12/2020



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Abstracts

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Sonika Pandey, Kulbhusan Mani Tripathi, Monika Mishra, R.K.Mishra, Krishna Kumar and Lalit Kumar (2019). Role of Nanotechnology in Agriculture sector. Dalhan Alok 17: 59-60

Uma Sah and Rashmi Yadav (2020). *Soochna proudyogiki ke anuprayog dwara dalhan utpadan taknikon ka prabhavi hastantaran*, Krishi Shodh Darpan 3 : 55-59.

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Oral Lead presentation

Uma Sah, N. Kumar, Sujayanand, G.K., R.K. Mishra, P.K. Katiyar, G.P.Dixit, S.K. Chaturvedi and

N.P.Singh(2020). Capitalizing farmers' institutions for strengthening the pulse seed system in central India, in International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities) organized by ISPRD, Kanpur to be held at Bhopal during Feb. 10-12, 2020.

Dubey,S.K.; Uma Sah and A. Singh. 2020. Geo-spatial Experiences in Front Line Extension of Potato Production Technologies in India. In Global potato conclave 2020, organised during 28-31 January 2020, Mahatma Mandir, Gandhinagar, Gujarat.

Pandey,N.K.; Uma Sah and S.K.Dubey. 2020. Technology Transfer, Policy and Social Issues in Potato Production: National and Global Perspectives. In Global potato conclave 2020, organised during 28-31 January 2020, Mahatma Mandir, Gandhinagar, Gujarat.

Singh, S.K., Uma Sah and M.S.Meena (2020). Effectiveness of Farmer to Farmers Extension model for enhancing technology uptake in pulses.In International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities) organized by ISPRD, Kanpur to be held at Bhopal during Feb. 10-12, 2020.

Uma Sah and S.K.Singh 2020. Institutionalizing farmer to farmer extension model: Evidences from pulse crops. (Lead Hamirpur)

Book

Padaria,R.N.; S.K.Dubey, Uma Sah, B P Mishra, B K Gupta, Dheeraj Mishra, P.K. Ojha, Diksha Patel, A.P. Verma and V. Joshi.2020. Abstracts: National Seminar on Socio-digital approaches for transforming Indian Agriculture, CCS HAU, Hisar, Haryana organized by Indian Society of Extension Education. pp. 152.

Papers presented in Conference/ Symposium

- Devraj, P.K. Katiyar and Rajesh Kumar (2020). Data Management System for Fieldpea Germplasm. International Conference on "Pulses as the climate smart crops" challenges and opportunities" held at Minto Hall, Bhopal during 10-12 Feb., 2020.
- Hemant Kumar, Sripad Bhatt, Devraj and Rajesh Kumar (2020). Decadal growth and decomposition analysis of chickpea production in India. International Conference on "Pulses as the climate smart crops" challenges and opportunities" held at Minto Hall, Bhopal during 10-12 Feb., 2020.
- Karthikeyan, Venkatesh M. S. and Gundlur S.S. (2020) Response of black gram to soil and foliar Application of Fe and Zn in vertisol of Northern Transitional zone of Karnataka. Internatonal conference on pulses as climate smart crops: challenges and opportunities, Feb 10-12, Bhopal, M.P.
- Kodandaram MH, Sabale PR, Sudhavati Iliger, Nikhil R Mohite and Venkatesh MS 2020. Effect of planting time and cultivar on the incidence of pod borer,Maruca Vitrata Geyer (Pyralidae: Lepidoptera) in cowpea. International Conference on Pulses the climate smart crops: Challenges and Opportunities (ICPulse 2020). 10-12 Feb, 2020, Bhopal, Madhya Pradesh, India pp.396-397
- Manu B., Aditya Pratap., Tiwari T N., Basu P S and Revanappa (2020). Morpho-physiological characterization of mungbean [*Vigna radiata* (L.) R.Wilczek] genotypes for drought tolerance: Pulses as the Climate Smart Crops: Challenges and Opportunities. Bhopal 10-12 February.
- Pawan shinde., Guljar dambal., Revanappa B., Manu B., Saabale P R., Kodandaram M H., Venkatesh MS (2020). Analysis of genetic diversity in blackgram (Vigna mungo L. Hepper) for seed yield and its component traits: Pulses as the Climate Smart Crops: Challenges and Opportunities. Bhopal 10-12 February.
- Revanappa SB. Manu B., Saabale PR., Rashmi S. Kodandaram MH. Venkatesh MS and NP singh (2020). Analysis of genetic diversity in blackgram for seed yield and its component traits. International conference on pulses the climate smart crops: Challenges and opportunities held at Bhopal from 10th to 12th Feb. 2020
- Saabale PR, Revanappa SB, Kodandaram MH, Nikhil M and Venkatesh MS 2020. Characterization of Emaravirus associated with Pigeonpea Sterility Mosaic Disease on a set differential cultivars. International Conference on Pulses the climate smart crops: Challenges and Opportunities (ICPulse 2020). 10-12 Feb, 2020, Bhopal, Madhya Pradesh, India. pp 392



Training and Capacity Building

Participation in Workshop Training

- Devraj attended participated online National Workshop on "Intellectual Property Management in Agriculture" organized by ICAR-IIAB, Ranchi on Nov. 28, 2020.
- Devraj attended Workshop on Modern Interventions in Environmental Management organized by ICAR-IIAB, Ranchi on December, 30, 2020
- Devraj participated in online training programme on "E-Office Implementation in ICAR Institutions" organized by ICAR-IASRI, New Delhi on April 30, 2020.
- Hemant Kumar attended Online training on "Analysis of Experimental Data using SAS" conducted by ICAR-NAARM Hyderabad during November 9-17, 2020
- Hemant Kumar attended Online training on" Quantitative Methods for Data Analysis organized by Ramanujan College, Delhi University, Delhi during August 12-25, 2020.
- Rajesh Kumar attended meeting related to crop insurance and crop cutting in DAC, Krishi Bhawan, New Delhi on 16.03.2020
- Rajesh Kumar attended review meeting of FLDs held at New Delhi on March 3, 2020.
- Uma Sah attended DST Sponsored Online training programme on "Creativity & Innovation Management In Research'' conducted by Engineering Staff College of India, Hyderabad during October 26-30 , 2020.
- Uma Sah attended National Webinar on 'Return to Roots: Possibilities and Strategies for Promotion of Grassroots Entrepreneurship', organized by BAU, Sabour, Bihar on June 19, 2020.
- Uma Sah attended participated in three days on line training program on "Strengthening Value Chains in Agriculture" organized by MANAGE, Hyderabad during November 24-26, 2020.
- Uma Sah attended Virtual Workshop-cum-training on "Intellectual Property Rights in Agricultural Research & Education in India" organized by IPTM unit, ICAR, New Delhi during September 12-28, 2020
- Uma Sah attended Webinar "Innovation Excellence Indicators for Public Funded R&D , Organized by CII, New Delhi, October 20, 2020
- Uma Sah attended Webinar on "Survive to Thrive: Resilient Entrepreneur" organized by National Productivity Council, New Delhi, on October 6, 2020.
- Uma Sah attended Webinar on Innovation Excellence Indicators Framework- organized by CII, New Delhi organized on September 17, 2020.
- Uma Sah attended Webinar Series on Quantitative Methods for Social Sciences: ICAR-NIAP, New Delhi organized by ICAR-NIAP, New Delhi during June 1-20, 2020.
- MS Venkatesh, Principal Scientist & I/C RRC guided/acted as advisory member for M.Sc students of UAS, Dharwad in Agronomy/ Soil Science.
- Dr C.S.Praharaj, PS & Head awarded ISPRD RECOGNITION AWARD 2020 on 10.2.2020
- Dr C.S.Praharaj, PS & Head received FIRST BEST ORAL Presentation Award in NATIONAL WEBCON BY CSAUAT, KANPUR, May 6-8, 2020
- Dr C.S.Praharaj, PS & Head received ICAR-IIPR Best Team Award 2019 on Institute Foundation Day on 5th September, 2019.
- Dr C.S.Praharaj, PS & Head was nominated as Mentor Scientist for Module III (2019-20) Certified Farm Advisor MANAGE PROGRAMME, HYD.
- Dr C.S.Praharaj, PS & Head acted as Controller of Examiner for Limited Departmental Competitive Examination for AAO, Assistant and UDC, ICAR-IIPR, Kanpur for 2019-20.
- Dr C.S.Praharaj, PS & Head acted as Organizing Secretary of ICPulse2020, Convener in Sessions & Presented Lead lectures.
- Dr C.S. Praharaj, PS & Head was nominated as a Member of Institute Management Committee (IMC)



of Indian Institute of Seed Science, Mau, Uttar Pradesh for a period of 3 years with effect from 23.02.2018 to 22.02.2021 and ICAR-ATARI, JODHPUR for a period of 3 years with effect from 16.02.2020 to 15.02.2023.

- Dr C.S.Praharaj, PS & Head acted as Co-Chairman in *STRESS MANAGEMENT* (TS II) on 07.05.2020 at National WEBCON on Agricultural Production and Support System for Managing Covid-19 Pandemic: Experience sharing & strategies, CSAUAT, Kanpur, May 06-08,2020.
- Dr Narendra Kumar, PS received International Travel Grant Award by SERB, DST in 2019 for 27th APWSS Conference at Kuching, Malaysia, Sept. 3-6, 2019 and presented an ORAL Paper on Weed Management in grain Legumes.
- Mr. Asik Dutta, scientist received second best poster presentation under the theme production management in the Inter. Conference (ICPulses 2020) held at Bhopal, India during February 10-12, 2020.
- Alok Das, attended Fourth Interactive session for IBSCs registered on Indian Biosafety Knowledge Portal, organized by DBT, 5 November, 2020
- Alok Das, attended Science Communication for Smart Scholars, organized by ICAR-Central Institute of Fisheries Education, Mumbai (*Distinction). 12-25 May, 2020.
- Alok Das, attended Science Leadership Workshop organized by Indian Academy of Sciences, Bangalore; Indian National Science Academy, New Delhi; National Academy of Sciences, India, Allahabad and Central University of Punjab, Bhatinda, June 22-28, 2020.
- Alok Das, attended Towards outcome based Agricultural Research, DBT-North East Centre for Agricultural Biotechnology, AAU, Jorhat. May 5, 2020
- Dr. Kiran B. Gandhi attended one-week training programme on "LC-MS data interpretation" at CSIR-CDRI, Lucknow on March 2-6, 2020.
- Dr. Kiran B. Gandhi attended 5-day training programme on "Agricultural Pest and Disease Simulation Modelling under a Climate Change Scenario" on 24-28 August, 2020.
- Dr. Manjunatha, L. attended 21 days ICAR sponsored training on "Novel technique for mass culturing of smart microbial biocontrol agents for the development of bio pesticides" organized by ICAR-NBAIR, Bangalore during 3-23 December, 2019.
- Dr. Naimuddin attended Online Training Programme on "Effective Health Management for Enhancing Work Efficiency of ICAR Employees" organised by HRD Cell, ICAR-IIHR, Bengaluru on October 22, 2020.
- Dr. Sujayanand G.K. attended advanced lab drying techniques organized by BUCHI on 23/07/2020 [webinar]
- Meenal Rathore, attended TMIS for HRD Nodal Officers of ICAR on 8.5.2020 by HRM unit, ICAR, KAB-II
- Meenal Rathore, attended IMIN Workshop on Market Segmentation and Product Profiles on December 8-9, 2020 by Syngenta II.
- Dr. Sujayanand, G.K. attended Online Workshop on Scientific Writing and Research Ethics for Veterinary and Animal Science Community, organized by DBT/Wellcome Trust India Alliance on August 14, 2020
- Rajesh Kumar, Devraj, Hemant Kumar, Shripad Bhat and K. Ravi Kumar (2020) attended Training Manual on enhancing of farmers income through improved pulses production technology, processing and marketing strategies. Sponsored by NIAM, Jaipur, Rajsthan. Published by Director, IIPR, Kanpur, pp. 1-123
- Rajesh Kumar, Devraj, Hemant Kumar, Shripad Bhat and K. Ravi Kumar (2019) attended Training Manual on Integrated Crop Management in Pulses. Sponsored by MANAGE, Hyderabad ICAR-IIPR, Kanpur, 1-194 p.
- Rajesh Kumar, Devraj, Hemant Kumar, Shripad Bhat and K. Ravi Kumar attended Training Manual on enhancing of farmers income through improved pulses production technology, processing and marketing strategies. Sponsored by NIAM, Jaipur, Rajsthan. ICAR-IIPR, Kanpur, 123 p.



