Azadi Ka Amrit Mahotsav

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
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वार्षिक प्रतिवेदन
Annual Report
2021

ISO 9001-2008

भाकृअनुप-भारतीय दलहन अनुसंधान संस्थान, कानपुर, 208 024

ICAR-Indian Institute of Pulses Research, Kanpur, 208 024

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ICAR-Indian Institute of Pulses Research

Kanpur 208 024

Published by	:	Dr. Bansa Singh, Director ICAR-Indian Institute of Pulses Research, Kanpur-208 024
Editing, designing and layout	:	Dr. Rajesh Kumar Srivastava
Publication Committee	:	Dr. Bansa Singh, Chairman Dr. (Mrs.) Meenal Rathore, Co-Chairperson Dr. Alok Das, Member Dr. K.K. Hazara, Member Dr. Uday Chandra Jha, Member Dr. Sanjay Bandi, Member Dr. Rajesh Kumar Srivastava, Member Secretary
Correct citation	:	Annual Report 2021 ICAR-Indian Institute of Pulses Research Kanpur-208 024

Printed by : Maheshwari & Sons, 289/214, Moti Nagar, Lucknow. Mob. : 9721505010

Director's Desk



It is my pleasure to present the Annual Report 2021 of ICAR-Indian Institute of Pulses Research, Kanpur. It is a privilege to lead such a vibrant Institute whose efforts and achievements have aided in making the nation self-sufficient in pulses production by achieving a record production to the tune of 25.75 million tonnes during 2020-21. This all had been possible due to collaborative efforts of policy makers, research scientists, frontline workers and the pulse farmers. Concerted efforts of the strong network of AICRP and NARS system along with modern infrastructure and technologies in pulses research has made this feat possible. This Annual report of the Institute highlights the significant achievements made under different research/extension and training programmes.

During this year, a total of 7 varieties have been released and notified from IIPR. Under the Crop Improvement Programme, one *kabuli* chickpea variety IPCK 2013-163 was released for cultivation in NWPZ; two *desi* chickpea varieties IPC 2010-134 (*Shiva*) and IPC 2007-28 (*Atal*) have been released for cultivation in UP under timely and late sown conditions. A *desi* chickpea variety *viz.* IPCMB 19-3 (*Samriddhi*), developed through MABC approach for resistance to *Fusarium* wilt, has also been released for cultivation under Central Zone. A lentil variety IPL 230 was released in UP under timely sown conditions for early maturity, resistance to rust and tolerance to *Fusarium* wilt. Fieldpea variety IPF 16-3 has been released for cultivation in UP and is resistant to powdery mildew, rust and *Aschochyta* blight. The urdbean variety IPU 17-1 was released for MP during *kharif* and is early maturing with high seed protein content.

Three *desi* chickpea donors for different traits *viz.*, IPC 2020-198(INGR 21141) for higher number of seeds/pod, ICC 12315 (INGR 21141) for tolerance to PoE herbicide imazethapyr, and IPC 15-925 (INGR 21144) for heat tolerance; one fieldpea genotype IPFD 18-14 (extra early line) and one mungbean genotype IPM 604-1-7 (INGR 21104) (unique golden yellow seed coat colour) have been registered with ICAR-NBPGR, New Delhi as genetic stocks.

A chickpea line IPCL 4-14 (IPCMAS-1) was developed in Plant Biotechnology Division through MABC breeding for improved drought tolerance and was released for NWPZ this year. Also, 4500 and 22500 SNPs have been identified in heat tolerance QTL intervals on chromosome 5 and 6 using resequencing data of 195 minicore lines of chickpea following GATK

tools. The draft genome of sequencing of 4 *Bacillus* isolates reveals presence of 102 insecticidal genes of which expression of 6 genes has been validated by LCMS/MS from the isolate F6.IIPR. Five independent transgenic chickpea lines harbouring the codon optimized Vip3Aa have been developed and tested for trait efficacy indicating larval mortality and degenerate larval development. CRISPR/Cas 9 constructs have been developed targeting the early flowering 1 (Efl1) gene in chickpea; the oxalyl-CoA synthetase and ODAP synthase in grasspea. The ODAP synthase gene was identified in grasspea and its sequence submitted to Genbank.

Under Crop Production programme, the maximum system productivity and profitability was recorded in maize-wheat-mungbean and maize + GM (*dhaincha*) – chickpea- mungbean systems under conservation agriculture module in IG plains. Also, improved crop management practices amalgamated with resource conservation technologies could play a role in enhancing productivity and profitability in rice fallow-pulse production systems. Foliar application of 1% KCl or 1% KNO_3 post-flowering increased chickpea productivity by 20-22% under terminal water deficit condition in Northern India. Pulse crop inclusion in upland maize-wheat and pearl millet-wheat systems increased nutrient (N, P and K) stock in both macro and micro aggregate soil fractions. Clusterbean-mustard and mungbean-mustard can be potential pulse inclusive cropping systems for arid ecosystem of the north western India. Cultivars of pigeonpea *viz.* IPA15-0 and IPA 203 and of chickpea IPC 2006-77 and IPC 2004-98 aids in improving productivity of sorghum+pigeonpea and chickpea + mustard intercropping systems. Cover cropping using *Lathyrus* and chickpea in moderately alkaline *Fluvisol* enhances P use efficiency in cropping systems.

The IIPR *dal* mill was found more operator friendly than Akola *dal* mill and can be run comfortably for 8-h/day. Maximum *dal* recovery has been obtained with three grit roller combination for pigeonpea, mungbean, lentil and urdbean. More than 14 edible products *viz.*, biscuit, pizza base, cake, muffins, buns, noodles, fortified *atta, etc.* have been developed using whole and powder components of pulse milling by products.

A number of pigeonpea lines have been identified as donors for resistance against biotic stress *viz.* resistance against *Fusraium* wilt [7 advanced breeding lines (for race 2) and 11 lines]; resistance against *Phytophthora* stem blight (4 early and medium duration lines) and for resistance to wilt and PSB both (8 genotypes). In chickpea, IPCK 2013-209 was found moderately resistant to *Ascochyta* blight at two locations. Two genotypes (IPC 15-273 and IPC 3013-248) were found resistant to BGM disease under field conditions; eight lines revealed low severity to rust disease and one pre breeding line was observed to be highly resistant against wilt. Eight genotypes in urdbean have been identified as stable sources of resistance against MYMIV. The developed emulsion from *Bt* isolates have significantly lower percent pod damage and higher yields wrt control in chickpea field trials. An improved and efficient screening method has been developed at Storage Entomology Lab for identification of sources of resistance in pulse crops against bruchids. Two pigonepea genotypes *viz.*, Pusa 992 and TDRG-59 were found highly resistant against *Meloidogyne javanica* and four lines were found resistant against *Heterodera cajani*. *Brassica* (cvs. GSL-2, Neelam and Sheetal) and *Eruca sativa* (Karan Tara) plants, when incorporated in soil and covered with polythene for 15 days, maximally reduce the nematode population. Bioformulation *Dalhanderma* reduced wilt incidence by 18-32% with a grain yield increase by 19-27%. Volatile extracts of

Pogostemon, Cuminum and *Cymbopogon* exhibited repellant activity against bruchids. Four accessions of *V. umbellata* and two accessions of *V. vexillata* were found resistant against *C. chinensis* and *C. maculatus*. One accession of V. *khandalensis* and four of V. *mungo* var. *mungo* were found resistant against *C. chinenesis.*

Screening of pulse genotypes for tolerance to abiotic stress led to identification of five genotypes in lentil for higher tolerance to heat. Six genotypes for tolerance to drought and three genotypes of pigeonpea tolerant to water logging. Stachyose and raffinose were found to be the major galacto-oligosaccharides in commonbean while glucose was detected in very few genotypes. Nodulation specific genes (26) were identified in chickpea following homology based search using genomic resources cv. Chickpea CDC Frontier. *Rajmash* genotype IC 356018 was identified as the highest nodulator among four genotype-*Rhizoboium* combinations studied.

In effort to disseminate efficient technologies to farmers, 128 Frontline demonstrations (FLDs) were conducted in six districts of UP; 250 FLDs were conducted in MP and Chhattisgarh in *Kharif* and 400 in *Rabi* for improved pulse production. As part of technological interventions, during *Kharif* 2021, high yielding paddy hybrid Arize 6444 Gold, hybrid pearlmillet Pioneer 86M84 and Navya hybrid of okra were introduced in Fatehpur district of UP under Farmers First project resulting in higher crop yields an income. Two MoUs for transfer of technology on Milling of Pulses in Mini *dal* mill and for incubation support was extended to one applicant under ABI unit at IIPR, Kanpur.

The regional Centre, Phanda, Bhopal has identified four high yielding entries in *kabuli* chickpea as donors for extra-large seed and five entries as heat tolerant chickpea. Wilt sick plots for chickpea, pigeonpea and lentil are under development here for races of Central Zone. The regional centre at Dharwad is engaged as the off-season nursery for pulse breeding material and evaluation of varied accessions for agro-morphological and yield traits and production of breeder seed other than basic trials. The Centre identified cowpea PL-3 and CPD 331 as root rot resistant. At Bikaner centre, three cowpea accessions *viz.*, EC 738156, EC 738206 and EC 738093 have been identified as early type; mungbean IPM 1103-1, IPM 410-3 and IPM 312-20 were identified as drought tolerant. Pearl millet + clusterbean intercropping recorded the highest yield at Bikaner. Recent research at Khorda centre revealed IPU 13-1 to yield more over other varieties tested and sowing in December to yield significantly higher.