Seminar Symposia/Webinar/e-conferences attended

- All Scientists of IIPR attended International Conference on "Pulses as the Climate Smart Crops: Challenges and Opportunities" (ICPulse2020) at Bhopal during February 10-12, 2020.
- Alok Das, attended Biotechnological Initiatives for Improvement of Pulse Crops (BIIPC-2020)", Bihar Agricultural University, Sabour, August 7, 2020
- Alok Das, attended "Revisiting strategy for Self Sufficiency Pulses: Introspection and Correction", IIPR, Kanpur, September 5, 2020
- Dr. Bansa Singh attended A brainstorming webinar on 'Revisiting Strategy for Self Sufficiency in Pulses : Introspection and Correction" organised by ISPRD and ICAR-IIPR, Kanpur on 5th September, 2020.
- Dr. Bansa Singh attended webinar on 'Export challenges and mitigation strategies for fresh and processed F & V in COVID-19 times' on 8th August, 2020.
- Dr. K R Soren and Dr. Shanmugavadivel, PS, Brainstorming Webinar on "Revisiting Strategy for Self-sufficiency in pulses: Introspection and Correction" 05-09-2020 organized by ICAR-IIPR, Kanpur.
- Dr.K R Soren and Dr. Shanmugavadivel, PS, attended MACFAST Webinar "Functional Foods: Food Matrix Composition, Interactions and Bioavailability" by Dr. Veda Krishnan, Ph.D. Fulbright Fellow Scientist (Senior Scale), Division of Biochemistry, ICAR-Indian Agricultural Research Institute, New Delhi, organised by Mar Athanasios College for Advanced Studies Tiruvalla (MACFAST) on August 11, 2020.
- Dr. K R Soren and Dr. Shanmugavadivel, PS, attended "One CGIAR Global Webinar Series on Genome Editing in Agriculture: Innovations for Sustainable Production and Food Systems Confirmation" 22-9-2020 to 20-10-2020 organized by ICRISAT, Hyderabad.
- Mr. Kuldeep Kumar, attended "Kosambi International Webinar Series on Plant Genomics" organized by the Department of Botany, Savitribai Phule Pune University, Pune from July 31-August 2, 2020.
- Mr. Kuldeep Kumar, attended Live Webinar in the Series of, "Next Generation Genomics and Integrated Breeding for Crop Improvement (VII-NGGIBCI) on Genomics for Food, Health and Nutrition organized by Centre of Excellence Genomics & Systems Biology (CEGSB) on May 14, 2020.
- Mr. Kuldeep Kumar, attended National Workshop entitled, "Intellectual Property Management in Agriculture, organized by ICAR-IIAB, Ranchi on November 28, 2020.
- Mr. Kuldeep Kumar, attended Two Days Hands on Training on, "RNA SEQ Data Analysis" organized by Bionivid Technologies Pvt. Ltd from April 7-8, 2020.
- Mr. Kuldeep Kumar, attended Five Days Virtual Scientist Training on, "Agrowaste Bioconversion and Microbial Inoculant Technologies for Use in Agriculture" organized by ICAR-NBAIM, Mau during November 3-7, 2020.
- Meenal Rathore, attended International Colloquium on Crop Physiology (ICPP 2020) - by TNAU on November 26-27, 2020
- Meenal Rathore, attended ISPRD Webinar on Revisiting strategy for self-sufficiency in pulses: Introspection and correction on September 5, 2020 on zoom.
- Meenal Rathore, attended National Virtual conference on Current trends and Challenges in Plant Biochemistry and Biotechnology by SPBB, New Delhi on November 20-21, 2020.
- Meenal Rathore, attended Webinar on Biotechnological Interventions for Improvement of pulse crops by BAU, Sabour on 7.8.2020
- Meenal Rathore, Neetu S Kushwah, Webinar on Gene Editing for Agriculture, Society & Sustainable Development: Prospects and Perspectives by TIGS (The Tata institute for Genetics and Society) on December 15, 2020



- Dr. Naimuddin attended Webinar on Gandhian Philosophy and Agriculture on 2 October, 2020 organised by ICAR-IIPR, Kanpur
- Dr. Naimuddin attended A brainstorming webinar on 'Revisiting Strategy for Self Sufficiency in Pulses: Introspection and Correction" organised by ISPRD and ICAR-IIPR, Kanpur on 5th September, 2020.
- Dr. Naimuddin attended Online Lecture on "Gandhian Philosophy and Indian Agriculture" by Dr. S.K. Chaudhary, DDG (NRM), ICAR organized by the Council on September 25, 2020, the first of a series of Workshop/Lectures on "Gandhian Philosophy" to commemorate the 150th Birth Anniversary of Mahatma Gandhi Ji.
- Dr. Neetu Singh Kushwah, attended One CGIAR Global Webinar Series with one delivered weekly on topic "Genome Editing in Agriculture Innovations for Sustainable Production and Food Systems" from Sep 22 to Oct 20, 2020. ICRISAT, Patancheru, Telangana, INDIA.
- Dr. Neetu Singh Kushwah, attended Webinar on "Global Impact of GM Crops on 15th July, 2020" conducted by ISAAA.
- Dr. Shanmugavadivel, PS, attended CRISPR in Agri & WUE. Speaker: Dr. Anindya Bandyopadhyay, organised by International Plant Science Research, Bioingene.com, on September 12, 2020.
- Shanmugavadivel, P.S, attended Ten Days Virtual Training on R programming Basics and Applications from November 2-14, 2020.
- Dr. Shanmugavadivel, PS, attended Genome Studio Genotyping: Creating Custom Cluster Files for Infinium Array Speaker: Vannessa Mok, organized by Illumina Inc. on August 28, 2020.
- Dr. Shanmugavadivel, PS, attended "Getting Started With Single Cells: Targeted Gene Expression on 16-09-2020 organized by Illumina Inc.
- Dr. Shanmugavadivel, PS, attended Identification of Eigen-genes, Consensus Modules and Network Motifs in Co-expression (or Other Biological) Networks. 10th Aug 2020. Speaker Gita Yadav. Organized by University of Cambridge Training.
- Dr. Shanmugavadivel, PS, attended "Chemistry, Biology and the Unity of Nature". Prof. P. Balaram, Former Director, Indian Institute of Science, Bangalore organised by Mar Athanasios College For Advanced Studies Tiruvalla (MACFAST).
- Dr. Shanmugavadivel, PS, attended India International Science Festival (IISF-2020)' during December 22–25, 2020 organized by Ministry of Science & Technology, Ministry of Health & Family Welfare and Ministry of Earth Sciences in association with Vijnana Bharati (VIBHA)
- Dr. Shanmugavadivel, PS, attended Integrating Genomics for Accelerating the Rate of Genetic Gain for Chickpea Improvement. Speaker: Dr Manish Roorkiwal, organized by International Plant Science Research, Bioingene.com on September 1, 2020.
- Mr. Sudhir Kumar, attended "How to Excel in Competitive Examination AIEEA (PG) JRF, All India Competitive AICE-JRF/SRF (Ph.D.) and GATE" (June 06-07, 2020): JNKVV, Jabalpur.
- Mr. Sudhir Kumar, attended Challenges, Opportunities and Future of Agri and Allied Research and Education: Post COVID Era. (May 30-31, 2020): AIASA, New Delhi.
- Mr. Sudhir Kumar, attended COVID-19 Pandemic: Prevention and Management. (June 04-06, 2020). Govt Holkar Science College, Indore.
- Mr. Sudhir Kumar, attended "Strategies and policy interventions for Agricultural Development in North East India during COVID – 19 era". (June 13-14, 2020): AIASA, New Delhi & CAU, Imphal.
- Dr. Sujayananda, G.K. attended A New Era for Food and Climate: Driving transformative Actions & 25/06/2020 [around-the-world virtual relay event] organized by CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Danish Agriculture and Food Council, University of Copenhagen.



- Dr. Sujayananda, G.K. attended Participated in Entomology Advocacy Week- World Humanitarian Day and the International Locust Crisis organized by Entomological Society of America 19 August 2020
- Dr. Sujayananda, G.K. attended IRMI webinar: Institutional pre-award support for researchers applying for funding organized by India alliance on 28th Aug 2020.
- Dr. Sujayananda, G.K. attended A Brainstorming Meeting on "Revisiting Strategy for Self Sufficiency in Pulses: Introspection and Correction organized by ICAR-IIPR on 5th September 2020
- Dr CS Praharaj, PS & Head, attended Crop Production participated in Webinar on "Export Challenges and mitigation strategies for fresh and processed F & V in Covid-19 Times", August 8, 2020 by Department of Agriculture and Environmental Sciences, Ministry of Food Processing Industries (MOFPI) and NIFTEM, New Delhi.
- Dr CS Praharaj, PS & Head attended delivered Training on Weed management in Kharif Pulses in *Weed management in Kharif pulses and cereal crops* organized under Farmer FIRST Project in Fatehpur district (U.P.) on 28 July 2020.
- Dr CS Praharaj, PS & Head, Crop Production participated/presented a paper in National Webinar on Technological advances in crop production during COVID-19 held on June 16,2020 organized by SKRAU, Bikaner.
- Dr CS Praharaj, PS & Head, Crop Production participated as a Trainer and delivered training on "Scaling IUE through Technological interventions in pulses while enduring Covid-19 Pandemic" 08.06.2020 under National Training Course (NTC 2020) on "Preparing and Management of Result Oriented Research Projects in Agriculture, Horticulture, Animal husbandry and allied Sectors" by National Agriculture Development Cooperative Ltd (NADCL), Delina, Baramulla (J &K) 193 103 and Agro-Environmental Development Society (AEDS), Rampur, Uttar Pradesh 244901 during May 26 to June 15, 2020.
- Dr CS Praharaj, PS & Head, Crop Production participated as a Core member in Second Meeting of Core Committee on preparation of policy document on futuristic crop planning for 2030/50 on June 10, 2020 organized by ICAR-IIFSR, Modipuram (chair: DDG, NRM)
- Dr CS Praharaj, PS & Head, Crop Production participated and acted as a Nodal Officer for Organizing Video Conferencing for conducting AGM of Kharif pulses held during June 2-4, 2020 through Online by ICAR-IIPR, Kanpur. Here, AICRP (MULLaRP, Pigeonpea and Arid Legumes).
- Dr CS Praharaj, PS & Head, Crop Production participated in Live Webinar in the series of "Next Generation Genomics and Integrated Breeding for Crop Improvement (VII NGGIBCI) on Genomics for Food, Health and Nutrition organized by ICRISAT, Hyderabad on 14.05.2020.
- Dr CS Praharaj, PS & Head, Crop Production participated Lead Speaker in National WEBCON on *Agricultural production and support system managing Covid-19 pandemic : Experience sharing and strategies* organized by C.S. Azad University of Agriculture & Technology, Kanpur during May 06-08, 2020.
- Dr CS Praharaj, PS & Head, Crop Production invited and participated in Rabi Scientists Meet at ICAR-IIPR, Kanpur held during February 27-28, 2020.
- Dr CS Praharaj, PS & Head, Crop Production presented a paper at MTC at IGFRI, Jhansi (Uttar Pradesh) for presenting our works on pulses entitled "Technological interventions for higher input use efficiencies in field crops" on 29.02.2020 in the Model Training Course organized (during February 27- March 3, 2020) by IGFRI, Jhansi.
- Dr CS Praharaj, PS & Head, Crop Production participated in Zaid Meeting organized by Director of Agriculture at Khishi Bhawan, Lucknow on dated 20.12.2019.
- Dr CS Praharaj, PS & Head, Crop Production participated in International Conference *on*



Pulses as the climate smart crops: Challenges and Opportunities organized by ISPRD, ICAR-IIPR, Kanpur and ICAR, New Delhi at Bhopal during February 10-12, 2020 and presented Lead paper on Converting rice-fallow system to rice-food legume system for food and nutritional security: An Indian perspectives and Pulses Sustainable Intensification through Legume based crop diversification during the Conference. Also evaluated posters under the theme "Participatory Technology Development and Adoption" on 12.2.2020.

- Dr. C.P. Nath attended 'International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities' (ICPulse 2020) at Bhopal during10-12th February, 2020.
- Dr. C.P. Nath attended Indian Society of Weed Science Biennial Conference on "Weed Management for Enhancing Farmers income and Food Security" at Goa on February 5, 2020.
- Dr. Narendra Kumar attended 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 attended Workshop on '*Soil Organic Carbon Status in UP: Strategies and Management*' at UPCAR, Lucknow during 29.06.2019
- Dr. Narendra Kumar attended XXVI-Annual Review Meeting of 'AICRP on Weed Management' at AAU, Jorhat, Assam during October 15-16, 2019.
- Dr. Narendra Kumar attended International Seminar on "*Agriskills for Convergence in Research, Industry & Livelihood*" at BCKV, Kalyani, West Bengal during November 28 – December 1, 2019.
- Dr. Narendra Kumar attended 'International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities" (ICPulse 2020) at Bhopal during10-12th February, 2020.
- Dr. Narendra Kumar attended XXVII Annual Review Meeting (online) of the AICRP on Weed Management during 8-10 June, 2020.
- Dr. Narendra Kumar attended Webinar on 'Micro-irrigation for Agricultural Transformation' organized by RAY Consulting LLP during 18 July, 2020.
- Dr. Narendra Kumar attended State level Rabi crop meeting (online) of UP state for finalization of 'Rabi Fasalon Ki Saghan Padhatiyan-2020' during 24 July, 2020.
- Dr. Narendra Kumar attended Webinar on 'Abiotic stresses in agriculture: Geospatial characterization and management options' organised by ICAR-NIASM, Baramati during 27 August, 2020.
- Dr. Narendra Kumar attended Webinar on 'Revisitng strategy for self sufficiency in pulses: Introspection and correction' organized by ISPRD and ICAR-IIPR, Kanpur during 5 September, 2020.
- Dr. Narendra Kumar attended Webinar on title 'Prospects of Entrepreneurship in Processing and Value Addition of Pulses' organized by ICAR-IIPR, Kanpur during 26 November, 2020.
- Dr. Narendra Kumar attended Webinar on title 'Business Opportunities in Seed Production of Pulses' organized by ICAR-IIPR, Kanpur during 28 November, 2020.
- Dr. Narendra Kumar attended Attended 'Zaid Crop Meeting' at Krishi Nideshalaya, Lucknow on 24 December, 2020.
- Mr. Asik Dutta attended 'International Conference on Pulses as the Climate Smart Crops: Challenges and Opportunities" (ICPulse 2020) at Bhopal during10-12th February, 2020.
- A 2 days training programme on "***Basic skill development in field management***" for SSS staff of ICAR-IIPR, Kanpur was organised during 02-03 March, 2020. Total 10 supporting staffs involved mainly in conducting field trials from different departments of the institute have participated in this training programme. Training was designed to give practical experience on field management subjects such as i) Sampling, observations and other parameters related to soil, ii) Observations related to plants, iii) Field preparation and lay-out planning for experiment design, iv) Major diseases of pulse crops and their management and v) Farm mechanization & post-harvest technology by different experts of the institute.



Awards & Recognitions

Awards/Honors

- Chief Development Officer of Fatehpur district has awarded an Appreciation Letter to Dr. Rajesh Kumar for outstanding work for doubling farmers income under Farmer FIRST project and other project (2020)
- *Dr. R.K. Mishra got Fellow* of Indian Society of Pulses Research and Development (ISPRD),- 2020
- Dr. Uma Sah received Fellow Mobilization Award 2020 on 16th February, 2020 during the Award Ceremony function of the 9th National Seminar on Doubling Farmers Income by 2022: Challenges, Opportunities and Way Forward organized by Society for Community Mobilization for Sustainable Development.
- Foundation day 2020- Best Team award was given to Dr.Yogesh Kumar, Dr. A.K.Srivastava, Dr. U C Jha, Dr. K R Soren, Dr. Archana Sing and Dr. Revanappa Biradar on 05-09-2020 at ICAR-IIPR, Kanpur
- Pragya Gramotthan Sewa Samiti of Fatehpur district has awarded an Appreciation Letter to Dr. Rajesh Kumar for outstanding work for doubling farmers income on 26/06/2020
- Mishra Monika, Mishra R.K., Naimuddin, Sonika Pandey, K.B.M. Tripathi and Bansa Singh received. Identification, pathogenicity and characterization of *Sclerotinia sclerotiorum* (Lib.) de Bary causing stem rot disease of pulse crops during National symposium cum zonal meeting Dated on 25-26 Nov, 2019, CSUAT, Kanpur from 25-26 Nov. 2019.
- Dr. Uma Sah received ISPRD Recognition Award 2020 in Social Science and Natural Resource Management Category 2020 from Indian Society of Pulses Research and Development on Feb. 10, 2020.