All achievements could be possible due to constant support from the Council. I am grateful to the Hon'ble Secretary, DARE and DG, ICAR, Dr. Trilochan Mohapatra; DDG (CS), Dr. T.R. Sharma and ADG (O&P), Dr. Sanjeev Gupta for their constant support and guidance. I appreciate the efforts of the Project Coordinators, Dr. G.P. Dixit and Dr. I.P. Singh, Heads of Divisions including Drs. Farindra Singh, Narendra Kumar, Bansa Singh, D.P. Patel, Uma Sah and Meenal Rathore for research inputs from their respective Divisions. I am equally thankful to all the members of the Publication Committee Drs Meenal Rathore, Alok Das, K.K. Hazra, Uday Jha, Sanjay M. Bandi and Member Secretary Dr. Rajesh Kumar Srivastava for their praiseworthy effort towards editing and bringing out this 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.

(Shiv Sewak)
Director

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Executive Summary

Crop Improvement

A. Chickpea

- *Kabuli* chickpea variety IPCK 2013-163 (Madhav) was released and notified for cultivation in NWPZ.
- *Desi* chickpea variety IPCMB 19-3 (Samriddhi) has been developed through MABC approach in the background of Pusa 256 with *Fusarium* wilt resistance locus transferred from cultivar Vijay. It has been released and notified for cultivation under Central Zone.
- Two desi chickpea varieties, IPC 2010-134 (Shiva) and IPC 2007-28 (Atal) have been released/notified for cultivation in UP under timely and late sown condition, respectively.
- Two chickpea genotypes, IPC 10-142 (Kuber) and IPCK 09-145 (Kanchan) were identified for release in UP.
- Three *desi* chickpea donors namely, IPC 2020-198 (INGR 21141) for higher number of seed/pod, ICC 12315 (INGR 21142) for tolerance to post emergence herbicide-Imazethapyr and IPC 15-925 (INGR 21144) for heat tolerance have been registered with ICAR-NBPGR, New Delhi
- Two *desi* chickpea entries, IPC 16-25 (Timely sown) and IPC 17-292 (Rainfed) were promoted to AVT-1 under ECZ and SZ, respectively. Similarly, three *desi* entries, IPC 17-253, IPC 15-132, IPC 17-141 (Mechanical harvesting) were promoted to AVT-1 in NEPZ under AICRP trials.
- Sixteen chickpea entries, IPC18-131, IPC18-38, IPC16-127 (TS); IPC17-373, IPC16-231, IPC14-88 (LS); IPC17-361, IPC19-222, IPC17-04 (RF); IPC18-59, IPC17-351, IPC18-39 (MHT); IPCK10-124, IPCK16-12, IPCK16-133, IPCK16-149 (*K*) are being evaluated in IVT during 2021-22.
- Total 88 crosses including 30, 25, 20 and 13 were developed for yield enhancement and stability, biotic stress resistance, abiotic stress tolerance and nutritional enhancement, respectively during 2020-21.
- The F_1 populations derived from 91 crosses were raised and SPS harvested. Total 3598 SPS including F_2: 954 SPS, F_3: 649 SPS, F_4: 1171 SPS, F_5: 630 SPS& F_6: 194 SPS were taken from 101, 59, 75, 56 & 55 crosses, respectively and harvested. Total 143 LB & 61 PB were harvested from different generations for sharing with NARS partners.
- Three hundred twenty five ABLs lines including 140 and 185 were evaluated as station trials (ST), preliminary yield trials (PYT), respectively under timely sown (TS), late sown (LS), rainfed (RF), pre-breeding (PB), mechanical harvesting (MH) *kabuli*, trait specific. Total 140 entries were tested as ST-1 (MHT), ST-2 (PB), ST-3 (TS), ST-4 (RF), ST-5 (LS), ST-6 (K), ST-7 (Trait specific) at Kanpur, Bhopal, Dharwad. Similarly, 191 lines with 6 PYT were evaluated as PYT-1 (MHT), PYT-2A (PB), PYT-2B (Nutrition), PYT-3 (TS), PYT-4 (RF), PYT-5 (LS).
- Total 337 chickpea trait specific germplasm lines were evaluated for hybridization and sharing with NARS partner. Total 113 wild lines from 7 *Cicer* species including *C reticulatum* (42), *C pinnatifidum* (27), *C echinospermum* (6), *C yamashitae* (2), *C bijugum* (1), *C cuneatum* (3), *C judaicum* (32) are maintained. *C reticulatum* & *C pinnatifidum* are being used as donor to enhance traits of heat/drought tolerance, yield, plant architecture, seed/pod, protein content. Germplasm accessions T 39-1, ICC 5912, ICC 8397 were identified as stable high protein (~28%) lines.
- Ten mapping populations were developed through SSD method for heat DCP 92-3/ICC 92944 (F_8 220); JG 315/ICC 92944 (F_6 206), JG 11/ICC 1205 (F_6 211), DCP 92-3/ICC 96030 (F_6 219), DCP 92-3/ICC 1205 (F_6 215) & nutrition [IPC 04-98/T 39-1 (F_7 305), JAKI 9218/T 39-1 (F_6 200), JG 16 / T 39-1 (F_6 188), DCP 92-3/T 39-1 (F_6 189), ICC 4958/T 39-1 (F_6 192)]. Two mapping populations were developed through SSD for DRR, IPC 05-28/BG 212 (F_5, 335), JSC 37/BG 212 (F_5, 355).
- Thirty chickpea lines for tolerance to post-emergence systemic herbicide imazethapyr @ 150 g a.i./ha with respect to recommended dose of 75 g/ha were evaluated during 2020-21 for confirmation. 5 lines performed better (ICC 12337, ICCIL 04004, ICC 92504, ICC 91902 & ICC 12315) to check IPC 18-186 with comprised of JG 16, JG 14, JSC 37, JG 11 showed resilience with lower yield.

- Total 168 chickpea advanced breeding lines were screened in sick plot at Kanpur and 18 lines (IPC 97-29, IPC 20-12, IPC 20-47, IPC 20-58, IPC 20-59, IPC 20-61, IPC 20-70, IPC 20-115, IPC 20-123, IPC 20-124, IPC 20-134, IPC 20-135, IPC 20-146, IPC 20-147, IPC 20-148, IPC 20-153, IPC 20-155, IPC 20-167, IPC 20-181, P1 3073) showed resistance reactionto wilt, while 7 lines (IPC 16-31, IPC 07-56, IPC 97-29, IPC 13-209, IPC 11-31, IPCK 12-306, IPCK 11-31) showed stable resistance over five years under AICRP. Tenlines/wild *Cicer* (ICC 17164, ICC 17151, ICC 182, ILWC 30, ILWC 95, ILWC 50, ILWC 182, ILWC 188, ILWC 223, ILWC 185) showed resistance to A. blight while six lines (ICC 17155, ICC 17116, ICC 17150, ILWC 238, EC 600099, EC 6000100) exhibited moderate resistance to *Ascochyta rabiei*. Four lines (IPC 12-98, IPC 13-33, IPC 11-85, IPC 10-219) showed modelate resistance to DRR under AICRP
- Eighty chickpea breeding lines with checks were raised on January 5, 2020 for screening to heat (>35°C) and selected five plants from each. Total 25 lines were found promising based on high podding, seed setting on terminal pod of plant in day temperature >35^{0}C and yield (IPC 19-79, IPC 19-216, IPC 19-93, IPC 19-136, IPC 19-188, IPC 19-173, IPC 19-177, IPC 19-24, IPC 19-104, IPC 19-102, IPC 19-179, IPC 19-192, IPC 19-26, IPC 19-199, IPC 19-175, IPC 19-34, IPC 19-216, IPC 19-157, IPC 19-153, IPC 19-74, IPC 19-37, IPC 19-217, IPC 19-144, IPC 19-119, IPC 19-19).
- Identified an early chickpea breeding line, IPC 2019-5 (Ist flowering-34 days) in comparison to check ICC 96029 (Ist flowering-36 days) and it can be used for transfer of earliness trait in cultivable varieties

B. Pigeonpea

- A long duration pigeonpea genotype IPA 15-21 was promoted to AVT-2. Entry IPA 19-26 (2631 kg/ha) was promoted to AVT-1. Beside this, four entries, IPAL 20-1, IPAL 20-5, IPAL 20-11, IPAL 20-24 were nominated for IVT for NWPZ.
- Two short duration pigeonpea entries IPAE 15-08 (CZ, SZ) & IPAE 15-05 (CZ) were promoted to AVT-1. Four entries IPAE 15-07, IPAE 19-04, IPAE 20-3, IPAE 20-11 were nominated in IVT trial.
- Total five hybrids with check were evaluated during 2020-21. Hybrid IPH 19-05 (2122 kg/ha) was top yielder. Seed size of IPH 19-05 (10.44 g/100 - seed wt.) is higher than IPH15-03 (8.84g/100 seed wt.).
- Two long duration genotypes, IPA 9-1, IPA 13-1 are being evaluated in SAT-2 and four entries, IPA 2014-2, IPA 2014-4a, IPA 7-2, IPA 18-33 are being evaluated in SAT-1 under UP SAT trial.
- Twenty six entries were evaluated in station trial under long duration trial. Entry IPA 20-11 (4217 kg/ha) was top yielder followed by IPA 20-5 (4094 kg/ha), IPA 20-1 (3967 kg/ha). Twenty seven entries with checks were evaluated as PYT under long duration and entry IPA 20-24 (4450 kg/ha) was found top yielder which registered 38.9%, superiority to IPA 203.
- Thirty four entries with 9, 9 and 16 were evaluated in station trial-1, 2 and 3 respectively under short duration pigeonpea during 2020-21 at Kanpur. Entries IPAE 19-04, IPAE 19-23, IPAE 19-16, IPAE 19-15, IPAE 20-1 & IPAE 20-10 have shown 25% yield superiority over best check of respective trials. The maturity range from 130-160 days and 100 seed wt. from 8.3-10.2 g were recorded.
- In long duration category, 13 crosses were attempted using wilt, SMD, high seed yield donors. Similarly, five crosses were attempted during 2020-21 under short duration category.
- Under short duration category, F_1 populations derived from 12 crosses were harvested. SPS from $10F_2$ $20F_5$, $17F_6$ & $7F_7$ generation were advanced. Progeny selections were made from fixed line. Similarly, F_1populations derived from 13 crosses were advanced in long duration category and SPS were harvested separately. Similarly, 3944 SPS including $10F_2$: 290 SPS, $13F_3$: 405 SPS, $23F_4$: 500 SPS, $49F_5$: 2500 SPS, $9F_6$: 200 SPS, $7F_7$: 49 SPS were harvested during *Rabi* 2020-21
- Identified a long duration pigeonpea breeding line IPAL 21-15 having relatively low chlorophyll content in leaf (34.66) as compared to high chlorophyll accumulation breeding line IPAL 21-33. The chlorophyll present in the plant is closely related to the nitrogen status of the plant.
- Total 490 kg nucleus seed of three pigeonpea varieties, IPA 203 (250 kg), IPA 206 (240 kg) and IPA 15-06 were produced during *Khairf* 2020. The elite patents of extra early and early genotypes were maintained through selfing. Beside this, 30 CMS lines (A lines) and their corresponding maintainer (B lines) was

maintained through controlled pollination under netting. In addition, 80 restorer (R) lines are being maintained through selfing under hybrid pigeonpea programme..

- Total 95 trait specific donors and parents are being maintained for long duration pigeonpea breeding programme. Similarly, 2535 pigeonpea germplasm lines including 1022 of *C cajan*, 160 *C cajan* collected through exploration, 1280 augmentation of *C cajan* through procurement and 73 wild relatives are being rejuvenated on regular interval and conserved in cold module
- Twelve wild species from three genera, *C scarabaeoides*, *C. platycarpus*, *C cajanifolius*, *C lineatus*, *C crassus*, *C. sericeus*, *C albicans*, *R minima*, *R bracteata*, *R suaveolens*, *R rufescens* and *R aurea* were maintained. Six crosses were made and advanced. $1F_2$, $7F_3$, $7F_4$, $3F_5$, $1F_6$ were advanced. Fixed lines from PAS 120/ICP 15685, Early 3/ICP 15761 and designated as IPAWD & WDBCU
- One hundred five fixed lines derived from pre-breeding were screened under wilt sick plot and 15 lines were found for wilt resistance, whereas 10 were segregating for resistante. 8 lines (IPA12W19, IPA12W18, IPA10W16, IPA10W20-1, IPA12W39, IPA12W41, IPA12W45, IPA12W61) were resistant for three consecutive years and three lines will be proposed for registration with ICAR-NBPGR
- Seven genetic stocks developed through pre-breeding activities were sown with wilt susceptible check. The observations were recorded in March 2021. These entries were inspected in wilt sick plot by IGIC and found highly resistant and hence, approved for registration with NBPGR.
- A population was reconstituted from intermating among IPAC 68, BSMR 853, BSMR 736, WRP 1, Maruthi, KPL 43, IPAC 66, C 11 followed by open pollination and selection for three generations. 100 resistant plants were selected for generation advancement.
- The advanced generation of C *scarabeoides* was screened in PSB under sick plot for identification PSB resistant genotypes. The disease incidence was less than 20% in candidate lines, IPAC 2, IPAE 15-08, SPD/DD-2 and SPD/DD-3 and PSB resistances of these lines were validated.
- Fourty two advance lines derived from *C. scarabaeoides* are being screened for tolerance to *Helicoverpa armigera* and *Maruca vitrata* for two years. Two lines namely, IPAWD 28-1 and WDBCE 6-3-4-6 were putatively identified as tolerant to pod borer.

C. Lentil

- Lentil variety IPL230 was released and notified for UP under timely sown conditions. It is early maturing (110-115 days) with small seed (2.4 g/100 seed wt) and resistance to rust, tolerance to Fusarium wilt diseases.
- Six entries (IPL 242-small seeded (NEPZ), IPL 801 (D)-large seeded (NWPZ, CZ), IPL 808 (A)-large seeded (NHZ), IPL 542-large seeded (NHZ), IPLB 702-large seeded (NHZ), IPL 347-large seeded (NHZ) were promoted to AVT-1 for evaluation in 2021-22. In addition, eight new entries, IPL 243, IPL 244 (small seeded), IPL 349, IPL 350, IPLRS 703, IPLRS 704 (large seeded) & IPL 607, IPL 608 (rice fallow) have been submitted for evaluation in IVT trial during 2021-22
- Total 16 entries were evaluated in UP SAT. A small seeded entry IPLS 238 and four large seeded (IPL 341, IPL 342, IPL 343 & IPL 344) and two late sown entries (IPL 540 & IPL 538) have been promoted to SAT-1. Two small seeded entries, IPLS 233 & IPLS 234 performed well and recommended for release in Uttar Pradesh. In addition, 6 new entries have also been submitted for evaluated during *Rabi* 2021-22.
- Two station trials with 15 entries each and PYT (60 entries) were evaluated during 2020-21. 8 entries (IPL 1936201, IPL 181591, IPL 14977, IPL 131225, IPL 1946104, IPL 191520, IPL 141563, IPL 11718) were found promising with yield ranges from 1434-1681 kg/ha over check IPL534 (1422 kg/ha) in ST-1. IPL 181591 showed early flowering (57 days) and early maturity (115 days), while IPL 141563 had high harvest index (0.39). Similarly, 7 small seeded entries (IPL 141570, IPL 131053, IPL 11671, IPL 171392, IPL 10834, IPL 141550, IPL 191498) were found promising with mean yield ranging from 1306-1442 kg/ha over check IPL 220 (1300 kg/ha) in ST-2.
- PYT with 18 lines (IPL 19-35, IPL 19-02, IPL 19-258, IPL 19-139, IPL 19-131, IPL 19-22, IPL 19-132, IPL 19-256, IPL 19-50, IPL 19-171, IPL 19-25, IPL 19-181, IPL 19-105, IPL 19-76, IPL 19-57, IPL 19-74, IPL 19-45, IPL 19-83) found promising over check IPL 220 with yield range from 1714 to 1984 kg/ha. Entry IPL 171398, IPL 19-04, IPL 19-

131, IPL 11718, IPL 19-03, IPL 141159) found promising at Bhopal with large seeded (>3.0 g/100 - seeds), maturity range from 112-116 days

- Twenty six lentil crosses were attempted using trait specific donors (heat tolerance, wilt resistance, drought/heat tolerance, seed size, lodging tolerance and new plant types) during *Rabi* 2020-21.
- F_1s seeds were grown derived from 31 lentil crosses including multi-parent crosses and 296 F_1 plants were harvested separately. Altogether,1234 SPS from 25 F_2 (596 SPS + 1 LB), 27 F_3 (261 SPS), 9 F_4 (119 SPS) and 21 F_5 (258 SPS) were done based on the targeted traits and harvested separately. A total of 259 line bulks derived from 21 F_6 were harvested for yield evaluation.
- Trait specific AB QTL mapping populations of lentil comprising >500 BC_2F_4 individual plants for yield traits (ILWL 118/IPL 220) has been advanced to F_5 for developing NILs. Mapping populations (RIL) with 200 SPS derived from cross (IPL 98/193//EC 208362) for root traits were evaluated under drought conditions in dug-out pots and maintained.
- Total 614 kg nucleus seeds of 12 lentil varieties (IPL 81, IPL 406, DPL 15, DPL 62, IPL 316, IPL 526, IPL 220, IPL 321, IPL 315, IPL 534, IPL 225 & IPL 329) were produced and 7800 SPS of above varieties were selected for next year nucleus seed production