Celebration of different events

- Celebration of *Mahila Kisan Diwas* was done on 15 October 2020 at Khadra Village, Fatehpur. Total 65 woman farmers participated on this programme
- Online celebration of World Soil Day on 05 December 2020 was done at IIPR, Kanpur. Total 72 farmers participated on zoom apps through online mode
- Online celebration of ***Kisan Diwas*** happened on 23 December 2020 at IIPR, Kanpur total 93 farmers participated on zoom apps through online mode

Best Poster Awards

- Dr. Devraj received Best Poster Presentation Award (Third position) for the paper "Decadal Growth and Decomposition Analysis of Chickpea Production in India" during the International Conference on "Pulses as the Climate Smart Crops: Challenges and Opportunities" held at Minto Hall, Bhopal during Feb. 10-12 , 2020.
- Dr. K R Soren was conferred Indian Society of Pulses Research and Development (ISPRD), Fellow 2020.
- Mishra, R.K., Kulbhushan Mani Tripathi, Monika Mishra, Sonika Pandey, Deepak Kumar, Uma Sah, Sanjay M. Bandi, Shripad Bhatt and Krishna Kumar received Influence of weather parameters on Wilt incidence of Pigeon Pea in Bundelkhand region of Uttar Pradesh during National symposium cum zonal meeting Dated on 25-26 Nov, 2019, CSUAT, Kanpur from 25-26 Nov. 2019.
- Monika Mishra, Mishra R.K., Sonika Pandey, Jagat, Deepak Kumar and Naimuddin (2020) received Biocontrol potential of *Trichoderma* and PGPRs against *Phytophthora drechsleri* f. sp *cajani* causing stem blight of pigeonpea during International conference on pulses the climate smart crops: challenges and opportunities (ICPulse2020). 10-12th Feb. 2020, Bhopal, MP.
- Sonika Pandey, Monika Mishra, Mishra R.K., Naimuddin and Bansa Singh received Production of cell wall degrading enzymes by *Trichoderma* isolates and their biocontrol potential for the management of wilt of major pulses during National Symposium cum Zonal meeting on Nov. 25-26, 2019 at CSUA&T, Kanpur from 25-26 Nov. 2019.
- Hemant Kumar, Sripad Bhatt, Devraj and Rajesh Kumar received Best Poster Presentation Award (Third position) in the International Conference held at Bhopal during February, 10-12, 2020
- Dr Shallu Thakur received Jerome P. Miksche Travel Grant Award to attend PAGXVIII, 2020.

On going Research Projects

DIVISION OF CROP IMPROVEMENT (3)

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period
1.	CRSCIIPRSIL 202000100156	**Development of biotic and abiotic stress resistant superior varieties/hybrids through integrated conventional and modern breeding approach.** **Dr. Farindra Singh**			2020-2025
	SP 1	Chickpea: Genetic enhancement (desi)	Dr. Yogesh Kumar	Dr. B. Mondal, Dr. U.C.Jha, Dr. K.R. Soren, Dr. Manjunatha, Dr. Revanappa	
	SP 2	Chickpea: Genetic enhancement (*kabuli*)	Dr. Archana Singh	Dr. Yogesh Kumar, Dr. Gritlehre S.K.	
	SP 3	Chickpea: Biotic stress resistance	Dr. A.K. Srivastava	Dr. Yogesh Kumar, Dr. K.R. Soren, Dr. Manjunatha	
	SP 4	Chickpea: Abiotic stress resistance	Dr. U.C. Jha	Dr. Yogesh Kumar, Dr. Archana Singh, Dr. S. Gurumurty	
	SP 5	Chickpea: Quality enhancement	Dr. B. Mondal	Dr. Vaibhav Kumar, Dr. Prasoon Verma, Dr. Yogesh Kumar	
	SP 6	Short duration pigeonpea	Dr. Dibendu Datta	Dr. Abhishek Bohra, Dr. Farindra Singh, Dr. Satheesh Naik S.J. Dr. Sujayanand, Dr. R.K. Mishra, Dr. Ram Lal Jat, Dr. S.K. Ghritlehre	
	SP 7	Medium duration pigeonpea	Dr. S.K. Ghritlehre	Dr. Archana Singh, Dr. Farindra Singh, Dr. R.K. Mishra	
	SP 8	Long duration pigeonpea	Dr. Satheesh Naik	Dr. Farindra Singh, Dr. D. Datta, Dr.Abhishekh Bohra, Dr. R.K. Mishra	
	SP 9	Mungbean	Dr. Aditya Pratap	Dr. Revanappa, Dr. Basavaraja, T., Dr. Mohd. Akram, Dr. Revanasidda, Dr. Ram Lal Jat	



S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 10	Urdbean: Genetic enhancement-Biotic Stress	Dr. P.K. Katiyar	Dr. Debjyoti Sen Gupta, Dr. A.K. Singh, Dr. Manu B., Dr. Archana Singh, Dr. Saabale, Dr. Anup Chandra	
	SP 11	Urdbean: Abiotic stresses	Dr. A.K. Singh	Dr. P.K. Katiyar, Dr. Debjyoti Sen Gupta, Dr. Archana Singh, Dr. Manu B., Dr. Vijayalakshamu	
	SP 12	Lentil	Dr. Jitendra Kumar	Dr. Debjyoti Sen Gupta, Dr. Naimuddin, Dr. D.P. Patel, Dr. Kuldeep Kumar	
	SP 13	Fieldpea	Dr. A.K. Parihar	Dr. R.K. Mishra, Dr. Anup Chandra	
	SP 14	Biofortifcation: Mungbean, Urdbean	Dr. Debjyoti Sen Gupta	Dr. Asik Datta, Dr. Aditya Pratap, Dr. Vaibhav Kumar	
2.	**CRSCIIPRSIL 202000200157**	**PGR Management and utilization Dr. Shiv Sewak**			
	SP 1	Chickpea (IIPR)	Dr. Shiv Sewak	Dr. Yogesh Kumar, Dr. B. Mondal, Dr. Amrit Lamichaney, Dr. Revanappa S.B.	
	SP 2	Chickpea (Bhopal)	Dr. Archana Singh	Dr. S.K. Ghritlehre, Dr. B. Mondal	
	SP 3	Pigeonpea (Kanpur)	Dr. Farindra Singh	Dr. Dibendu Dutta , Dr Abhishekh Bohra, Dr. Satheesh Naik	
	SP 4	Pigeonpea (Bhopal)	Dr. S.K. Ghritlehre	Dr. Archana Singh	
	SP 5	Lentil	Dr. Jitendra Kumar	Dr. Debjyoti Sen Gupta	
	SP 6	Mungbean	Dr Aditya Pratap	Dr. Revanappa S.B., Dr. Basavaraja T.	
	SP 7	Urdbean	Dr. A.K. Singh	Dr. Debjyoti Sen Guptam, Dr. P.K. Katiyar, Dr. B. Manu	

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period
	SP 8	Fieldpea	Dr. A. K. Parihar	Dr. RK Mishra	
	SP 9	Horsegram	Dr. Revanappa S.B.	Dr. Manu B., Dr. P.R. Saabale	
	SP 10	Cowpea (Dharwad)	Dr. B. Manu	Dr. A.K. Parihar	
	SP 11	Rajmash (including genetic enhancement)	Dr. Basavaraja	Dr. Kalpana Tiwari, Dr. Manjunatha, Dr. Mohar Singh (ICAR-NBPGR, Shimla)	
	SP 12	Cowpea (including genetic enhancement)	Dr. A.K. Parihar	Dr. B. Manu, Dr. Revanasidda, Dr. Ram Lal Jat	
	SP 13	Grasspea (including genetic enhancement)	Dr. Archana Singh	Dr. Neetu Kushwaha	
	SP 14	PGR Conservation	Dr. Amrit Lamichaney	Dr. Jitendra Kumar	
3.	CRSCIIPRSIL 202000300158	**High value seed production and quality control: Dr. P.K. Katiyar**			2020-2025
	SP 1	Seed technological studies in pulses	Dr. Amrit Lamichaney	Dr. P.K. Katiyar, Dr. D.S. Gupta	

DIVISION OF BIOTECHNOLOGY (1)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
4.	CRSCIIPRSIL 202000400159	**Genomics, Genetic Engineering and New Breeding Technologies for Pulses Improvement. Dr. Meenal Rathore**			2020-25
		Theme I. Genomics for Pulse Improvement			
	SP 1	Marker-assisted gene introgression for abiotic stress tolerance and their effect on primary metabolites in chickpea	Dr. K. R. Soren	Dr. Shanmugavadivel, P. S., Dr. B Mondal, Dr. Archana Singh, Dr. Revanappa Bridar	
	SP 2	Molecular mapping of heat stress tolerance QTLs and understanding heat stress induced transcriptome dynamics in chickpea	Dr. Shanmugavadivel, P. S.	Dr. K.R. Soren, Dr. Archana Singh, Dr.Surendra Kumar Meena, Dr. Revanappa Bridar, Dr. Uday Chand Jha	
	SP 3	Molecular diagnosis of *Fusarium* sp infecting chickpea and pigeonpea	Dr. Shanmugavadivel, P. S.	Dr. K.R. Soren, Dr. Aravind Kumar Konda, Dr. R. K. Mishra, Dr. Manjunath L	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 4	Molecular Dissection of loci for Powdery Mildew (PM) Resistance and Photo-thermo insensitivity (PTI) in *Vigna mungo* (Urdbean)	Mr. Sudhir Kumar	Dr. Shanmugavadivel, P. S. Dr. Debjyoti Sen Gupta Dr. P.R. Saabale	
		Theme II. Pulse Improvement through genetic engineering and new breeding technologies			
	SP 5	Precision plant breeding and rapid generation advance-ment in chickpea	Dr. Alok Das	Dr. Meenal Rathore, Dr. Neetu Singh Kushwah	
	SP 6	Molecular approaches for improving the nutritional quality of grasspea	Dr. Neetu Singh Kushwah	Dr. Meenal Rathore, Dr. Alok Das, Dr. Archana Singh	
	SP 7	Transforming *Vigna* for tolerance to whitefly (*Bemisia tabaci*)	Dr. Meenal Rathore	Dr. Neetu Singh Kushwah Dr. Alok Das	
	SP 8	Gene identification and development of triple gene technologies for pod borer resistance in transgenic chickpea	Dr. Aravind Kumar Konda	Dr. Senthilkumar, M., Dr.Sujayanand G.K	

DIVISION OF CROP PRODUCTION (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
5.	CRSCIIPRSIL 202000500160	**Development of climate smart agro-technologies for pulses under diversified agro-ecological regions of India: Dr. C.S. Praharaj**			2020-25
	SP 1	Long-term effect of pulses in rice-wheat cropping systems on soil health and crop productivity under gangetic plains	Dr. C.S. Praharaj	Dr. Narendra Kumar, Mr. K.K. Hazra Dr. C.P. Nath, Mr. Krishnashis Das, Mr. Asik Dutta	
	SP 2	Developing climate-resilient agro-technologies to alleviate nutrient and abiotic stresses in pulses	Mr. K.K. Hazra	Dr. C.P. Nath, Mr. Asik Dutta	
	SP 3	Soil phosphorus dynamics and its release kinetics under pulse based cropping system for sustainable P management in an inceptisol	Mr. Asik Dutta	Mr. K.K. Hazra	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 4	Precision irrigation scheduling for higher productivity and input use efficiency in pulses based cropping systems (including evaluation of new varieties)	Dr. C.S. Praharaj	Mr. Asik Dutta	
	SP 5	Development of conservation practices in pulse production systems for cost reduction and higher productivity under changing climate	Dr. Narendra Kumar	Dr. C.P. Nath, Mr. Asik Dutta, Mr. Krishnashis Das, Dr. R.L. Jat	
	SP 6	Designing weed and input management practices in pulses under conservation agriculture system for sustainable production and ecosystem services	Dr. C.P. Nath	Dr. Narendra Kumar, Mr. Asik Dutta	
	SP 7	Enhancing input use efficiency and productivity of pulses production system in central India	Dr. Narendra Kumar (till new Scientist join at IIPR, RC Bhopal)	Dr. Narendra Kumar	
	SP 8	Enhancing input use efficiency and productivity of pulses in arid ecosystem	Dr. R.L Jat	Dr. Narendra Kumar, Dr. S.K. Meena, Dr. N.D. Yadav (CAZRI RS Bikaner)	
	SP 9	Enhancing productivity in diverse pulses based cropping systems through improved nutrient management in deccan Plateau	Dr. M.S. Venkatesh	Dr. Revanappa B., Mr. Asik Dutta	
	SP 10	Sustainable intensification of rice fallows with inclusion of pulses in eastern India	Mr. K.K.Hazra (till new Scientist join at IIPR, RS Khordha)	Dr. C.S. Praharaj	
	SP 11	Farm mechanization suitable for pulses and its cropping system in gangetic plains	Er. Man Mohan Deo (on study leave)	Dr. Prasoon Verma, Dr. C.S. Praharaj	
	SP 12	Organic farming in pulses and its cropping system with technological interventions in gangetic plains	Dr. C.S. Praharaj	Dr. C.P. Nath, Mr. Asik Dutta	



S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period
6.	CRSCIIPRSIL 202000600161	**Post harvest management of pulses, value addition and by-product utilization: Dr. Prasoon Verma**			2020-25
	SP 1	Evaluation of existing pre-milling treatments and development of improved pre-milling treatments for ease of pulse milling	Dr. Prasoon Verma	Er. Man Mohan Deo (on study leave)	
	SP 2	Processing of pulse seeds and development of methods for their long term storage	Dr. Prasoon Verma	Dr. P.K. Katiyar, Dr. Amrit Lamichaney, Mr. Revanasidda	