D. Fieldpea

- Fieldpea variety IPF 16-3 has been released and notified for cultivation in entire Uttar Pradesh. It is resistant to powdery mildew, rust and *ascochyta* blight disease.
- A fieldpea genotype, IPFD 18-14 (Extra early line, flowered -36 days & matured-85 days) has been registered with NBPGR as genetic stock during 2020-21. Five fieldpea lines, IPFD 18-26 (extra early, dwarf and green seeded, matured in <100 days), IPF 14-13 (rust resistant), IPF 14-16 (rust resistant), EC 564816 (intact funiculus with tall, tendrilled), EC 564814 (intact funiculus with dwarf and leafy) were identified and recommended by GIC for registration with NBPGR.
- Two dwarf lines, IPFD 19-1 & IPFD 19-3 were promoted to AVT-2 (NEPZ) during 2021-22. Rice fallow lines IPFD 20-8 has been promoted to AVT-1. Total 14 entries have been nominated in IVT trials.
- Total 12 entries are being tested in UP SATs during *Rabi* 2021-22**.** Seven entries (IPFD 17-2, IPFD 18-8, IPFD 18-2, IPFD 19-9, IPF 17-19, IPF 18-17 & IPF 19-15 were promoted to SAT-2 & SAT-1 while five new entries (IPF 19-18, IPF 19-11, IPF 20-20, IPFD 18-1 & IPFD 18-9) are being evaluated under UP SAT during 2021-22. Total 10 entries have been contributed for testing under UP SAT
- Crosses were made to develop MAGIC population. Mapping population [HFP4(S)/FC1®] was developed for rust resistance (F_8: 310 SPS) and generation advancement during *Rabi* 2021-22.
- In *ST-1* (Dwarf), IPFD 2021-7 (4278 kg/ha) & IPFD 2021-5 (4378kg/ha) were performed better than the best check IPFD 12-2 (3875 kg/ha). In *ST-2* (Tall), IPF 2021-13 (2958 kg/ha), IPF 2021-21 (2847 kg/ha) & IPF 2021-16 (2875 kg/ha) were found superior over the best check IPF 16-13 (2701 kg/ha).
- In PYT (Tall), 16 entries demonstrated yield superiority over the best check IPF 16-13. In PYT (Dwarf), 12 entries registered yield advantage over check IPFD 12-2. In PYT (Extra Early), 21 entries portrayed yield superiority over check IPFD 99-13.
- Total 315 fieldpea accessions were evaluated for different yield attributing traits disease resistences and identified trait specific donors during *Rabi* 2020-21.
- Total 315 fieldpea lines screened for rust severity under field conditions. 10 resistance and 10 susceptible genotypes were identified based on disease severity.

E. Mungbean

- The mungbean genotype IPM 604-1-7 (INGR 21104), a unique line (golden yellow seed coat colour), was registered with NBPGR New Delhi as a genetic stock. Two lines, *V. glabrescens* (IC 251372/INGR 21143) and V *umbellata* (IC 251442/INGR 21226) were registered for photo- and thermo-period insensitivity.
- The genotype IPM 1604-1 was promoted to AVT-1 in CZ during *Kharif* 2021 with yield superiority of 16.28% over the best check. Entry IPM 20-1 was promoted to AVT-1 in NEPZ & CZ with yield superiority of 8.90 & 6.84% over the

best check in the respective zones. Another genotype IPM 20-2 was promoted to AVT-1 in NEPZ & NHZ with a yield superiority of 15.38 and 20.63%, respectively.

- Three entries IPM 1603-1 & IPM 1610-1 (NHZ) and IPM 604-16 (NWPZ) were promoted to AVT-I for spring cultivation. Four entries IPM 1603-1 & IPM 1610-1 (NWPZ), and IPM 1103-1 & IPM 1610-1 (NEPZ) were promoted to AVT-I for summer cultivation. Ten entries including IPM 1205-2 (spring), IPM 1704-14 & IPMD 1202-1 (summer) and IPM 1603-3, IPM 13-6 & IPMD 1603-7 (*kharif*) are being evaluated under AICRP
- Seven promising donors, IPM 409-4 (extra early, synchronous maturity), IPM 410-3 (cluster/plant, pod no, YMV), EC 398889 (heat/drought tolerance), IC 2527442 (photo-thermo insensitivity), RBL 50 (long pod, YMD resistance), IC 277021 (YMD resistance, pod/plant) and IPM 512-1 (pod no/plant, plant type) were included in National Crossing Programme during *kharif* across different centres.
- In *ST-1*(Spring), IPM 02-3 (1553 kg/ha) was found top yielder followed by IPM 9901-6-1 (1528 kg/ha), IPM 312-18 (1518 kg/ha), IPM 02-3 (1511 kg/ha), IPM 604-1-6 (1411 kg/ha), IPM 1603-7 (1377 kg/ha) and the best check IPM 02-3 (1344 kg/ha). In *ST-2*, IPM 1703-1 (1711 kg/ha) was found top yielder followed by IPM 1704-14 (1670 kg/ha) and check IPM 410-3 (1545 kg/ha).
- In *ST-1* (Summer), IPM 1205-2 (1687 kg/ha) produced higher yield than IPM 604-1-6 (1628 kg/ha), IPM 1202-1 (1611 kg/ ha), IPM 312-18-1 (1578 kg/ha), IPM 101-102-1 (1570 kg/ha), IPM 1604-5 (1595), IPM 701-704 (1570 kg/ha), IPM 1620-5 (1553 kg/ha) and check IPM 409-4 (1528 kg/ha). In *ST-2*, IPM 1718-3 (1787 kg/ha) was found top yielder than IPM 1732-2 (1495 kg/ha), check IPM 409-4 (1494 kg/ha).
- In *ST-1 (kharif)*, IPM 1718-3 (1146 kg/ha) was found top yielder by IPM 312-18 (1008 kg/ha), check IPM 410-3 (904 kg/ha). In *ST-2*, IPM 1604-1 (945 kg/ha) was found higher yielder than IPM 1620-6 (942 kg/ha), IPM 1604-1 (904 kg/ha), check IPM 410-3 (766 kg/ha). In ST-3, IPM 1722-1 (1288 kg/ha) was found top yielder by IPM 701-704 (1033 kg/ha), IPM 1704-14 (1000 kg/ha) and check IPM 512-1 (996 kg/ha).
- Two PYTs were conducted during *kharif* 2021 with 36 entries and checks. In *PYT-1*, IPM 21-15-7 (1726 kg/ha) was found top yielder followed by IPM 21-15-5 (1456 kg/ha), IPM 21-15-1 (1310 kg/ha), IPM 21-23-13 (1268 kg/ha), IPM 21-23-1 (1248 kg/ha), IPM 21-23-5 (1227 kg/ha), IPM 21-13-7 (1206 kg/ha), check IPM 512-1 (1019 kg/ha). In *PYT-2*, IPM 1704-13 (2017 kg/ha) was found top yielder followed by IPM 1718-2 (1560 kg/ha), check IPM 512-1 (1268 kg/ha)
- During *kharif* 2021, 1067 lines included 314 active collections, 21 landraces, IMIN minicore set (296 lines), 90 AVMU ABL supplied by World Vegetable Centre, 96 supplied under DBT-minor pulses and 250 wild lines were rejuvenated. 296 minicore line were raised during *Kharif* (Kanpur) and Summer (Dharwad). Data were recorded on 24 morpho-physiological traits at Kanpur. 250 lines of 21 *Vigna* species were evaluated during *Kharif* 2021 for morpho-physiological traits.
- Thirty intra-and inter-specific crosses were generated using 10 cultivars (IPM 410-3, IPM 02-3, IPM 409-4, IPM 2-14, IPM 2K14-9, IPM 302-2, IPM 99-125, PDM 139, IPM 205-7) as recipients and 9 donor (ML1808, SPS5, CoGG 8, LGG 460, ML 1808, PDM 54, Co 6, ML 2479, MH 421) during *kharif* 2021 for MYMV resistance, yield traits, earliness and bruchid resistance. Besides this, eight multi-parent crosses were also developed to generate new variability.
- Total 642 SPS in 89 inter- and intra-specific crosses including 66 SPS (F_2), 106 SPS (F_3), 170 SPS (F_4), 42 SPS (F_5), 28 SPS (F_6), 10 SPS (F_7) and 11 SPS (F_8) were harvested. Besides this, 68 outstanding lines were bulked in different generations. Similarly, inter-specific crosses involving urdbean, *V umbellata, V unguiculata, V glabrescens, V sylvestris* as donors and 267 SPS including 41 SPS (F_3), 198 SPS (F_4) and 28 SPS (F_5) were selected. Besides, 22 outstanding lines were bulked for evaluation in PYT. Eleven bulks were isolated for sharing with NARS partners.
- Total 750 kg nucleus seed of nine mungbean varieties, Soorya (150 kg), Virat (172 kg), IPM 02-3 (78 kg), Shikha (130 kg), IPM 2-14 (105 kg), Kanika (45 kg), Versha (25 kg), Heera (82 kg), Vasudha (24 kg) was produced. Besides, >3,500 SPS of nine varieties were taken for growing single plant progeny rows.

F. Urdbean

- Urdbean variety IPU 17-1 was released and notified for cultivation in Madhya Pradesh during *Kharif*. It is early maturing (73 days),

black seed colour, medium large seeded (3.35 g/100 seeds) with high seed protein content (24%).

- Twenty four crosses were obtained involving diverse parents under genetic enhancement. F_1 population derived from 31 crosses were harvested during *Kharif* 2021. Total 490 SPS & 239 bulks derived from 10 F_2 (10 LB), 12F_3 (150 SPS + 12 LB), 21 F_4 (200 SPS + 178 LB), 40 F_5 (140 SPS + 19 LB) and 20 F_6 were harvested. In addition, 16 pre-breeding crosses were attempted during *Kharif* 2021 for development of improved urdbean lines for new niches of different agro-ecology.
- Sixty three urdbean crosses were attempted for development of breeding lines of abiotic stress tolerance coupled with new plant type of different agro-ecological conditions during *Kharif* 2021. Total 43 F_1 were harvested during *Kharif* 2021 for advancement. Total 1308 SPS & 175 line bulks derived from 36F_2 (36 LB), 31 F_3 (320 SPS + 28 LB), 28 F_4 (523 SPS + 28LB), 31 F_5 (465 SPS + 31 LB) and 9 multiline crosses (53 SPS + 9 LB) were harvested based on the targeted traits.
- The yields ranged from 800 to 1200 kg/ha station trials. The trial was affected due to excessive rainfall. Similarly, 67 urdbean entries were tested under PYT and yielded in range 120 to 310 g and high performing entries will be promoted to station trials in the next *Kharif* season.
- Total 310 and 98 urdbean germplasm lines were evaluated during *Kharif* 2021 and *Summer* 2020, respectively for characterization, maintainence and further utilization in future breeding. Total 150 lines were evaluated and maintained at IIPR-Regional Station, Dharwad during *Rabi* 2020.
- A set of 326 urdbean germplasm lines were raised during *Kharif* 2021 for evaluation of biotic and abiotic stress resistant coupled with yield traits (reproductive phenology, seed/pod, pod/plant, 100-seed weight and yield/plant). Five plants were randomly selected from each line.

G. Cowpea

- Total 25 crosses were made using trait specific donors during *Kharif* 2021. Total 19 F_3, 10 F_5 (100 LB) & 2 F_6 (13 LB) were harvested during summer 2021. F_1generations derived from 20 crosses were harvested during *Kharif* 2021. Similarly, 13 F_2(700 SPS), 10 F_3(548 SPS), 5 F_4(300 SPS), 5 F_5 (100 lines) and 12 F_6 (75 lines) were harvested during *Kharif* 2021.
- Total 570 cowpea germplasm lines were evaluated during *Kharif* 2021. 340 lines were vitiated due to heavy rains. Besides, 100 accessions were evaluated for growth habit, days to 50% flowering, pod length, days to pod maturity, testa texture, eye colour, 100-seed weight, seed coat colour, flower colour, pod no/peduncle, pod colour and yield/plant. In addition, 30 released varieties were maintained and evaluated for different yield contributing traits.

H. Rajmash

- Total 1946 *rajmash* germplasm accessions has been procured and maintained at Kanpur. Six hundred thirty one accessions were evaluated for morphological and agronomic traits. In addition, 101 biofortified lines of *Rajmash* received from CIAT were evaluated and characterized.
- Fourteen *rajmash* crosses were attempted for desired traits during *Kharif* 2021. Total 14 F_1 were harvested at NBPGR-RS Shimla for generation advancement. Similarly, 3 F_3, 4 F_4 & 2 F_6 progenies were advanced at IIPR-RS Dharwad. Similarly, 14 F_2, 3 F_4, 4 F_5 & 2 F_7 progenies will be advanced during *Rabi* 2021-22. A mapping population for anthracnose disease resistant (F_3: 210 SPS) derived from Uday/EC 931194 cross were planted at IIPR, Kanpur
- A total of 12 entries with four checks (Uday, Arun, Utkarsh & HUR15) were evaluated as station trial and for yield and yield attributing traits. Two entries IPR 242-20 (1768 kg/ha) & IPR 236-20 (1720 kg/ha) yielded more over the best check Utkarsh (1569 kg/ha) with BCMV disease.

Plant Biotechnology

- Attempts were made towards developing Advance intercross lines (AILs) using contrasting sister lines for the traits derived from RIL DCP 92-3 x ICCV 10 in different combinations (RIL L 156 x RIL L 169, and RIL L168 x RIL L166) and harvested more than 45 F_1s seeds sown in the field in this current season.
- Chickpea breeding line (CIL 166) has been identified by Institute Germplasm Identification Committee for salinity stress tolerence and

recommended for registration as donor line with NBPGR, Delhi.

- Chickpea line IPCL 4-14 (IPCMAS-1) was developed through marker-assisted backcross (MABC) breeding for improved drought tolerence for NWPZ in India and was identified for release by Varietal Identification Committee (VIC) meeting held on August 17, 2021 under the Chairmanship of Dr. T.R. Sharma, Deputy Director General (CS), ICAR, New Delhi.
- Four MLO based SSR markers have been designed from two different chromosomes for candidate gene based association mapping against powdery mildew in *Vigna mungo*.
- Identified 4500 and 22,500 SNPs in the heat tolerance QTL intervals on chromosome 5 and 6, respectively from re-sequencing data of 195 mini-core lines of chickpea following GATK tools
- Identified 5 (*SIX4* (1), *SIX8*, (2), *SIX9* (1) and *SIX13*(1)) and 19 (*SIX1*(2), *SIX4* (6), *SIX5*(1), *SIX8*(1), *SIX11*(1), *SIX13*(6) and *SIX14*(2)) *SIX* coding genes in *Fusarium udum* and *Fusarium oxyspisum f.sp. ciceris* genome assembly.
- Draft genome sequencing of potent *Bacillus* isolates: Ak2.iipr, F1.IIPR, F5.IIPR, and F8.IIPR has been deciphered, revealing the presence of 28, 19, 26, and 29 insecticidal genes, respectively.
- The *Bt* isolate F6.IIPR genome included 26 insecticidal genes. The expression of the major cry and vip genes, namely: Cry1Ac29, Cry1Aa17, Cry2Aa9, Cry2Ab35, Cry1Ia40, and Vip3Aa7, has been validated by LC-MS/MS.
- Under field conditions, expression profiling of the herbivore and pathogen inducible chitinase genes in chickpea upon *Helicoverpa* herbivory and foliar spray of salicylic acid and jasmonic acid identified Car_Chi-1 as being salicylic acid inducible.
- Molecular docking and simulation studies of herbivory and salicylic acid inducible chitinases in chickpeas identified Car_Chi-15, Car_Chi-13, and Car_Chi-17 as the most effective at binding chitin oligomers.
- Embryonic axis with cotyledon (EA-C) as choice explant regenerates higher number of shoots *in vitro* on MSB5 supplemented with BAP in mungbean cvs. Virat and ML 267.
- Two wild species of mungbean viz. *Vigna glaberescence* and *Vignavexillata* could be successfully regenerated *in vitro* using embryonic axis as explants on basal media supplemented with cytokinin.
- Codon optimized Vip3Aa (NCBI Accession No MZ130099) harboring five independent chickpea plants were developed and characterized for presence and expression of transgene.
- Trait efficacy testing of the five Vip3Aa transgenic chickpea lines indicated larval mortality and degenerate larval development.
- WHITE and RED LED have positive impact on reducing days to first flowering and filled/unfilled pods ratio in a panel of 17 genotypes tested, under simulated conditions.
- 20-24 d old green immature chickpea seeds, after anthesis, were found suitable for *in vitro* germination and subsequent establishment in soil, thus reducing seed to seed cycle.
- Early Flowering 1 (*Efl1*) gene (an orthologue of *Arabidopsis* ELF3) in chickpea harbors SNPs across the coding region and a 11-bp deletion in the first exon of the gene, resulting in premature stop codon.
- CRISPR/Cas9 gene construct based on p201N-Cas9 vector (Addgene, USA) targeting the deletion region were synthesized using InFusion cloning, confirmed by restriction digestion and Sanger sequencing.
- Two long duration chickpea genotypes (IPC 2011-112 and GNG 2171) responded well, among five tested chickpea genotypes, based on multiple shoots induction (12.03±2.11) and subsequent establishment as plants, in Transgenic Containment Facility (PBSL-1).
- The ODAP synthase gene sequence was submitted to Genbank.
- CRISPR/Cas vector from Addgene, USA was procured for cloning multiple single guide RNA (sgRNA) using standard molecular biology technique.
- The three sing guide RNA (sgRNA) for the oxalyl-CoA synthetase and three for ODAP synthase were designed, synthesized, and cloned into Cas9 carrying pKSE401 binary vector. The constructed vectors were mobilized into Agroabcterium for plant transformation.
- New CRISPR-Cas9/gRNA constructs having 4 different sgRNAs targeting two domains (TIFY and CCT_2) were prepared and confirmed by

restriction digestion and PCR and mobilised into Agrobacterium tumefaciens strain LBA4404.

- Seeds (53) were harvested from the established 17 T_0 plants (Construct T_6). DNA was isolated from the all the plants and checked for the insertion of T-DNA and the editing of the target locus.