DIVISION OF CROP PROTECTION (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
7.	CRSCIIPRSIL 202000700162	**Biotic stresses management through bio-intensive and novel eco-friendly approaches in pulse crops: Dr. Bansa Singh**			2020-25
	SP 1	Root-knot nematode management in pulse cropping system using bio-fumigation and trap crops	Dr. Bansa Singh	Dr. Jagadeeswaran	
	SP 2	Development of *Trichoderma* based formulations and their exploitation for management of wilt disease of pulse crops	Dr. R.K. Mishra	Dr. Naimuddin, Dr. Manjunatha L., Dr. Arvind Konda	
	SP 3	Development consortium of nematode biocontrol agents for the management of phyto-nematodes in pulses	Dr. Jagadeeswaran, R.		
	SP 4	Management of major sucking insect-pests in greengram and blackgram	Dr. Anup Chandra	Dr. Mohd. Akram, Dr. MH Kodandaram	
	SP 5	Insect pest dynamics and their management in long duration pigeonpea	Dr. Sanjay M. Bandi	Mr. Revanasidda	
	SP 6	Management of major soil borne diseases of chickpea through bio and chemo priming	Dr. Manjunatha, L.	Dr. R.K. Mishra, Dr. Amrit L.	
	SP 7	Development of liquid bio-formulation of indigenous *Bacillus thuringiensis* strains for enhancing its shelf life and field-efficacy against pod borer	Dr. Sujayananda G.K.	Dr. Anup Chandra	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 8	Identification of bioactive metabolites from potential actinobacteria against major pest of pulses	Dr. Kiran Gandhi, B.	Dr. Jagadeeswaran, Dr. Manjunatha, L., Dr. Kalpana Tiwari	
	SP 9	Pre and post-harvest management of bruchids in cowpea, mungbean and pigeonpea	Mr. Revanasidda	Dr. Sanjay M. Bandi, Er. Prasoon Verrma	
	SP 10	Ecofriendly management of insect pests in *Vigna* pulses (mungbean, urdbean, cowpea) and horsegram for Southern India	Dr. M.H. Kodandaram		
	SP 11	Integrated disease management for foliar diseases of *Vigna* pulses and horsegram	Dr. P.R. Sabale		
8.	**CRSCIIPRSIL 202000800163**	**Epidemiology and characterization of major and emerging pests and diseases of pulses and diagnostics for seed borne viruses: Dr. Naimuddin**			
	SP 1	Exploring the effect of abiotic factors on incidence of dry root disease (*Rhizoctonia bataticola)* of chickpea	Dr. Manjunatha, L.	Dr. Rishikesk Kumar	
	SP 2	Epidemiology of major fungal pathogens of pigeonpea	Dr. R.K. Mishra	Dr. Naimuddin	
	SP 3	Molecular epidemiology of yellow mosaic disease in mungbean and urdbean and diagnostics for seed borne viruses	Dr. M. Akram	Dr. Anup Chandra, Dr. Naimuddin, Dr.PR Sabaale	
	SP 4	Development and maintenance of lentil wilt sick plot at RRS, Phanda and Kanpur	Dr. Naimuddin	Dr. R K Mishra	
	SP 5	Species diversity and magnitude of phosphine resistance in bruchids (*Callosobruchus* spp.) infesting mungbean and cowpea	Dr. Revanasidda	Dr. Sanjay M Bandi, Dr. M H Kodandaram	
	SP 6	Forecasting the inter- and intra-seasonal pattern of major insect pest of pulses using machine learning methods	Dr. Kiran Gandhi B.	Dr. Anup Chandra, Dr. Hemant Kumar	
	SP 7	Characterization of root knot nematode populations in major pulses growing regions and development of micro sick plots of important nematodes	Dr. Bansa Singh	Dr. Jagadeeswaran, R.	
	SP 8	Seasonal dynamics of major insect pest/diseases in southern India	Dr. P.R. Sabaale	Dr. M.H. Kodandaram	



DIVISION OF BASIC SCIENCE (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
9.	**CRSCIIPRSIL 202000900164**	**Physio-biochemical intervention for improving climate resilience and nutrition enriched pulses: Dr. P. S. Basu**			**2020-25**
	SP 1	Physiological mechanisms of jasmonic acid & brassinosteriodes in amiliorating drought & improving yield in chickpea	Dr. P.S. Basu	Dr. U.C. Jha,	2020-22
	SP 2	Physiological Characterization of pigeonpea Genotypes for Water Logging Tolerance	Dr. T.N. Tewari	Dr. D. Datta, Dr. Kalpana Tewari	
	SP 3	Biochemical responses of chickpea to heat stress and identifying key factors limiting its productivity	Dr. Vaibhav Kumar	Dr. Kalpana, Dr. Biswajit Mondol,	
	SP 4	Identification of donors & physiological traits for high temperature & drought tolerance in lentil	Dr. D.P. Patel	Dr. J. Kumar	Extended upto 2021
	SP 5	Identification of donors and physiological traits for drought and heat tolerance in legume crops (mungbean, mothbean and pigeonpea) under arid environments	Dr. S.K. Meena	Dr. R.L. Jat	
	SP 6	Strategies for improving yield stability in urdbean through photothermo – insensitivity	Dr. Vijay Laxmi	Dr. A.K. Singh	Extended upto 2021
	SP 7	Exploring bioactive compounds associated with antioxidant potential health promoting attributes & carbohydrate intolerance in Rajmash (*Phaseolus vulgaris)* genotypes	Dr. Kalpana Tewari	Dr. Vaibhav Kumar, Dr. Basavraja T.	
10.	**CRSCIIPRSIL 202001000165**	**Establishment of effective symbiotic nitrogen fixation in pulses: Dr. Senthilkumar M.**			**2020-25**
	SP 1	Identification of signalling pathway, key genes and their allelic variations associated with nodule initiation and symbiotic efficiency in chickpea	Dr. Senthil Kumar	Dr. P.S. Shanmugavadivel, Dr. Kalpana Tewari	
	SP 2	Deciphering the root signals for effective nodulation of Rajmash	Dr. Krishnashis Das	Dr. Senthil Kumar, Dr. Basavraja T.	

DIVISION OF SOCIAL SCIENCE (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
11.	**CRSCIIPRSIL 202001100166**	**Innovative extension approaches for livelihood and nutritional security through pulse production technology in India: Dr. Rajesh Kumar**			**2020-25**
	SP 1	Development of model pulses village through integrated technological interventions for livelihood and nutritional security in selected agro-ecological regions	Dr. Rajesh Kumar	Dr. C.S. Praharaj, Dr. Archana Singh, Dr. Kodandaram, Dr. Ram Lal Jat, Dr. C.P. Nath	
	SP 2	Development and evaluation of e learning platform for pulse production technologies (*eLeaP-Pulse*)	Dr. Uma Sah	Dr. Hemant Kumar	
	SP 3	Impact assessment of pulse based bio-village sustainable model project of IIPR in Uttar Pradesh	Mr. K. Ravi Kumar	----	
12.	**CRSCIIPRSIL 202001200167**	**IT enabled data management in pulses for policy support system: Dr. Devraj**			
	SP 1	Development a procedure for promotion of AICRP crop performance trials	Dr. Hemant Kumar	Dr. A.K, Srivastava, Dr. G.P. Dixit	
	SP 2	Validation and implementation of online data submission and report generation system for AICRP	Dr. Hemant Kumar	Dr. Devraj, Dr. Sanjeev Gupta	



Externally Funded Projects

Crop Improvement Division (11)

S. No.	Name of the project	Fund-ing Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
1	Seed production in agricultural crops	DAC	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	2005-06 to March 2021	Plan Scheme of ICAR
2	ICAR (NSP) crops	DAC	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	April 2007 to March 2021	Plan Scheme of ICAR
3	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	2015-21	28.80 lakh
4	CRP on hybrid technology in pigeonpea	ICAR	Dr.Abhishak Bohra	Dr. Satheesh Naik S.J. Dr. Alok Kumar	2015-16 To 2019-21	88.00 lakh
5	Establishing the International Mungbean Improvement Network	AVRDC	**Prog. Coordinator** : Dr. N.P. Singh **PI**: Dr. Aditya Pratap	Dr. Sanjeev Gupta	2017- June 2020	150.10 lakh
6	CRP on Agro-biodiversity 1. Pigeonpea 2. Chickpea	ICAR	Dr. I. P. Singh Dr. G. P. Dixit	Dr. Archana Singh Dr Manjunath L	2014 - 17 2017 - 21	47.35 lakh 40.90 lakh
7	Delivering more produce and income to farmers through enhancing genetic gains for chickpea and pigeonpea	NFSM	**Chickpea:** Dr. Yogesh Kumar **Pigeonpea:** Dr. Abhishek Borha	Dr. K.R. Soren Sh. Shanmugavadivel, P.S.	2017-18 to 2019-20	71.20 lakh

S. No.	Name of the project	Fund-ing Agency	Principal Investigator	Associate	Period	Budget (₹in lakh)
8	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)	Dr. Satheesh Naik SJ		2018-2021	36.68 lakh
9.	Development of improved Indian common bean (Phaseolus vulgeris L) lines resistant to Anthracnose diseases by employing molecular breeding	SERB (DST)	Dr. Basavaraja T		2019-2022	35.085 lakh
10	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	
11	Institute Technology Management Unit: Component I: Intellectual Property Management and Transfer/ Commercialization of Agricultural Technologies Component II : Agri-business Incubation Centres in institutions developing agricultural technologies Incubation Fund (ABI)	ICAR (NAIF)	Component I: Dr. Aditya Pratap Component II : Dr. Uma Sah		2016-Plan Scheme 2019-Plan Scheme	Plan Scheme of ICAR



Plant Bio-Technology Division (5)

S No	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
12.	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 2021	X Plan : 93.11 XI Plan : 90.78 XII Plan : 90.78 2017-18 : 6.50
13.	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 to17.11.14)	Sep.2005 to March 2021	X Plan : 93.11 XI Plan : 96.40 XII Plan : 44.19
14.	Incentivizing research in agriculture - molecular approaches for mapping of novel gene(s)/ QTL(s) for resistance/ tolerance to salinity stress in chickpea	ICAR-CRRI	Dr. K.R. Soren	Dr. B. Mandal	2015 to 2021	15-16 : 26.35 lakh
15.	Functional genomics in pigeonpea (Genetic mapping of *Fusarium* wilt and SMD in pigeonpea)	NPTC-G (ICAR)	Dr.Shanmugavadivel, P. S.	Dr. Abhisekh Bohra Dr. P.R. Saable	2015-21	2015-18-7.00 2018-19-5.30
16.	Development of early flowering chickpea genotype using CRISPR/Cas9 technology	SERB (DST)	Dr. Alok Das		2020-23	



Crop Production Division (3)

S No	Name of the project	Funding Agency	Principal Investigator	Associate/Co-PI	Period	Budget (₹ in lakh)
17.	Utilization of pulse milling by-product for edible use	Ministry of Food Processing Industries (GOI)	Dr. 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
18.	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)	Dr. Prasoon Verma	Dr. Kiran Gandhi Bapatla Mr. Revanasiddha	March 2019 - February 2021	32.45
19	Evaluation of efficacy of Biozyme Soya Pulse L on chickpea wrt quality and yield contr. parameters	Consultancy Project	CP Nath & CS Praharaj	-	(Feb – Oct 2021)	3.00

Crop Protection Division (4)

S No	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
20.	Nematophagous bacteria: Identification and profiling of host specificity of *Pasteuriapenetrans* infecting *Meloidogyne* spp. in pulses.	SERB (DST)	Dr. R. Jagadeeswaran		21.02.2017 to 20.02.2021	37.48
21.	Bio-prospecting plant essential oils for insecticidal properties against pulse beetle infesting stored legumes	SERB (DST)	Dr Sanjay M. Bandi		2018-21	29.34
22.	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.	2018-2021	80.7984
23.	Management of wilt disease in pulse crops using bio-fertilizer	UPCAR	Dr. Naimuddin	Dr. Mohd. Akram Dr. R. K. Mishra	2020-23	



Basic Science Division (2)

S No	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
24.	Rhizosphere micro-biome for improving symbiotic nitrogen fixation and yield in lentil in North Eastern State of India	Biotech Consortium India Limited	**Centre PI**: Dr. M. Senthilkumar		2016-2019 Extended up to 19.04.2020 with in budget	24.76
25.	Identification and characterization of nodule –specific cysteine rich (NCR) peptide in chickpea	DBT	Dr. M. Senthilkumar	Dr. P.S. Shanmugavadivel, Mr. Arvind Kumar	2018-2021	56.30

Social Science (3)

S No	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
26.	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 (CSAUA&T) 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 lakh
27	mKrishi Platform in collaboration with Tata Consultancy Services	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	
28	Value chain analysis of pulse crops in Bundelkhand region of Uttar Pradesh State	ICSSR	Dr. Uma Sah	Dr. Shripad Bhat	2019-21	10.50



Multidisciplinary Mega- Project (7)

S No	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
29.	Implementation of PVP legislation, DUS test.	Chick-pea	Dr. G.P. Dixit	Dr. A. K. Srivastava	2007 to Continued Project)	PPV & FRA Budget
30.	Implementation of PVP legislation, DUS test.	Pigeon-pea	Dr. I.P. Singh	Dr. Farindra Singh	2007 to Continued Project)	PPV & FRA Budget
31.	Implementation of PVP legislation, DUS test.	MULLa RP	Dr. Sanjeev Gupta	Dr. A.K. Parihar	2007 to Continued Project)	PPV & FRA Budget
32.	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. C.S. Praharaj	2016-2020 (Continued Project from revolving fund)	22531.08 lakh
33.	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	2016-2020 (Continued Project from revolving fund)	2039 lakh
34.	Genetic enhancement of miner pulses: characterization, evaluation, genetic enhancement 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 & Techno-logy)	**National Coordinator :** Dr. N.P. Singh	Dr. Mohd. Akram, Dr. Aditya Pratap Dr. Meenal Rathore Dr. A. K. Singh Dr. Naimuddin Dr. A.K. Parihar Dr. Debjyoti Sen Gupta Dr. Sudhir Kumar Dr. Revannasidda Dr. P R Sabaale Dr.Revanappa B	2018-2021	441 lakh
35.	DBT - Chickpea mission Programme of characterization of genetic resource: **Component 6:IIPR Kanpur- "Characterization of chickpea germplasm resource to accelerate genomic-assisted crop improvement"**	DBT (Min of Science & Techno-logy)	Dr. N.P. Singh	Dr. Archana Singh Dr. G.P. dixit Dr. Surendra K. Ghritlahre	2020-2025	718.725 lakh

Young Scientist Project (1)

36.	Agrobacterium tumefaciens-mediated geneediting in chickpea (*Cicer arietinum*) using CRISPR-Cas9 system	DST (INSPIRE)	Dr. Shallu Thakur		2017-2022	127000/= per month + 35 lakh res grant.



Institute Management Committee

As on 31.12.2020

Dr. N.P. Singh Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
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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
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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



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As on 31.12.2020

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Dr. N.P. Singh Director, ICAR-Indian Institute of Pulses Research, Kanpur	Member
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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 31.3.2020

Dr. N.P. Singh Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
Assistant Director General (O&P), ICAR Krishi Bhavan, New Delhi	Member
All Scientists of the Institute	Member
Dr. Aditya Pratap Principal Scientist, Division of Crop Improvement, ICAR-IIPR, Kanpur	Member Secretary

Important Committees of the Institute

As on 31.12.2020

1.	Monthly Review Committee (MRC)	**Chairman**	:	Director
		Members	:	All Project Coordinators, All Head of Divisions, All Scientists, Sr. AO., F&AO, AAOs, Chairmen of various committees, Secretary-IJSC, and I/c of various activities.
		Member Secretary	:	Dr. Naimuddin, Sr. Scientist
2.	Farm Advisory Committee (FAC)	**Chairman**	:	Dr. C.S. Prahraj, Pr. Scientist & Head
		Members	:	All HoDs, I/c Farms, I/c Security & Dr. D.P. Patel, Dr. Narendra Kumar, Dr. P.K. Katiyar, Nodal Officer (Seed)
		Member Secretary	:	Dr. A.K. Singh, Principal Scientist
3.	Estate Management Committee	**Chairman**	:	Director
		Members	:	Dr. Narendra Kumar, Dr. C.S. Prahraj Dr. P.K. Katiyar, Dr. R.K. Mishra, Dr. Omkar Nath, Sr. Administrative Officer, F. &A.O., Mr. S.K. Garg, Mr. R.M. Pal,
		Member Secretary	:	Er. PrasoonVerma, Scientist (SG)
4.	Publication Committee	**Chairman**	:	Director
		Co. Chairman	:	Dr. P. S. Basu, Pr. Scientist & Head
		Members	:	Dr.(Mrs.) Meenal Rathore, Dr. Uma sah Dr. Mod. Akram, & Dr. Aditya Pratap
		Member Secretary	:	Dr. Rajesh Kumar Srivastava
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		Member Secretary	:	AAO (S)
6.	Results Framework Document Committee	**Chairman**	:	Director
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		Nodal Officer	:	Dr. Mohd Akram
		Co-Nodal Officer	:	Dr. Senthil Kumar
7.	Institute Technology Management Committee (ITMC)	**Chairman**	:	Director
		Members	:	Dr. Bansa Singh, Dr. Shiv Sewak, Dr. C.S. Prahraj, Dr. T.N. Tiwari, Dr. Rajesh Kumar, Dr. Devraj and Dr. Meenal Rathore



		Ex-Officio	:	Dr. Sanjeev Gupta, Dr. I.P. Singh &
		Member		Dr. G.P. Dixit
		Member Secretary	:	Dr. Aditya Pratap
8.	Resource Generation and Farm Produce Price Fixation Committee	**Chairman**	:	Dr. Farindra Singh
		Members	:	Er. Prasoon Verma, Dr. Devraj, Sr. Administrative Officer, Finance & Accounts Officer and Dr. (MRs.) Uma Sah, I/c Library,
		Member Secretary	:	Dr. D.P. Patel, Pr. Scientist
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. Kodandaram (RS, Dharwad), Dr. Sripad Bhatt, Dr. Abhisek Bohra
		Member Secretary	:	Dr. C.S. Prahraj
10.	Library Committee	**Chairman**	:	Director
		Members	:	All HoDs, Sr. AO and F&AO
		Member Secretary	:	Dr. (Mrs.) Uma Sah, Pr. scientist
11.	Institutional Bio-safety Committee	**Chairman**	:	Director
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		Member Secretary	:	Dr. Alok Das, Sr. Scientist
12.	Germplasm & Genotype Identification Committee	**Chairman**	:	Director
		Members	:	Dr. Farindra Singh, Dr. D. Datta, Dr. Sujayanand, G.K., Dr. Yogesh Kumar, Dr. Mohd. Akram and Dr. Jitendra Kumar
		Member Secretary	:	Dr. Aditya Pratap, PS
13.	Academic and HRD Committee	**Chairperson**	:	Dr. (Mrs.) Meenal Rathore, Pr. Scientist & Head
		Members	:	Dr. R.K. Mishra, Dr. Senthil Kumar, Dr. Abhisek Bohra, Dr. Sripad Bhatt, Dr. Neetu Kushwaha, Sudhir Kumar Jha
		Member Secretary	:	Dr. Alok Das, Sr. Scientist
14.	Grievance Cell	**Chairman**	:	Dr. Rajesh Kumar, Pr. Scientist & Head
		Members	:	Dr. Jitendra Kumar, Dr. (Mrs.) Archana Singh (RS, Bhopal), Dr. (Mrs) Vijay Laxmi, Dr. Revanappa, (Dharwad), Dr. Surendra Kumar Meena, (Bikaner) & Dr. Omkar Nath
		Member Secretary	:	Sr. Administrative Officer

15.	Computer/ ARIS Cell & Instrumentation Committee	**Chairman**	:	Dr. P.S. Basu, Pr. Scientist & Head
		Members	:	Dr. Senthil Kumar, Dr. Hemant Kumar, Dr. Shanmugavadivel PS, Dr. Abhisekh Bohra,
		Member Secretary	:	Dr. Devraj, Pr. Scientist
16.	Consultancy Processing Cell	**Chairman**	:	Dr. Bansa Singh, Pr. Scientist
		Members	:	Dr. Rajesh Kumar, Dr. Farindra Singh, Narendra Kumar, Dr. T.N. Tiwari Dr. A.K. Parihar, Dr. K.R. Soren, Dr. A. K. Srivastava,
		Member Secretary	:	Dr. Narendra Kumar, Pr. Scientist
17.	Guest House Management Committee	**Chairman**	:	Dr. Shiv Sewak, Principal Scientist & Head
		Members	:	Dr. Rajesh Kumar, Dr. Farindra Singh, Dr. K.R. Soren, Sr. A.O & F & AO
		Member Secretary	:	Mr. Sukhdeo Mahto, AAO & I/c Guest House
18.	Vehicle Maintenance Committee	**Chairman**	:	Dr. Naimuddin, Pr. Scientist
		Members	:	Dr. Revanappa, (RS, Dharwad), Dr. (Mrs.) Archana Singh (RS, Bhopal), Dr. Omkar Nath Sr. A.O., F&AO, AAO(S)
		Member Secretary	:	Mr. Rajendra Kumar Nigam, AAO
19.	Sports Committee	**Chairman**	:	Dr. Bansa Singh, Pr. Scientist & Head
		Members	:	Dr. (Mrs.) Vijay Laxmi, Dr. K.R. Soren, Dr. Jagdeeswaran, Dr. M.P. Singh, Mr. Yashwant Singh, Secretary IJSC
		Member Secretary	:	Dr. K.R. Soren, Sr. Scientist
20.	Rajbhasha Implementation Committee	**Chairman**	:	Director
		Members	:	All HoDs, Dr. Devraj, Dr. (Mrs.) Uma Sah, Dr. R.K. Mishra, Dr. Udai Chand Jha, Mr. A.P. Singh
		Member Secretary	:	Dr. Rajesh Kumar Srivastava
21.	Technical Advisory & Proprietary Committee	**Chairman**	:	Dr. P.S. Basu, Pr. Scientist & Head
		Members	:	Dr. Mohd. Akaram, Dr. Lalit Kumar, Dr. Senthil Kumar, Dr. K.R. Soren
		Member Secretary	:	Dr. (Mrs.) Meenal Rathore
22.	Local Purchase Committee	**Chairman**	:	Dr. Narendra Kumar, Pr. Scientist
		Members	:	Dr. T.N. Tiwari, Dr. Hemant Kumar, Dr. Yogesh Tiwari, 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, Pr. Scientist
		Members	:	Dr. Omkar Nath, Mr. Rajendra Kumar Nigam, AAO

24	Women Grievance Cell	**Chairperson**	:	Dr. (Mrs.) Meenal Rathore Pr. Scientist
		Member	:	Dr. (Mrs) Vijay Laxmi, Sr. Scientist Dr. (Mrs) Archana Singh, RS, (Bhopal), Dr. (Mrs) Neetu Kushwaha, Mrs. Reeta Mishra,
		Member Secretary	:	Sh. Rajeev Nigam, A.A.O
25.	Institute Microbial Germplasm Registration Committee	**Chairman**	:	Dr. Bansa Singh
		Member	:	Dr. R.K. Mishra Dr. Kiran Gandhi
		Member Secretary	:	Dr. M. Santhilkumar
26.	In-charges	Sr. Administrative Officer, Head of Office Dr. C.S. Prahraj I/C PMEC & Member Secretary QRT Dr. Aditya Pratap, PS – Member Secretary, IRC Dr. Mod. Akram, PS - Member Secretary, RAC Dr. P.K. Katiyar PS- I/c Seed&Farm Dr. Rajesh Kumar PS & head (SS) I/c Photgraphy Dr. Dharmendra Patel I/c Guest House Dr. Devraj Mishra I/c Computer Dr. Dharmendra Patel Pr. Scientist I/c Farm, (Main Campus) Dr. A.K. Singh I/c Farm (NRC) Dr. Amrit LamichaneyI/c Gene Bank Including Cold Module Under Supervision of HoD (CI) Dr. (Mrs.) Uma Sah, PS I/c Library & Convener Seminar Er. PrasoonVerma I/c Estate Management Mr. S.K. Garg,ACTO *I/c Farm Machinery & Seed Processing Plants * I/c Maintenance of Power supply & other electrical work related to NRC under the supervision of I/c NRC, Shri R.S. Mathur, CTO I/c Security Shri. R.K. Singh,STO Farm Manager, (NRC) Mr. Krishna Avatar STO Farm Manager, (Main Farm) Under Supervision of Dr. D.P. Patel Shri Rajendra Kumar Nigam, AAO I/c Vehicle Shri R.M. Pall, T.O I/c Electricity Shri Krishna Awatar, STO I/c Horticulture under Supervision of Dr. D.P. Patel Shri Shiv Saran Singh, Assistant I/c Sanitation under supervision of Sr. A.O. Shri Yaduveer Singh I/c EPBX and other electronic facilities under supervision of Er. PrasoonVerma		
27.	Nodal Officer/Link Officer/ Liaison Officer	Dr. P.K. Katiyar: Link Officer, IIPR RS, Phanda, Bhopal (M.P) Dr. Dr. Narendra Kumar: Nodal Officer, IIPR RS, Bikaner (Rajasthan) Dr. C.S. Prahraj: Nodal Officer, IIPR RRC, Khordha (Odisha) Dr. G.P. Dixit: Link Officer IIPR RC, Dharwad (Karnataka)		

IIPR, Regional Research Centre, Khordha	: Dr. C.S. Prahraj, Nodal Officer Shri S.P.S. Chauhan, Farm Manager

ICAR - IIPR Regional Research Centre, Dharwad

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 (IGFRI-Dharwad)
		Member Secretary	: Dr. P.R. Sabale
2.	Seed, Security & Farm Development Committee	**Chairman**	: Dr. Kodandaram, PS (RRC-Dharwad)
		Members	: Dr. Shiv Kumar, BG Head (IGFRI-SRRS) : Dr. Suma Mogali (MULLaRP Scheme, USA, Dharwad) : Dr. Jayanth Bhat, (IARI,RRS)
		Member Secretary	: Dr. Ravanappa, Scientist
3.	I/C Gardening, Land Scape and Campus Development	Dr. P.R. Sabale	
4.	I/C Seeds	Dr. Revanappa	

ICAR - IIPR Regional Research Station, Phanda, Bhopal

1.	Purchase Committee	**Chairperson**	:	Dr. (Mrs.) Archana Singh, Pr. Scientist Scientist & I/c IIPR Research Station, Phanda, Bhopal
		Members	:	Dr. R.P. Singh, PS, AICRP-MULLaRP, College of Agriculture, Sehore
			:	Dr. Surendra Gitlahre, Scientist
		Member Secretary	:	Mr. Priyank Srivastava
2.	Seed/Grain Auction Committee	**Chairman**	:	Dr. P.K. Katiyar, Principal Scientist & Link Officer
		Members	:	Dr. S.C. Gupta, PS, College of Agriculture, Sehore
			:	Dr. (Mrs.) Archana Singh, Principal Scientist
			:	Dr. Surendra Gitlahre
		Member Secretary	:	Mr. Amit Bhatore

ICAR - IIPR Regional Station, Bikaner (Rajasthan)

1.	Purchase Committee	**Chairperson**	:	Dr. Narendra Kumar, Nodal Officer
		Members	:	Dr. Nathawat, Principal Scientist CAZRI, Regional Station, Bikaner
			:	Dr. Surendra Meena, 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

International Conference on "Pulses as the climate - smart crops"

Indian Society of Pulses Research and Development and ICAR-Indian Institute of Pulses Research (IIPR), Kanpur jointly organized an International Conference on "Pulses as the Climate Smart Crops : Challenges and Opportunities" at Bhopal during February 10-12, 2020. Dr. T.R. Sharma, Deputy Director General (CS) ICAR, New Delhi was the Chief Guest on this splendid function. On this occasion, Dr. M.C. Saxena (Ex-DDG, ICARDA), Dr. K.P. Vishwanathan (VC, VNMKV), Dr. P.M. Salimath (Former VC, UAS, Raichur), Dr. S.K.