Crop Production

- Pulse crop inclusion in upland maize-wheat and pearl millet–wheat systems increased nutrient (N, P and K) stock in both macro and micro-aggregate soil fractions. Integrated nutrient management involving 50% NPK + crop residue recycling + bio-fertilizers increased soil nutrient stock over the recommended sole fertilizer treatment (100% NPKSZnB) in long-run (17 years).
- Maize-wheat-mungbean and maize+GM (*dhaincha*)-chickpea-mungbean systems could be productive and profitable cropping systems under conservation agriculture (CA) module in Indo-Gangetic plains.
- In maize-chickpea cropping system, grain yields of component crops and system productivity did not influence significantly due to tillage practices (conventional tillage and zero tillage). The highest system productivity (4.33 t chickpea equivalent yield/ha) was recorded in 100% RDF + post-emergence herbicide application.
- Clusterbean-mustard and mungbean-mustard could be the potential pulse-inclusive cropping systems for arid ecosystem of north-western India.
- Application of pendimethalin 1 kg a.i./ha (PE) - bispyribac sodium 20 g a.i./ha at 20 days after sowing (POE) in rice and oxyflurofen 150 g a.i./ha (PE) – propaquizafop 100 g a.i./ha at 25 days after sowing (POE) in chickpea effectively controlled weeds under zero tillage condition and gave significantly higher yields.
- Selectivity and dose/time were optimized for topramezone (20.6 ml a.i./ha at 14 days after sowing) in chickpea and clodinafop-propargyl + Na-acifluorfen (183.5 g a.i./ha at 15 days after sowing) in mungbean.
- Stale bed techniques (irrigation - halosulfuron-methyl 70 WG at 67.5 g a.i./ha) reduced purple nutsedge (*Cyperus rotundus* L.) and other weeds in successive rainy season crops (pearl millet, pigeonpea) and increased crop productivity.
- Integrated P management involving organic amendments (poultry manure, crop residue), suboptimal rate of fertilizer-P (60% of the recommended rate) and phosphate solubilising bacteria increased P availability and system productivity of pearl millet-chickpea and pigeon pea-wheat systems over the recommended sole fertilizer-P treatments in moderately alkaline soil (*Inceptisol*) of Kanpur.
- Improving productivity of sorghum+ pigeonpea and chickpea + mustard intercropping systems with appropriate cultivar selection of pigeonpea (IPA 15-0, IPA 203) and chickpea (IPC 2006-77, IPC 2004-98)
- Foliar application of 1% KCl or 1% KNO_3 at post-flowering stage could increase chickpea productivity (20-22%) under terminal water-deficit condition in the northern India.
- Lathyrus and chickpea had higher rhizospheric P mobilization capacity over the field pea and lentil crops in moderately-alkaline *Fluvisol*, and thus, their cover cropping could enhance P use efficiency in cropping systems.
- Soil application of 25 kg $ZnSO_4$ increased chickpea yield by 11-14% in Zn-deficient sandy-loam soils of Kanpur. Chickpea genotypes RSG 888, GNG 2207, IPC 10 62, Vijay, JG 24, JG 14 with high Zn concentration (45-46.5 ppm) were found to be efficient and responsive to 25 kg $ZnSO_4$ (soil application).
- Supplementary irrigation twice at branching and pod development stages by sprinkler could sustain field pea productivity and upscale higher water use efficiency.
- Foliar application of salicylic acid (100 ppm), urea (2%) or NPK (0.5%) at flowering and pod development stages improved chickpea performance under rainfed/soil moisture deficit conditions.
- Organic farming (particularly organic nutrient management) was found promising for pulse crops (chickpea and pigeonpea) in low fertility/light soils of Gangetic plains. Chickpea responded to foliar supply of the organic forms of Zn (Biozinc) and P (Biophos). The planting geometry of 75 × 20 cm was found optimal for higher productivity of long-duration pigeonpea

under organic-based management practices.

- Improved crop management practices amalgamated with resource conservation technologies (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 –pulse production systems.
- IIPR mini *dal* mill (83 dB) was found operator friendly with lower noise level as compared to Akola *dal* mill (91 dB) (loaded conditions) and thus, can be run comfortably for 8-h a day.
- Edible products, *viz*., biscuits, pizza base, cakes, buns, muffins, *idali*, *halwa*, *dal*, soup, instant *dal*/soup powder, noodles, fortified *atta*, *dal* analogue *etc*., were developed using whole and powder components of the pulse milling by-product.
- Three set of combination rollers, *viz*., i) Roller-I 24:30 mesh; ii) Roller-II 18:24:30; Roller-III 14:16:20:24:30, got fabricated and evaluated in experimental dal mill for pitting percentage and *dal* recovery efficiency. Three grit combination rollers gave the highest pitting of 44.4%, whereas two grit combination rollers gave the pitting of 41.7% pitting in the first pass. Maximum *dal* recovery of 69.8, 72.6, 75.5 and 70.4% were obtained with three grit combination roller for pigeonpea, mungbean, lentil and urdbean, respectively.
- The highest *dal* recovery of 79% in urdbean was obtained with water soaking as pre-treatment and milling in emery roller.

Crop Protection

- Advanced pigeonpea breeding lines, IPAC 66, IPAC 67, IPAC 68, IPA 10w12, IPA 20-2, IPA 10W1-8, and IPA 12W26-1) have been identified as donor for *Fusarium* wilt (*Fusarium udum*, race-2).
- Promising pigeonpea lines *i.e.* DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-11, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16 and IPA-38, IPA 16F, and IPA 15F) showed resistant reaction against wilt.
- Early and medium duration piegonpea lines, IPAB 7-2-1-7, IPAC 3, IPAC 2 and IPAE 15-8 have been identified as donor for *Phytophthora* stem blight resistance.
- Promising genotypes, DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-12, DPPA 85-13, DPPA 85-14 and DPPA 85-16 identified as donor for wilt as well as *Phytophthora* stem blight.
- Among the 75 chickpea genotypes screened against *Ascochyta* blight, only IPCK 2013-209 (4), showed moderately resistant reaction both under field/hot spot condition at PAU, Ludhiana and green house condition at ICAR-IIPR, Kanpur.
- Among the 75 chickpea genotypes screened against BGM disease, only two entries such as IPC 15-273 (3) and IPC 2013-248 (3) showed resistant and IPC 2015-15 (4) showed moderately resistant reaction under field condition (GBPUA&T, Pantnagar).
- A total of 1181 chickpea entries were screened for early and late wilting under sick plot condition and 72 entries were found resistant for early as well late wilting phase.
- Out of a total 272 chickpea genotypes screened against rust disease, only eight chickpea lines *viz*., P15108, P15115, P15119, P15182, P15235, 15270, 15356 and P15252 observed low severity of rust of disesae.
- Out of 188 pre-breeding lines screened against wilt, one line (IPL 406 x IG 136667-1) showed highly resistant reaction against wilt.
- Lentil genotype IG 54 showed resistance (wilting <10%) against wilt in the third year of testing.
- Out of 24 wild lentil accessions, 11 accessions namely, IG 146777, ILWL 20, ILWL 168, ILWL 93, ILWL36, ILWL 149, ILWL 420, IG 136651, ILWL 432, ILWL 73, ILWL 92 showed resistant reaction against wilt.
- Eight genotypes of urdbean namely IPU 10-1, IPU 96-6, IPU 99-220, IPU 13-7, NP 21, PDU-3, IPU 13-3, PLU 99-10 and IPU 12-4 have shown resistant reaction consistently for 6 years (disease rating scale 1) with no visible symptoms on leaves indicating that these genotypes have stable resistance for MYMIV.
- Secondary metabolite profiling and whole genome sequences of *Trichoderma asperellum* (IIPRTh-31) strain and *T. afroharzianum* (IIPRTh-33) were performed. Identified salt/thermo tolerant strain of Trichoderma (*T. harzianum*) for pigeonpea wilt disease management under saline conditions.

- Out of four biocontrol agents (*Trichoderma viridae*, *T. afroharzianum*, *T. asperellum* and *Bacillus subtilis)* tested against *Fusarium oxysporum* f. sp. *ciceri* (*FOC*) and *Rhizoctonia bataticola* (Rb), only *Trichoderma asperellum* and *T. afroharzianum* inhibited 86.39% and 81.70% mycelial growth of *FOC* and *Rb*, respectively under *in vitro* and proved very effective for the control of both the pathogens of chickpea.
- Among the different fungicides evaluated, only two fungicides *viz*., thiophanate methyl (Topsin M) and carbendazim (bavistin) proved significantly effective in inhibiting the *FOC* and *Rb*
- The defense inducers such as salicylic acid (SA), adipic acid (AA) at 500 ppm concentration and potassium dichromate (PD) at 500 and 100 ppm concentration showed 100 per cent inhibition of *Ascochyta rabiei* under *in vitro* conditions using food poisoning method.
- The seed treatment with salicylic acid, adipic acid and potasium dichromate at higher concentration showed negative effect on seed germination with respect to delay in germination, blackening of seed colour, reduced length of radicle and plumule.
- The fungicides such as difenoconazole 25 EC 0.1%, azoxystrobin 20% +difenconazole 12.5% w/v 0.1%, tebuconozole+trifloxystrobin 0.1% sprayed chickpea plots recorded rust severity of 17.8%, 24.1% and 24.4%, respectively.
- Early-April sowing of summer mungbean attracted less whitefly (1.31 and 3.6 adult white flies per plant at vegetative and flowering stages respectively) but high aphid infestation (10.85 and 8.71 infested plants per 30 sq-meters) at vegetative and flowering stages, respectively.
- *Bagrada hilaris* (Burmeister), a generally known pest of crucifers, was noticed with 4.92, 3.14, and 3.64 bugs per meter row length in early, mid and late-April sown crops, respectively.
- Two population peaks of whitefly, *Bemisia tabaci* (Gennadius), one at 23 to 26 (major) and another at 37 to 38 SMW (minor), were observed in greengram and blackgram during the year 2021. Urdbean crop ecosystem attracted higher population of whitefly as compared to mungbean.
- The SCM of *Bt* isolates, F8.IIPR and AK2.IIPR were extracted and formulated as 9 different invert emulsion and 4 invert emulsions (IE9, IE11, IE13 & IE14) were found to have >70% stability for >60 days in preliminary screening. The invert emulsion has found to have significantly lower percent pod damage and higher yield than untreated control in chickpea field trials.
- Nine genotypes of pigeonpea had recorded <10% seed damage and subsequently grouped as least susceptible category. Two genotypes (WDBCE 6-3-4-7 and WDBCE 6-6-2-2) were found as pod borer tolerant by No choice assay method based on pod weight consumption per larva and larval weight gain per larva.
- The screening of four different doses of E2Y45 600SC g/l along with three standard insecticides for management of *Helicoverpa armigera* in chickpea revealed that E2Y45 600SC @ 35 g ai/ha resulted in the highest yield (1239.43 kg/ha), yield gain over control (265.14) and lowest per cent pod damage (2.48/plant) than remaining all other treatments. Interestingly, no phytotoxicity was recorded from the highest dose E2Y45 600 SC @ 50 g ai/ha and it didn't reduced the natural enemy activity also.
- The pest diversity of pigeonpea included 22 insect pests belonging to five insect orders; *Hemiptera, Lepidoptera, Coleoptera, Thysanoptera* and *Diptera.*
- Leaf webbers, leaf hoppers, thrips, pod sucking bugs, green stink bugs were found to be the *regular pests* in long duration pigeonpea. The pod borer (*Helicoverpa armigera*), pod fly were the *major pests* during reproductive stage of the crop.
- Pod borer (*H. armigera*) caused 5% pod damage in IPA-203 and 11% in Bahar while pod damage due to pod fly was 16 % in IPA-203 and 47 % in Bahar.
- The field infestation of bruchids on pigeonpea commenced from 8th WAFI and was found incremental towards crop maturity. Field-carry-over infestation to storage was confirmed through laboratory storage experiments.
- An improved and efficient screening method was developed at Storage Entomology Laboratory, Division of Crop Protection, ICAR-IIPR, Kanpur for the identification of sources of resistance in pulse crops against bruchids.
- A systematic methodology was developed to identify the crop stage where bruchids initiate

the primary infestation on standing crop (*i.e.* infestation window) and its subsequent losses at storage level arising due to field-carry-over infestation in stored pulses.