Sharma (Former VC, CSKHPKV, Palampur), Dr. P.N. Behl (Ex-DDG, ICAR), Dr. S.K. Rao, VC, RVS Krishi Vishwavidyalya, Gwalior (MP) Dr. N. Nadarajan, Dr. Masood Ali (Ex-Directors IIPR, Kanpur), Dr. V.S. Gautam (Ex-Dean, RAK College of Agriculture, Sehore), Sri Dev Narayan Patel (Mahamatri Kisan Sanghamitra, M.P.), Mr. S.C. Bansal (CGM, NABARD, Bhopal) and delegates like Dr. Kiran Sharma (DDG, ICRISAT), Dr. Jacques Wery (DDG, ICARDA) were among the eminent diginitories present in the Conference. More than 500 scientists and research scholars from different areas of pulses research across the world participated in this event.

Dr. T.R. Sharma, Chief Guest urged the scientists to work for the all round benefit of the farmers. He admired the research works of the pulses scientists and "Seed Hub" programme and expressed views on the research advancements in achieving the self sufficiency and nutritional security of pulses in the country. He also encouraged the farmers to be active partner in various research based programmes. Speaking on the occasion, the chief guest also congratulated the pulse scientists for achieving an all time record production of pulses. The invited eminent delegates also addressed the august gathering.



Dr. N.P. Singh, Director, IIPR and Chairman, Organising Committee welcomed the honourable guests and participants. He briefed about the on-going activities on pulses. He stated about the successful implementation of the various projects under the National programmes. As the President ISPRD, he briefed about the activities of the Society as well.

During the function, a book titled "Pulses Production in India" written by Dr. N.P. Singh and others was also released by the Chief Guest. On this occasion, Life Time Achievement Award was given to Dr. P.N.



Behl, (Ex. DDG, ICAR) & ISPRD Excellence Awards were given to Dr. Ashutosh Sarker, Dr. Kiran Sharma, Dr. (Smt.) Om Gupta and Dr. S.K. Singh. Pulse Expert, a Mobile App for Pulse Crops prepared by Dr. Devraj in collaboration with IIPR and TCS was also released by the Chief Guest. The programme was conducted by Principal Scientists, Dr Aditya Pratap, Dr (Smt) Meenal Rathore and Dr (Smt) Uma Sah. Dr. P.K.Katiyar, Organising Secretary proposed vote of thanks to all the esteemed guests and participants.



World pulses day-cum-exhibition organized at IIPR, Regional Centre, Bhopal

The ICAR-Indian Institute of Pulses Research-Regional Centre, Phanda, Bhopal organized the **World Pulse Day-cum-Exhibition** for the pulse farmers of central region of country on 10th Feb, 2020. The event was inaugurated by Dr. T.R. Sharma, Dy. Director General (CS), ICAR, New Delhi who was the Chief Guest on the occasion. The "World Pulse Day-cum-Exhibition" registered total 34 stalls, 150 farmers and 30 college students. A Scientific Review Meeting of seed hub was also organised.

Dr. N.P. Singh, Director, IIPR welcomed the honourable guests and participants. While addressing the august gathering, he focussed on the success story of the development & scientific progress of IIPR-Regional Centre, Phanda, Bhopal. Dr. Singh also emphasized about the "National Seed Hub" programme which are spread across the country at 150 centres. He also informed to the farmers about the 6 new high yielding pulse varieties, released during 2019 for Central India farmers and urged them to adopt the improved technologies for doubling the farmer's income. The Chief Guest, Dr. T.R. Sharma, admired the research works of the IIPR Scientists and "Seed Hub" programme and expressed his views on the research advancements in achieving the self sufficiency and nutritional security on pulses in the country. He was happy to see the progress and activities of IIPR-Regional Centre, Phanda, Bhopal.

The progressive farmers also narrated their experiences and advantages they have been deriving from pulses cultivation. Ten innovative farmers were also honoured for their proactive role



on the pulses cultivation. The senior officials of ICAR Institutes and State Government Departments were also present during the occasion and took active part in the exhibition and exhibited their new technologies. The programme was convened by Dr. Sanjeev Gupta. The programme ended with vote of thanks given by Dr. Archana Singh, Principal Scientist and In-Charge, IIPR-Regional Station, Phanda, Bhopal. Dr. Rajesh Kumar, PS & Head, Social Science supervised the organization of the event over all.

ISPP North Zonal Seminar-2020 on Crop Productivity and Stress Management

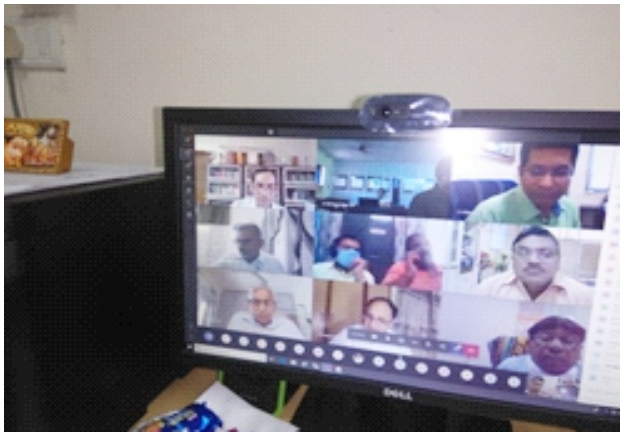
Indian Society of Plant Physiology, New Delhi in association with the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. organized an ***ISPP North Zonal Seminar-2020*** on ***"Crop Productivity and Stress Management"*** at CSAUA&T on February 22, 2020.

The seminar was inaugurated by Dr. N.P. Singh, Director, ICAR-IIPR as the Chief Guest. The Chairperson Dr. Poonam Singh, Dean, College of Agriculture, CSAUA&T along with Dr. H.G Prakash, Director Research, and Dr. Madan Pal, Treasurer, ISPP, New Delhi were present to grace the occasion. Dr. N.P. Singh during his inaugural address emphasised about the climate change and boosted the scientific community with different angle of views to tackle the climate change issues and its effect on crop productivity. Dr. Poonam Singh also narrated about the relevance of this seminar and its importance in solving the present-day issues of stress management for increasing crop productivity. Three publications *viz.*, Souvenir-cum-Abstracts book, Biodiversity and Crop Improvement in the Era of Climate Change and Objective General Agriculture were also released on the occasion. The vote of thanks was given by Dr. Gurumurthy S., Organizing Secretary.

Annual Group Meet of AICRP *Kharif* Pulses (2019-20)

The Annual Group Meet of *Kharif* pulses *i.e.* AICRPs on Pigeonpea, MULLaRP and Arid Legumes was organized during June 2-4, 2020 at ICAR-IIPR, Kanpur through video conferencing. The Chief Guest of Plenary Session, Dr. Trilochan Mohapatra, Secretary (DARE) & DG (ICAR) appreciated the efforts made by pulses fraternity under the aegis of IIPR & AICRP for bringing out a revolution in pulses production in the country resulting in self-sufficiency in the commodities. Dr. Mohapatra valued the current efforts being made towards digital communication to deliver outcomes amid the Covid-19 pandemic. Dr Mohapatra reiterated the need to sustain the remarkable productivity gains witnessed recently in pulse crops through adopting holistic approach. Dr. Tilak Raj Sharma, Deputy Director General (Crop Sciences), ICAR stressed upon intensifying research efforts on pre-breeding through embracing new tools and technology to overcome a variety of barriers that hamper the progress of pre-breeding programmes. Dr. N.P. Singh Director, ICAR-IIPR, Kanpur apprised about that technological breakthroughs in pulses research and development delivered by the NARS that led to self-sufficiency in pulses production.

Invited crop experts including Dr. P.M. Salimath (Ex. Vice Chancellor, University of Agricultural Sciences, Raichur), Dr S.K. Sharma (Ex.Vice Chancellor, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur), Dr B.B. Singh (Ex. ADG, Oilseeds and Pulses, ICAR, New Delhi), Dr. Masood Ali (Ex. Director, ICAR-IIPR, Kanpur), also provided valuable suggestions/ recommendations to improve further the efficacy of AICRPs during



three day long deliberations. Dr. S.K. Jha (ADG, Oilseeds and Pulses, ICAR, New Delhi) also offered critical remarks on the current progress and future outlook of these AICRPs.

Earlier, during the three days of virtual meeting Dr. I.P. Singh, (Project Coordinator, ICAR-AICRP on Pigeonpea), Dr Sanjeev Gupta (Project Coordinator, ICAR-AICRP on MuLLaRP) and Dr. Shiv Sewak (Nodal Officer on Arid Legumes) detailed about the progress made during 2019-20 under the respective AICRP and also finalized the technical programmes for coming *Kharif* season. Based on three years performance in IVT, AVT 1 and 2, six new pigeonpea varieties *viz.*, RKPV 413-02 in NWPZ, KRG 33 in CZ, WRGE 121 & PT 0723-1-2-3 in SZ, KA 16-1 & IPA 15-2 in NEPZ were proposed for identification. The meeting was attended by nearly 150 participants in five sessions in three days from various parts of the country involved in research on these pulse crops. The Group Meet ended with a vote of thanks by Dr. Shiv Sewak, ICAR-IIPR, Kanpur.

Webinar organized on Revisiting Strategy for Self Sufficiency in Pulses

The Indian Society of Pulses Research and Development and the ICAR-Indian Institute of Pulses Research, Kanpur jointly organized an online brainstorming webinar on "Revisiting Strategy for Self Sufficiency in Pulses: Introspection and Correction" on September 05, 2020, which was attended by 150 researchers and academia



working on food legumes from across the globe. Prof. S.K. Sharma, Former Vice Chancellor, CSK HPKV, Palampur and the former Chairman of the Research and Advisory Committee of ICAR-IIPR was the moderator while Dr. Masood Ali, Former Director, ICAR-IIPR; Dr. B.B. Singh, Former ADG (O&P), ICAR; Dr. Kiran Sharma, ICRISAT, Dr.

Ashutosh Sarker, ICARDA; Dr. P.M. Gaur, ICRISAT; Dr. Rajeev Varshney, ICRISAT; Dr. Shiv Kumar, ICARDA, Dr. Om Gupta, JNKVV, Jabalpur and Dr. Bidyut Sarmah, AAU, Jorhat were the eminent panelists who deliberated upon the research, development and policy issues which could lead to bridging the yield gap and enhance availability of pulses in the country. The project coordinators of different pulses and the Heads of the constituent Divisions of ICAR-IIPR were also present prominently in this webinar. Dr. N.P. Singh, Director, IIPR made an opening presentation summarizing the research and policy initiatives which steered a quantum jump in production of pulses in the country in the last decade and emphasized upon the grey areas which needed attention. Dr. I.P. Singh, President, ISPRD welcomed the participants, guests and the special invitees and briefed about the webinar. Dr. Aditya Pratap, Organizing Secretary of the Brainstorming Webinar and Secretary, ISPRD conducted the programme and finally proposed formal vote of thanks.

ONLINE Celebration of Foundation Day at ICAR-IIPR

ICAR-Indian Institute of Pulses Research Kanpur celebrated its **28th Foundation Day** on virtual mode due to COVID-19 pandemic on 05th September 2020 following its establishment in 1993. **Dr Trilochan Mohapatra,** Secretary, DARE and Director General ICAR, New Delhi was the Chief Guest of the function. The programme was presided over by Dr T.R. Sharma, Deputy Director General (Crop Science), ICAR, New Delhi. On this important occasion, various constraints related to pulses production targeting at 32 million tonnes (m t) by 2030 and 39 m t by 2050 by the country remained in focus. Director, ICAR-IIPR and staff members of the institute, eminent scientists, research scholars and farmers from different areas of Pulses Research participated in this ONLINE event.

The Chief Guest **Dr Trilochan Mohapatra,** Secretary, DARE and DG, ICAR in his special remarks, congratulated the scientists and staffs of ICAR-IIPR for the accomplishments made by the institute under the able guidance of its Director, Dr N.P. Singh. He also praised all the pulse scientists for achieving an average record production of 23-25 million tonnes of pulses consecutively for the last 4 years. He urged the scientists to work for the all round benefit of the farmers and stressed on minimizing production cost and bridging in productivity gaps in pulses. He reiterated that farmers ought to be partners in various research based programmes and the fruits of participatory research and extension should be translated on large scale for realization of higher yield and income.

Chairman of function, Dr Tilak Raj Sharma, Deputy Director General (CS), ICAR widely applauded the remarkable works & efforts made by ICAR-IIPR for all round development of the institute. He added that there is still a lot yet to be done in respect of diverse aspects in pulses especially breaking the current stability in production. He said that farmers are the SOUL of a nation and being the owner of his land, they should be selfsustained in order to enable our country self-sufficiency in pulses in time to come.

While delivering his remarks, Dr N.P. Singh, Director, ICAR-IIPR stressed on the importance of pulses, current scenario, research activities and future strategies. Dr Singh also discussed research advancements and priorities in achieving the self-sufficiency and nutritional security in pulses. In the



last few years, he informed that the various projects/programmes under National/international collaborations have given us rich dividends and were again carried forward to achieve the desired targets by 2030. In addition, a **Brainstorming Session** on *Strategies for self-sufficiency in pulses: Introspection and Correction* to address the issue of sustained growth in pulses further was held in the afternoon of foundation day wherein eminent scientists from India and abroad participated on virtual mode.

During the Foundation Day function, Dr. M. Senthil Kumar, Principal Scientist (Best Scientist Award 2020 under Senior Category), Dr Debjyoti Sen Gupta, Scientist Sr Sc. (Young Scientist Award 2020), Mr RS Mathur (Best Technical Officer), Mr.Brij Kishore Verma (Best Worker in Administrative Category), and Mr DK Agnihotri (Best Worker in Accounts & Audit) were awarded for their outstanding work on research and institutional activities. The Best Team Award went to Dr Yogesh Kumar and his team viz., Drs AK Srivastava, UC Jha, B Mondal, KR Soren Manjunatha L, Archana Singh (Bhopal Centre) and Revnappa Birader (Dharwad station).

Dr G.P. Dixit, Project Coordinator (Chickpea) offered vote of thanks while Dr CS Praharaj, PS & Head, Crop Production Division conducted the Foundation Day programme.

Webinar on *Gandhian* Philosophy and Agriculture

150th Birth Anniversary of Mahatma Gandhi was celebrated with a WEBINAR on 30.09.2020 on virtual mode by ICAR-Indian Institute of Pulses Research, Kanpur which coincided with **Nutrition Month** as pulses play the key role in nutritional security of the country. The main function of webinar on **Gandhian Philosophy and Agriculture** on the eve of 151st birth day of Father of the nation was held at Kanpur where Dr Shyam Babu Gupta, Director, Deen Dayal Research Centre, Chatrapati Shahu Ji Maharaj University, Kanpur and Dr Narendra Pratap Singh, Director, ICAR-IIPR, Kanpur participated.

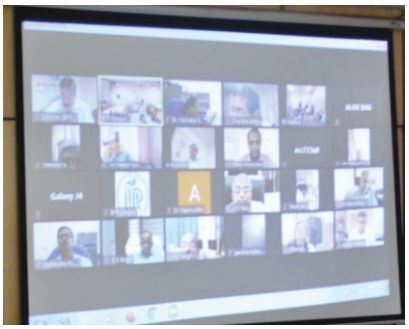


In his address, Chief Guest Dr Shyam Babu Gupta, Director, Deen Dayal Research Gentre, Chatrpati Shahu Ji Maharaj University, Kanpur reiterated that Gandhian philosophy provided a viable and authentically Indian with conceptual foundation on which to build genuinely sustainable development. Gandhian values needed to be accepted as the guiding principles underlying all our development planning including Agriculture. Since Gandhian values had worldwide appeal, so should their application to important, burning issues of ecology and sustainability. Besides a symbol of peace and nonviolence to the whole world, Gandhiji's ideologies as an Environmentalist was important in the context of present and future days to come, he added.

In his address in the Webenar, Chairman Dr Narendra Pratap Singh, Director, ICAR-IIPR, Kanpur said that the well-known Gandhian prescription of "simple living" attempted both to curb human overreaching and greed, and to prevent the mindless exploitation of natural resources. Therefore, it was clear that, while we must have some form of development, it had better be sustainable. In order to solve the pressing problems of the present times, Gandhi's principles of Swaraj, power decentralization, and Swadeshi (atmanirbhar Bharat) needed to be systematically inculcated in our nation, he said.

Earlier in the Webenar, Convener Dr CS Praharaj, PS & Head, Crop Production Division welcomed all the participants which included Project Coordinators, Heads of Division from ICAR-IIPR, Kanpur Scientific, Administration, Finance, Technical and Supporting Groups of ICAR-IIPR, Kanpur & its 4 regional centres at Bhopal, Bikaner, Dharwad and Khordha, Partners/stake holders of pulses in ICAR, SAU and CG Institutions, retired





members of our Pulses Family, faculty and staffs of Deen Dayal research centre, farmers, and members of press and media.

The webiran ended with Vote of Thanks to the Chair by Dr CS Praharaj with famous saying of father of the Nation ***"The Earth provides enough to satisfy every man's need, but not any man's greed".***

Kisan Diwas celebrated at ICAR-IIPR in Virtual Mode

Kisan Diwas was celebrated on 23rd December 2020 at ICAR-IIPR, Kanpur in Virtual Mode wherein 93 farmers from different districts of Uttar Pradesh participated in the profound remembrance of the former Prime Minister of India, Shri Chaudhary Charan Singh Ji. On this occasion, a *Kisan Chowk* near the technology park of the institute was inaugurated by Dr. N.P. Singh, Director, ICAR-IIPR. In his address, Dr. N.P. Singh high lighted the importance of pulses for human health and environment. He stressed on the fact that research and development activities of the institute have been further strengthened towards increasing production of pulses which have resulted in continuous high production & productivity. He urged the scientists of the Institute



to work for all round benefit of the farmers & stressed on minimizing the production cost of pulses. He said that farmers ought to be partners in various research programmes for better results.

Dr. C.S. Prahraj, PS & Head, Division of Crop Production delivered a lecture on importance of pulses for health and environment to mark the values of pulses in farming system to increase the soil fertility and save environment. Dr. Rajesh Kumar, PS & Head, Division of Social Science congratulated all the farmers on *Kisan Diwas* and appreciated their hard work for feeding the nation and their contribution in the development of the country. All the scientific, technical and supporting staff participated in the programme.

ICAR-IIPR celebrated Indian Constitution Day

ICAR-IIPR, Kanpur organized an extempore talk-cum-awareness programme on "Constitutional Values and Fundamental Principles of the Indian Constitution" on 26th November, 2020. All the scientists, technical and other staff members participated in the programme. While addressing on this important occasion, Dr. N.P.



Singh, Director, ICAR-IIPR, emphasized on respecting the "Constitutional Values and Fundamental Principles of the Indian Constitution" for the development of our country. Some of the staff members were honoured by the Director, Indian Institute of Pulses Research, Kanpur. Dr. Rajesh Kumar, PS & Head, Social Science Division coordinated the programme.

Celebration of *Kisan Diwas* at ICAR-IIPR, Kanpur

Online *"Kisan Diwas"* was celebrated on 23rd December 2020 at ICAR-IIPR, Kanpur, in which 93 farmers from different districts of Uttar Pradesh online participated and remembrance of former Prime Minister of India Shri Chaudary Charan Singh Ji. On this occasion inaugurated *Kisan Chowk* near the technology park. Director, Dr. N.P. Singh also highlighted the importance of pulses for health and Environment. Dr. C.S. Prahraj, PS & Head, Division of Crop Production delivered lecture on importance of pulses for health and Environment to give the importance of pulses in farming system to increase the fertility and save environment. Dr. Rajesh Kumar, PS & Head, Division of Social Science congratulated all the farmers on *Kisan Diwas* and appreciated the hard work and dedication of farming



community to feed the nation and contributing for development of the country. The scientific staff of Social Science Division along with technical and supporting staff participated on the *Kisan Diwas* programme organized at the institute main campus.

Exhibition

An agricultural exhibition was organized on February 10, 2020 at IIPR, RS Phanda, Bhopal, Madhya Pradesh. The Exhibition was inaugurated by Dr. T.R. Sharma, DDG, Crop Science, ICAR, New Delhi in the presence of Dr. N.P. Singh, Director, IIPR, Kanpur, Dr. G.P. Dixit, PC AICRP, Chickpea and many others dignitaries with lighting of lamp on February 10, 2020. Farmers were honoured in the programme by the Chief Guest.





Dr. T.R. Sharma, DDG, Crop Science visited IIPR, Stall

Celebration of 'Mahila Kisan Diwas' on 15.10.2020 at Khadra Village of Fatehpur District of Uttar Pradesh

ICAR-IIPR celebrated 'Gosthi' (Pulses for Nutrition) on the occasion of *Mahila Kisan Diwas* on October 15, 2020 at Khadra Village of Fatehpur District of Uttar Pradesh. Dr. Rajesh Kumar, PS & Head, Social Science Division, Dr. Vijay Laxmi, Senior Scientist, Basic Science Division and Dr. C.P. Nath, Scientist, Agronomy of ICAR-IIPR graced the occasion. Village Pradhan of Khadra Mrs. Sangeeta Gupta was the Chief Guest of programme. A total of 65 women farmers participated in the *'Mahila Kisan Diwas'*. At the outset, Dr. Rajesh Kumar briefed about the programme and highlighted the importance of women in agriculture and nation development. He also highlighted the role of pulses in nutrition and health for women and children. Dr. C.P. Nath emphasized the importance of pulses for crop intensification and doubling farmer's income. He eventually mentioned that bringing new area





under pulses with summer mungbean and chickpea. These crops can eliminate malnutrition and hunger. Dr. Vijay Laxmi mentioned that pulses are the main sources of proteins and essential elements and vital for eliminating protein-calorie malnutrition. She emphasized the role of pulses for protein nutrition and vegetarian diets particularly for pregnant women and children. Importantly, role of women in agriculture and societal upliftment were highlighted. Women empowerment through mainstreaming them in agriculture and societal activities will pave the way for nation development and doubling farmer's income. ICAR-IIPR is working on holistic development of model village and doubling farmer's income at Fatehpur district through integrated approach under Farmer FIRST programme. The village Pradhan, Mrs. Sangeeta Gupta also stressed upon the role of pulses for crop intensification, income and employment generation, and nutrition. In this direction, role of ICAR-IIPR was highlighted and requested farmers to adopt the improved technologies demonstrated by the Scientists.

Celebration of Indian Constitution Day on 26th November, 2020

ICAR-IIPR, Kanpur organized extempore talks cum awareness programme on "Constitutional Values and Fundamental Principles of the Indian Constitution" on 26th November, 2020. Scientists, Technical and other staff participated in this programme. On this occasion, Director of the Institute, Dr. N.P. Singh addressed and emphasized to respect the "Constitutional Values and Fundamental Principles of the Indian Constitution" for the development of our country. The some of the staff were also honored by the Director, Indian Institute of Pulses Research, Kalyanpur, Kanpur. Dr. Rajesh Kumar, PS & Head, Social Science Division coordinated the programme.





Extempore talks cum awareness programme on Constitutional Values and Fundamental Principles of the Indian Constitution

फार्मर फर्स्ट परियोजना की सफलता

फार्मर फर्स्ट परियोजना का क्रियान्वयन फतेहपुर जनपद के तीन गाँव करचलपुर, मिराई व खदरा में भा.कृ.अनु.प.–भारतीय दलहन अनुसंधान संस्थान के माध्यम से किया जा रहा है। इस परियोजना के माध्यम से किसानों को उन्नतशील प्रजाति का बीज प्रदर्शन लगाने हेतु दिया जाता है। चूंकि इस परियोजना का क्रियान्वयन भारतीय दलहन अनुसंधान संस्थान के द्वारा किया जा रहा है। अतः परियोजना क्षेत्र में दलहनी फसलों पर विशेष ध्यान केन्द्रित किया जा रहा है। दलहनी फसलों से न केवल किसानों की आय में वृद्धि होगी। बल्कि किसानों का परिवार प्रोटीनयुक्त दालें आहार के रूप में भी ले सकेगा। जिससे किसान परिवारों की खाद्य सुरक्षा को भी सुनिश्चित किया जा सकेगा। डा. राजेश कुमार, प्रधान वैज्ञानिक, सामाजिक विज्ञान ने बताया कि *फार्मर फर्स्ट* परियोजना के माध्यम से किसान की अनाज, दलहनी, तिलहनी, सब्जी आदि फसलों के बीजों को परियोजना क्षेत्र में प्रदर्शन लगाने हेतु दिया जाता है। इस प्रकार से किसानों को उन्नतशील प्रजाति के बीज मिल जाते हैं। इस क्षेत्र के किसान सब्जियों वाली फसलें बहुतायत रूप से पैदा करते है। इसी को ध्यान में रखते हुए इस बार भिंडी की प्रजाति (नव्या गोल्डन) का बीज 42 किसानो को दिया गया था। इन सभी किसानों में सें करचलपुर के निवासी श्री बब्बू कुशवाहा ने 02 मई 2020 को पंक्ति विधि से भिंडी की बुवाई की थी। जिसमें पौधे व पंक्ति के बीच की दूरी 70 x 30 से.मी. रखी। श्री बब्बू कुशवाहा ने बताया कि 45 दिन की फसल होने के पश्चात भिंडी की तुड़ाई शुरू कर दी थी। उन्होने बताया कि 4 बिसवां में लागत तो मात्र ₹ 1700 लगी है, जबकि उत्पादन के मामले में देखा जाए तो प्रत्येक तीसरे दिन 30 से 40 कि.ग्रा. भिंडी उत्पादित होती है। जून के अन्तिम सप्ताह से लेकर अक्टूबर के प्रथम सप्ताह तक लगभग ₹ 20000 की भिंडी बेच चुके हैं, और इसके साथ ही घरेलू उपयोग के लिए भी समय–समय पर इसको प्रयोग में लाया गया है। जिससे घरेलू उपयोग के लिए सब्जियों पर भी व्यय कम दर्ज हुआ।



फार्मर फर्स्ट परियोजना से गेहूँ की *रिज* विधि का सफल प्रदर्शन

भाकृअनुप–भारतीय दलहन अनुसंधान संस्थान, कानपुर के द्वारा *फार्मर फर्स्ट* परियोजना का सफल क्रियान्वयन फतेहपुर जनपद के तीन गाँव करचलपुर, खरौली एवं मिराई में किया गया। वर्ष 2019–20 में गेहूँ की उन्नतशील प्रजाति के.–1006 का बीज 10 किसानो को दिया गया था। एक किसान ने गेहूँ को ***रिज विधि*** के द्वारा एवं अन्य किसानों ने पंक्ति विधि व छिड़कवा विधि से बुआई की। यदि मुख्य रूप से गेहूँ की पंक्ति विधि एवं *रिज* विधि को तुलनात्मक तरीके से देखा जाए, तो *रिज* विधि से बोए गेहूँ में पानी देने मे आसानी तथा फसल को कम पानी की आवश्यकता होती है और इसके साथ ही फसल के पौधों को पर्याप्त हवा, पानी एवं उर्वरक, खतपतवार की अपेक्षा, अधिक मिल पाते हैं। क्योंकि अधिकतर खरपतवार दो *रिज* के बीच मे सिंचाई के द्वारा दिया गया पानी अधिक भर जाने के कारण कमजोर हो जाते हैं। जिससे खरपतवार व फसल के बीच वानस्पतिक वृद्धि 10–15 प्रतिशत तक कम हो जाती है और गेहूँ की फसल के पौधों का वृद्धि एवं विकास अच्छा होता है। इस विधि से गेहूं की फसल को बोने से खरपतवारनाशी एवं कीटनाशक के छिड़काव करने में भी आसानी रहती है। इस विधि से बुआई करने में एक और फायदा है कि पंक्ति विधि से की गई बुआई में ऐसी समस्या कम ही देखने को मिलती है और इसके साथ ही अगर देखा जाये तो *रिज* विधि से एक जुताई, 15 से 20 कि.ग्रा. बीज, 20 प्रतिशत उर्वरक एवं एक सिचाई की बचत हो जाती है तथा रिज विधि से बोए गये गेहूँ का उत्पादन सामान्य से विधि से बोये गये गेहूँ के उत्पादन से 02–04 क्विटंल प्रति हेक्टेयर अधिक होता है। इस प्रकार एक हेक्टेयर में किसान को ₹ 6000 से 10,000 तक की अतिरिक्त बचत हो जाती है।