- Two pigeonpea genotypes Pusa 992 and TDRG - 59 were highly resistant and 2 lines IPAE 15-06 and Pusa 2018-4 were resistant against *Meloidogyne javanica*
- One line of mungbean KM 2241 was resistant against *M. javanica*.
- Four lines of urdbean namely, OBG 41, PU 1541, TPU 4 and TU 94-2 were moderately resistant against *M. javanica*.
- One wild accession of chickpea was moderately resistant against *M. javanica*.
- Three lines of fieldpea namely, HFP 9907-B, IPFD 19-1 and HFP 1574 were moderately resistant to *M. javanica.*
- Four lines of pigeonpea namely, WD 2019-45-2, WDBCE 4-5-3-9, WDBCE 9-4-3-1 and WD 2019-35 were observed highly resistant and three lines WD 2019-40-1, WD 2019-40-2 and WD 2019-45-1 were observed resistant against pigeonpea cyst nematode, *Heterodera cajani.*
- Six lines of urdbean namely, BDU 12, IPU 2-43, OBG 41, Pant U 31, PU 1617, SKNU 1716 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.
- Bio-formulation *Dalhanderma* reduced wilt incidence by 21-32% in Hamirpur and 18-21% in Banda district. Grain yield was also increased by 19-27% .
- PCR detection using specific primers indicated the mixed infection of three (MYMIV, MYMV and HgYMV) viruses in 5.88% samples, two viruses in 26.47% samples and 55.88% samples showed the infection of single virus.
- A detailed analysis of genetic diversity of YMD causing viruses involved in moth bean revealed the presence of multiple DNA-A and DNA-B molecules of MYMIV, MYMVand HgYMV.
- The volatile oil extract of *Pogostemon patchouli* showed the highest contact toxicity (0.040 µl/cm^2) to 1-3 days old adults of bruchid, *Callosobruchus analis* (F.).
- The volatile oil extract of *Cuminum cyminum* showed highest fumigant toxicity (21.72 µl/L) to adult beetles (1-3d) of *C. analis*.
- In repellency assay, *Cymbopogon martini* exhibited strong repellent activity (>90 %) to 1-3 d old beetles of *C. analis.*
- The volatile oil extracts of *Cymbopogon martini, C. winterianus, Tagetes minuta* and *Acorus calamus* demonstrated over 75% oviposition deterrency to *C. analis* female beetles and over 80 % inhibition to F_1 progeny emergence.
- The accessions of *V. umbellata* (IC 251439, IC 251442, PRR 2007-2 and C 251440) and *V. vexillata* (IC 248326 and IC 248343) were found resistant against *C. chinensis* and *C. maculatus*. The accession of *V. khandalensis* (Kumur local) and *V. mungo* var. *mungo* (IC 251397, IC 251390, IC 251385 & IC 251387) were found to be resistant against *C. chinensis*. The accessions belonging to *V. trinervia* (JAP 10-51), *V. trinervia* var. *bournei* (IC 247407), *V. pilosa* (IC 210575, IC 210580 and IC 210576) and *V. dalzelliana* (IC 203864) were found moderately resistant.

Basic Sciences

- Lentil genotypes IG 3522, IG 4112, IG 2959, IG 2960 and IG 2507 showed higher tolerance towards heat stress, whereas, lentil genotypes IG 3522, IG2959, IG 2960, IG 2580, IG 2507 and IG 2754 showed higher tolerance to drought stress. It was observed that the genotypes having higher crop vigour, MSI, NBI and Chlorophyll index could produce higher dry biomass and grain yield under stress condition.
- Pigeon pea genotypes ICPL 87091, ICP 5028 and ICPL 20241 were found to be water logging tolerant while genotypes like ICP 149, MA 3 and ICPL 2376 showed moderate reaction. Development of adventitious roots was observed under water logged condition by ICP 5028, ICPL 2376, ICPL 20241 and MA 3 genotypes.
- After preliminary screening based on crop phenology, urdbean genotypes UH 32-3, PLU 294, LBG 787, BG 367, IPU 2-43, BGP 247, IPU 94-1 were selected for further studies on heat tolerance.
- A comprehensive analysis of galacto-oligosaccharides (raffinose, stachyose and verbascose) and sugars (glucose, sucrose and

maltose) of 30 common bean genotypes was carried out using HPLC. Stachyose (28.38- 47.73 mg/g of dry weight) and raffinose (4.89-18.87 mg/g of dry weight) were found to be the major galacto-oligosaccharides in common bean. Sucrose + maltose content ranged from 15.34-39.78 mg/g of dry weight while glucose (0.07 mg/g -1.34 mg/g of dry weight) was detected in very few genotypes of common bean.

- Twenty six nodulation specific genes in chickpea were identified following homology based search (blastp) using genomic resources of chickpea cv CDC frontier.
- Transcriptome sequence analysis of small nodule, large nodule and root samples of *Cicer arietinum* cv RSG 888, *Cicer reticulatum* cv ILWC116 and *Cicer echinospermum* – ILWC-246 was carried out to identify the tissue specific expression pattern NCR peptide coding genes. The processed data of each samples varied form 5.1-8.1 Gb of data with an average of 6.35 Gb. A total of 4378, 4702 and 199 DEGs were observed in Root *vs* Small nodule, Root vs large nodule, and Small *vs* large nodule respectively at corrected P value of <0.05 and down and up regulation are within the range of -7.53 to 10.38 fold.
- Four selected Rajmash genotype-*Rhizobium* combinations (genotype IC 417352, IC 356018, EC 150250, IC 356072 and Rhizobial isolate IIPR-RR 11, IIPR-RR 14, IIPR-RR 17, IIPR-RR 40) were evaluated for their nodulation potential using 3 different growth medium (sterilized soil, sand and hydroponics system). All the combinations were found positive for nodulation with genotype IC 356018 being the highest nodulator.

Social Science

- A total of 128 Front Line Demonstrations on chickpea (var. GNG 2207), lentil (var. IPL 220) and field pea (IPFD 12-2 & IPFD 10-12) were conducted in 6 districts , Kanpur dehat, Jalaun, Hamirpur, Banda and Fatehpur, of Uttar Pradesh states in different production situations. About 60 ha area was covered under these demonstrations
- For enhancing pulse production for food, nutritional security and rural livelihoods of tribal farmers of Madhya Pradesh and Chhattisgarh state, 250 demonstrations on improved pigeon pea, urd bean and mung bean production technologies were conducted in different districts of Madhya Pradesh and Chhattisgarh during *Kharif* 2021. Similarly, 400 demonstrations on improved pulse production technologies in Rabi 2021-22, covering 160 hectares were anducted.
- During *Kharif* 2021, as a part of technological interventions, high yielding paddy hybrid named Arize 6444 Gold was introduced first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh, under farmer FIRST project. A total 29 farmers were part of this intervention that covered about 12.04 hectares. The introduced hybrid yielded 44.26 q/ha which was almost double the productivity of popular traditional variety Sarbati (21.27 q/ha) in the area.
- As a part of technological interventions in *kharif* 2021, a hybrid Pearl millet Pioneer 86M84 was introduced the first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh on 3.86 ha area. Total 8 farmers partnered the introduction of hybrid pearl millet in the project villages under farmer FIRST project were the part of intervention.
- Navya hybrid of okra was introduced for the first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh during kharif 2021 under Farmer FIRST project. A total of 10 partner farmers cultivated the introduced hybrid in almost 3 ha of the area. Partner farmers could receive an average yield of 17.35 t/ha which was higher than the average yield of other popular hybrids i.e. 16.50 t/ha in the region.
- The data collection schedule was prepared for data collection from farmers, aggregators, wholesalers and input dealers. A total of 840 farmers from all 7 districts, 14 blocks and 28 villages were interviewed. In addition value chain actors like input dealers (12), aggregators (28), wholesalers (28), processors (12) and retailers (12) were also interviewed for the study Value.
- The screening committee of ABI unit ,selected one applicant for extending the incubation support by ABI unit for business development under the thrust area of pulse processing. For the purpose two MoA, for transfer of technology on Milling of Pulses in Mini Dal Mills and for incubation support were signed with Mamta Agro-India Kanpur.