संस्थान में विडियो कांफ्रेसिंग से मना हिंदी दिवस

भाकृअनुप.–भारतीय दलहन अनुसंधान संस्थान में दिनांक 17 सितम्बर, 2020 को हिन्दी दिवस *विडियो कांफ्रेसिंग* के माध्यम से हर्षोल्लास के साथ मनाया गया। राष्ट्रीय स्तर के लोकप्रिय कवि, लेखक एवम् शिक्षाविद् डॉ. सुरेश अवस्थी कानपुर इस समारोह के मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक, डॉ. नरेन्द्र प्रताप सिंह ने की। *विडियो कांफ्रेसिंग* के माध्यम से संस्थान के सभी वैज्ञानिक, तकनीकी, प्रशासनिक एवं सहायक वर्ग के कर्मचारियों ने इस कार्यक्रम में भाग लिया। अपने उद्‌बोधन में मुख्य अतिथि, डॉ. सुरेश अवस्थी ने कहा कि हमारे बहुभाषी देश में, सम्पर्क भाषा के रूप में हिन्दी का महत्वपूर्ण योगदान रहा है। आज विकास की गति में हमारी राजभाषा हिन्दी एक मजबूत सूत्रधार का कार्य कर रही है। हम अपनी भाषा में अधिक स्पष्ट एवं प्रभावी ढंग से अपने विचार एवं विषय को प्रकट कर सकते हैं।

अध्यक्षीय उद्‌बोधन में संस्थान के निदेशक, डॉ. नरेन्द्र प्रताप सिंह ने कहा कि राजभाषा अर्थात सम्पूर्ण राष्ट्र की भाषा किसी भी देश के विकास में राजभाषा का महत्वपूर्ण स्थान होता है क्योंकि ज्ञान का आदान–प्रदान, संचार और संरक्षण भाषा द्वारा ही किया जाता है। हिन्दी एक समृद्ध भाषा है और इसकी सम्प्रेष्णीयता भी उच्च कोटि की है। संस्थान में राजभाषा हिन्दी के प्रचार–प्रसार एवं प्रयोग को आगे बढ़ाने के लिए बहुआयामी प्रयास किए गए हैं। इसी क्रम में हिन्दी में



मौलिक वैज्ञानिक लेखन, कार्यालीन पत्राचार और सृजनात्मक अभिव्यक्ति को बढ़ावा दिया गया है। तकनीकी क्षेत्रों के साथ–साथ, गैर तकनीकी क्षेत्रों में भी हिन्दी के प्रयोग में लगातार बढ़ोत्तरी हो रही है और संस्थान में राजभाषा हिन्दी का भरपूर प्रचार हो रहा है। डॉ. राजेश कुमार श्रीवास्तव, सचिव, राजभाषा ने संस्थान में राजभाषा की प्रगति आख्या प्रस्तुत करते हुए कहा कि हिंदी दिवस का आयोजन, महज एक समारोह अथवा परंपरा नहीं है, अपितु यह आयोजन, एक आवाहन है, जिसके माध्यम से हम संस्थान में ज्यादा से ज्यादा काम, हिंदी में करने का संकल्प लेते हैं। कार्यक्रम के अन्त में डॉ. शिव सेवक, प्रभारी, मरू दलहनी फसलें, ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन डॉ. राजेश कुमार श्रीवास्तव, सचिव, राजभाषा द्वारा किया गया।

As on 31.12.2020

Personnel

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 (In-Charge)

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. Farindra Singh	Genetics & Plant Breeding	Principal Scientist & Head (In-charge)
7. Dr. P.K. Katiyar	Genetics & Plant Breeding	Principal Scientist
8. Dr. Jitendra Kumar	Genetics & Plant Breeding	Principal Scientist
9. Dr. Aditya Pratap	Genetics & Plant Breeding	Principal Scientist
10. Dr Dibendu Datta	Genetics & Plant Breeding	Principal Scientist
11. Dr Awnindra Kumar Singh	Genetics & Plant Breeding	Principal Scientist
12. Dr Yogesh Kumar	Genetics & Plant Breeding	Principal Scientist
13. Dr. A.K. Srivastava	Genetics & Plant Breeding	Senior Scientist
14. Dr. Udai Chand Jha	Genetics & Plant Breeding	Scientist (Senior Scale)
15. Dr. Debjyoti Sen Gupta	Genetics & Plant Breeding	Scientist (Senior Scale)
16. Dr. Abhishek Bohra	Genetics & Plant Breeding	Scientist (Senior Scale)
17. Dr. Ashok Kumar Parihar	Genetics & Plant Breeding	Scientist (Senior Scale)
18. Dr. Biswajit Mondal	Genetics & Plant Breeding	Scientist(Senior Scale)
19. Dr. Amrit Lamichaney	Seed Science & Technology	Scientist
20. Dr. Satheesh Naik S.J.	Genetics & Plant Breeding	Scientist
21. Dr. Basavaraja T.	Genetics & Plant Breeding	Scientist

Plant Biotechnology		
22. Dr. (Mrs.) Meenal Rathore	Biotechnology	Principal Scientist & Head (In-charge)
23. Dr. Khela Ram Soren	Biotechnology	Senior Scientist
24. Dr. Alok Das	Biotechnology	Senior Scientist
25. Dr. G.K. Sujayanand	Entomology	Scientist
26. Dr. P.S. Shanmugavadivel	Biotechnology	Scientist
27. Mr. Arvind Kumar Konda	Biotechnology	Scientist

28. Dr. Neetu Singh Kushwah	Biotechnology	Scientist
29. Mr. Sudhir Kumar	Biotechnology	Scientist
30. Sh. Kuldeep Kumar	Biotechnology	Scientist

Crop Production		
31. Dr. C.S. Praharaj	Agronomy	PS & Head (In-charge)
32. Dr. Narendra Kumar	Agronomy	Principal Scientist
33. Dr. Raghavendra Singh	Agronomy	Principal Scientist
34. Dr. Prasoon Verma	ASPE	Scientist (SG)
35. Dr. Kali Krishna Hazra	Agronomy	Scientist
36. Dr. Chaitanya Prasad Nath	Agronomy	Scientist
37. Mr. Man Mohan Deo	FMP	Scientist (Study Leave)
38. Mr. Asik Dutta	Soil Science	Scientist
39. Ms. Kancheti Mrunalini	Agronomy	Scientist

Crop Protection		
40. Dr. Bansa Singh	Nematology	PS & Head (In-charge)
41. Dr. Mohd. Akram	Plant Pathology	Principal Scientist
42. Dr. Naimuddin	Plant Pathology	Principal Scientist
43. Dr. R.K. Mishra	Plant Pathology	Principal Scientist
44. Dr. R. Jagdeeswaran	Nematology	Scientist
45. Dr. Sujyanand G.K.	Entomology	Scientist
46. Dr. Bandi Sanjay Maruti	Entomology	Scientist
47. Mr. Devindrappa	Nematology	Scientist (Study Leave)
48. Dr. Manjunatha L.	Plant Pathology	Scientist
49. Dr. Kiran Gandhi Bapatla	Entomology	Scientist
50. Mr. Ravanasidda	Entomology	Scientist
51. Dr. Rishikesh Kumar	Plant Pathology	Scientist
52. Dr. Anup Chandra	Entomology	Scientist

Basic Science		
53. Dr. P.S. Basu	Plant Physiology	PS & Head (In-charge)
54. Dr. M. Senthilkumar	Microbiology	Principal Scientist
55. Dr. D.P. Patel	Plant Physiology	Principal Scientist
56. Dr T.N.Tiwari	Plant Physiology	Principal Scientist
57. Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
58. Dr. Kalpana Tiwari	Biochemistry	Scientist
59. Dr. Vaibhav Kumar	Biochemistry	Scientist
60. Mr. Krishnashis Das	Microbiology	Scientist

Social Science		
61. Dr. Rajesh Kumar	Agril. Extension	PS & Head (In-charge)
62. Dr. (Mrs.) Uma Sah	Agril. Extension	Principal Scientist
63. Dr. Dev Raj Mishra	Computer Application	Principal Scientist
64. Dr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)

G. Regional Station-cum-Off-Season Nursery, Dharwad (Karnataka)		
65. Dr. M.S. Venkatesh	Soil Science	Principal Scientist & Station In-charge
66. Dr. M.H. Kodandaram	Entomology	Principal Scientist
67. Dr. Revanappa	Plant Breeding	Scientist
68. Dr. P.R. Saabale	Plant Pathology	Scientist
69. Dr. Manu B.	Genetics & Plant Breeding	Scientist
H. Regional Centre, Bhopal (Madhya Pradesh)		
70. Dr. (Mrs.) Archana Singh	Eco. Botany & P.G.R.	Principal Scientist & Station In-charge
71. Dr. Surendra Kumar Ghritlahre	Genetics & Plant Breeding	Scientist
72. Mr. Alok Kumar	Seed Science & Technology	Scientist (Study Leave)
73. Dr. Sandeep Kumar	Agronomy	Scientist
I. Regional Centre, Bikaner (Rajasthan)		
74. Dr. Ram Lal Jat	Agronomy	Scientist & I/C Farm
75. Dr. Surendra Kumar Meena	Plant Physiology	Scientist
76. Dr. Banwari Lal	Agronomy	Scientist
77. Dr. Lalit Kumar Rolaniya	Agronomy	Scientist
78. Dr. (Mrs.) Monika Punia	Genetics & Plant Breeding	Scientist
J. Regional Station Khordha (Odisha)		
79. Mr. S.P.S. Chauhan	Chief Technical Officer (T-9)	Farm Manager
K. Technical		
80. Dr. M.P. Singh	Chief Technical Officer (T-9)	
81. Mr. R.S. Mathur	Chief Technical Officer (T-9)	
82. Dr. G.K. Srivastava	Chief Technical Officer (T-9)	
83. Dr. Omkar Nath	Chief Technical Officer (T-9)	
84. Mr. S.K. Garg	Chief Technical Officer (T-9)	
85. Mr. Radha Krishan	Assistant Chief Technical Officer (T-7/8)	
86. Mr. A.P. Singh	Senior Technical Officer (T-6)	
87. Mrs. Rashmi Yadav	Senior Technical Officer (T-6)	
88. Dr. Rajesh Kumar Srivastava	Senior Technical Officer (T-6)	
89. Mr. Krishna Autar	Senior Technical Officer (T-6)	
90. Mr. Lakhan	Senior Technical Officer (T-6)	
91. Mr. R.K.S. Yadav	Technical Officer (T-5)	
92. Mr. R.K. Singh	Technical Officer (T-5)	
93. Mr. Rakesh	Technical Officer (T-5)	
94. Dr. Kanhaiya Lal	Technical Officer (T-5)	
95 Mr. Malkhan Singh	Technical Officer (T-5)	
96. Mr. Ashraf Khan	Technical Officer (T-5)	
97. Mr. Arvind Singh Yadav	Technical Officer (T-5)	
98. Mr. R.M. Pal	Technical Officer (T-5)	



99. Mr. H.N. Maurya	Technical Officer (T-5)
100. Mr. K.S. Meena	Technical Officer (Driver) (T-5)
101. Mr. S.N. Hatiya	Technical Officer (Driver) (T-5)
102. Mr. Satish Kumar Singh	Technical Officer (Driver) (T-5)

L. Administrative	
103. Mr. Kumar Vivek	Senior Administrative Officer
104. Mr. D.K. Agnihotri	Finance & Accounts Officer
105. Mr. Sukhdeo Mahto	Assistant Administrative Officer
106. Mr. Rajendra Kumar Nigam	Assistant Administrative Officer
107. Mr. Brij Kishore	P.S. to Director



Appointment, Transfer, Promotion, *etc.*

Appointments

Name	Post	Discipline/Division	Date of joining
Sh. Kuldeep Kumar	Scientist	Plant Biotechnology	04/04/2020
Ms. Kancheti Mrunalini	Scientist	Agronomy	04/04/2020
Dr. Sandeep Kumar	Scientist	Agronomy	04/04/2020

Promotions

Name	Promoted to	W.e.f.
Sh. Sanjay Kumar Garg	Chief Technical Officer	24/02/2018
Sh. Kamlesh Chandra	Technical Officer	21/10/2018
Sh. Lakhan Verma	Senior Technical Officer	01/01/2019
Sh. Ramesh Chandra	Chief Technical Officer	01/07/2019
Sh. Ram Babu	Sr. Technician	04/07/2019
Sh. Ram Swaroop Kushwaha	LDC	04/12/2020
Sh. Yashwant	LDC	17/12/2020

Transfers

Name	Designation	From	To	W.e.f.
Dr. Rishikesh Kumar	Scientist (Plant Pathology)	IIAB, Ranchi	IIPR, Kanpur	17/06/2020
Dr. Shripad Bhat	Scientist (Agril. Economics)	IIPR, Kanpur	ICAR-CCARI, North Goa	31/07/2020
Dr. Gurumurthy	S.Scientist (Plant Physiology)	IIPR, Kanpur	ICAR-NIASM, Baramati	14/08/2020
Dr. Lalit Kumar Rolaniya	Scientist (Agronomy)	ICAR-IIFSR, Modipuram	IIPR-Regional Station, Bikaner	05/08/2020
Mrs. Monika Punia	Scientist (Genetics & Plant Breeding)	ICAR-CIAH, Bikaner	IIPR-Regional Station, Bikaner	30/09/2020
Sh. K. Ravi Kumar	Scientist(Agril. Extension)	IIPR, Kanpur	ICAR-NIASM, Pune	21/11/2020

Retirements

Name	Post held	Date of retirement
Sh. Ramesh Chandra	ACTO	31/03/2020
Sh. Om Prakash	Skilled Supporting Staff	30/06/2020
Mrs. Asha Maurya	Skilled Supporting Staff	30/06/2020
Sh. Harbansh	Skilled Supporting Staff	30/06/2020
Km. Sushma Saxena	Skilled Supporting Staff	30/06/2020
Mrs. Vimla	Skilled Supporting Staff	30/06/2020
Sh. Ram Babu	Sr. Technician(T-2)	31/07/2020
Sh. Rati Pal Maurya	Skilled Supporting Staff	31/07/2020
Sh. Kailash Chandra	Technical Officer(T-5)	31/10/2020
Sh. Samar Singh	LDC	31/12/2020

Obituary

- Sh. Govind Ram, Sr. Technical Assistant(T-4) left for Heavenly Abode on September 11, 2020. May the departed soul rest in peace.





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