IIPR Regional Centre, Phanda, Bhopal

- Urdbean variety IPU 17-1 was released and notified for Madhya Pradesh state including Bundelkhand Region. Seven entries [Pigeonpea short duration entries (02), *Kabuli* chickpea entries (02) and *desi* chickpea entries (03)] were submitted to AICRPs for multi-location evaluation under various categories of trials. M.P. State trials for summer mungbean (07) and urdbean (04); *Kharif* urdbean (01) and pigeonpea (06) and, for lentil (07) during rabi 2021-22 are conducted. Four Germplasm submitted for registration for specific traits *viz*., large seed size in grasspea (IC 296745), earliness in chickpea (IC 209236) and pigeonpea (IC 523649) and, large seed size in pigeonpea (IC 634397). Total 6920 germplasm (indigenous, exotic and wild accessions) are being maintained at the centre.
- ICARDA global nursery of *Kabuli* chickpea evaluated and entries, X016TR82 (56.8 gm), X016TR92 (55.8 gm), X016TR91 (54.8 gm), X016TR74 (51.6 gm), X016TR 86 (51.0gm), X016TR85 (50.0 gm) were identified as donors for the extra large seed size. However, few high yielding *Kabuli* chickpea entries *viz*., X016 TR 85 (3641.7 kg /ha), X016TR 50 (3432.8 kg/ha), X016TR 46 (32.18.6 kg/ha) were selected.
- Heat tolerant genotypes, IC 83888, IC 486922, EC 267221, IC 83777 and IC 83459 were identified out of 2460 chickpea germplasm under Characterization of Chickpea germplasm Resources to accelerate Genomics-assisted Crop Improvement of DBT funded programme.
- Total 407 pigeonpea germplasm received from NBPGR is characterized under CRP on pigeonpea (characterization) programme. Trait-specific pigeonpea genotypes, IC 523649 for earliness (118-120 days), IC 634397 for large seed size (21.-0-25.8 gm / 100 seed wt.) having reddish-brown seed coat, IC 468496 for large seed size (18.2-20.7 gm / 100 seed wt.) with white seed coat are being used as donors in pigeonpea improvement programme.
- A set of 486 germplasm of grasspea have been purified and characterized for morphological traits and low ODAP content.
- 139 grasspea mutants were advanced to M_6 generation to select the low ODAP mutant lines. GML 2016-5, GML 2016-6, GML 2016-7 and GML 2016-18 were identified as low ODAP lines as compared to check variety Mahateora (0.04%). Gamma irradiated (BARC) grasspea mutants of M_1 generation (200, 300, 400, 500 and 600 kGy treated) are grown and being characterized for germination and morphological variation.
- FLRP & International ICARDA grasspea nursery comprised of 183 entries for low ODAP, earliness and high biomass are being evaluated.
- Wilt sick plots for chickpea, pigeonpea and lentil are under development for races of Centra Zone.
- Total 170.27 q breeder seed produced against the target of 117.80 q and 1075.15 q quality seed produced during 2020-21 against the target of 1000 q.
- 70 FLDs on pigeonpea (10), urdbean (05) chickpea (25), lentil (15) and field pea (15) are conducted.
- Three hundred thirty five farmers were benefitted with the seed distribution of new pulse varieties under SC-sub-plan during 2021.

IIPR Regional Centre, Dharwad

- During off-season, chickpea breeding materials from AICRP centres and chickpea breeding material generated at IIPR were advanced.
- Total 300 accessions of cowpea, 140 accessions of horsegram, 300 accessions of mungbean and 230 accessions of urdbean were maintained and evaluated for different agronomic traits.
- Wild *Vigna* species (*Vigna trilobalata, Vigna stipulacea, Vigna umbellata and Vigna aconitifolia, Vigna dalzelliana, Vigna glabrescence, Vigna hainiana, Vigna pilosa, , Vigna sublobata, Vigna sylvestries, Vigna trinervia* var.*bourbeae, Vigna vexillata)* were maintained for their utilisation in pre-breeding programme.
- Chickpea (IPC-17-54, IPC-19-41 and IPC-17-139), and mungbean (IPM-14-10 and IPM-1205-2) genotypes were found promising for cultivation during spring/summer.
- Promising entries of mungbean (IPM-14-10 and IPM-14-35) and desi chickpea (IPC-17-292, IPC-19-222) are evaluated in state multi-location trial to assess their suitability for cultivation in Karnataka.
- Total 900 Kg of breeder seeds of kharif pulses and 650 kg of truthful labelled seeds of different pulse rabi crops were produced.

- Pigeonpea + sorghum intercropping system recorded higher system productivity of 2623.9kg/ha.
- Application of 100% recommended rate of fertilizer(RRF) +Rhizobium + Microbial Consortia+0.5% spray ZnS04 and FeS04 recorded a significantly increase in mungbean yield (417.7 kg/ ha) with 32% increase over farmers' practice (315.8 kgha-1). Even in the maize crop the grain yield and WUE increased by 21% with same treatment during kharif 2021.
- In cowpea, Pant Lobia-3& CPD-331 was resistant and VCP-18-032 and PGCP-74 were moderately resistant to root rot disease.
- Foliar sprays Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V) at 0.1% was found to be effective against powdery mildew in horsegram
- A total of 152 pigeonpea entries were evaluated against SMD disease by leaf stapling technique under field conditions.
- Mungbean line (KME-21-52), urdbean (KUE-21-21) and cowpea (CPE -3) were identified as promising with pod damage less than 15 %

ICAR- IIPR, APRC, Bikaner

- Out of 300 mothbean accessions, IC-8851, IC-370508, IC-415116, IC-415127, IC-415139 IC-415143 IC-415155, IC-415164 and IC-120963 were identified early type, and IC-402285, IC-11352, IC-315520, IC-329051 and IC-370508 exhibited yield advantage over the check varieties.
- Total 50 cowpea accessions evaluated in hot-arid region; among those three accessions EC-738156, EC-738206 and EC-738093 were identified early type (50% flowering < 45 days), however, based on maximum no. of seeds/pod accession EC-723808 was identified best (> 17 seeds/pod).
- In mothbean, genotypes RMO-2251 and RMB-25 showed the least reduction in dry matter and seed yield under water deficit conditions as compared to controlled conditions. Similarly, mungbean genotypes IPM 1103-1, IPM410-3 and IPM 312-20 varieties were identified as drought tolerant as they maintained the higher values of RWC, MSI, cooler canopy, leaf area, and yield traits.
- Higher yield of chickpea and mustard were recorded with 75% RDF + 5.0 t FYM which was at par with 100% RDF. In both crops higher net return and BC ratio were observed with 100% RDF followed by application of 75% RDF + 5.0 t FYM.
- Exogenous growth supplements i.e. thiourea (1000 ppm), K2SO4 (0.2%), Salicylic acid (100 ppm), Urea (2%), NPK solution (0.5%), acetic acid (20mM), MgSO4 (0.5%), and water were applied as foliar spray at vegetative and pre-flowering stage. Among these growth supplements, K2SO4 showed its superiority in enhancing drought tolerance in both the crops which was at par with thiourea.
- In intercropping experiments, pearlmillet + clusterbean (1:1) recorded highest total yield having land equivalent ratio of 1.33 indicating yield advantage over sole crop. Pearlmillet + clusterbean (2:1) observed to be second best treatment.

ICAR-IIPR Regional Station Khordha, Odisha

- Among the urdbean varieties screened, IPU 13-1 had significantly higher seed yield over other varieties tested.
- In respect of dates of sowing, sowing done on 10 December had significantly higher yield as compared to sowing done on 30 November and 20 December and IPU 13-1 recorded maximum seed yield (1103 kg/ha) .
- Among the mungbean varieties tested, significantly higher grain yield was recorded in IPM 2-14 as compared to IPM 205-7 and Kamdev.
- Five genotypes of uradbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check mungbean (DGGV 2) & urdbean (MDU 1) were screened against YMD during kharif season & found that the YMD was observed only in susceptible check (MDU-1) with DI of 100 %, DS of 73% & rest others line are free from YMD & the susceptible check (DGGV-2) was also free from YMD.
- Ninety nine entries of uradbean were evaluated against powdery mildew during rabi season and found that none of the entries were resistant or moderately resistant.

Off-Season Activity at Kullu (H.P.)

- During rabi 2021 seed multiplication of chickpea, lentil and fieldpea was undertaken. The crop performed well and the total produce is still to be weighed. Simultaneously, exploratory trials comprising 33 genotypes in chickpea, 29 in lentil, 09 in rajmash, 10 in fieldpea, 11 in mungbean, 5 in urdbean and 6 in fieldpea were raised at CSKHPKV, Highland Agricultural Research Station, Kukumseri, Distt. Lahaul and Spiti during rabi 2020-21. All the trials were conducted in two replications and data were recorded w.r.t. morpho-physiological traits. Superior genotypes were identified. Mungbean and urdbean materials could not adapt to the local conditions. The same materials were also raised at CSKHPKV, Sundarnagar and 5 genotypes in chickpea viz., GNG-1958, DCP 92-3, IPC 20011-112, GNG-2144 and IPC 2010-142, 6 in fieldpea viz., IPFD 14-2, IPFD 9-2, IPFD 13-2, IPFD 6-3, HFP 9426 and IPFD 12-2 and 5 in lentil (IPL315, IPL526, PPL321, IPL81 and IPL220_ were found to be superior and adapted to local conditions. Likewise, evaluation trials comprising 10 varieties of mungbean and 5 each of rajmash and urdbean were also raised at CSK Himachal Pradesh Krishi Vishvavidyalaya, Regional Station, Berthin during Kharif 2021.

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.

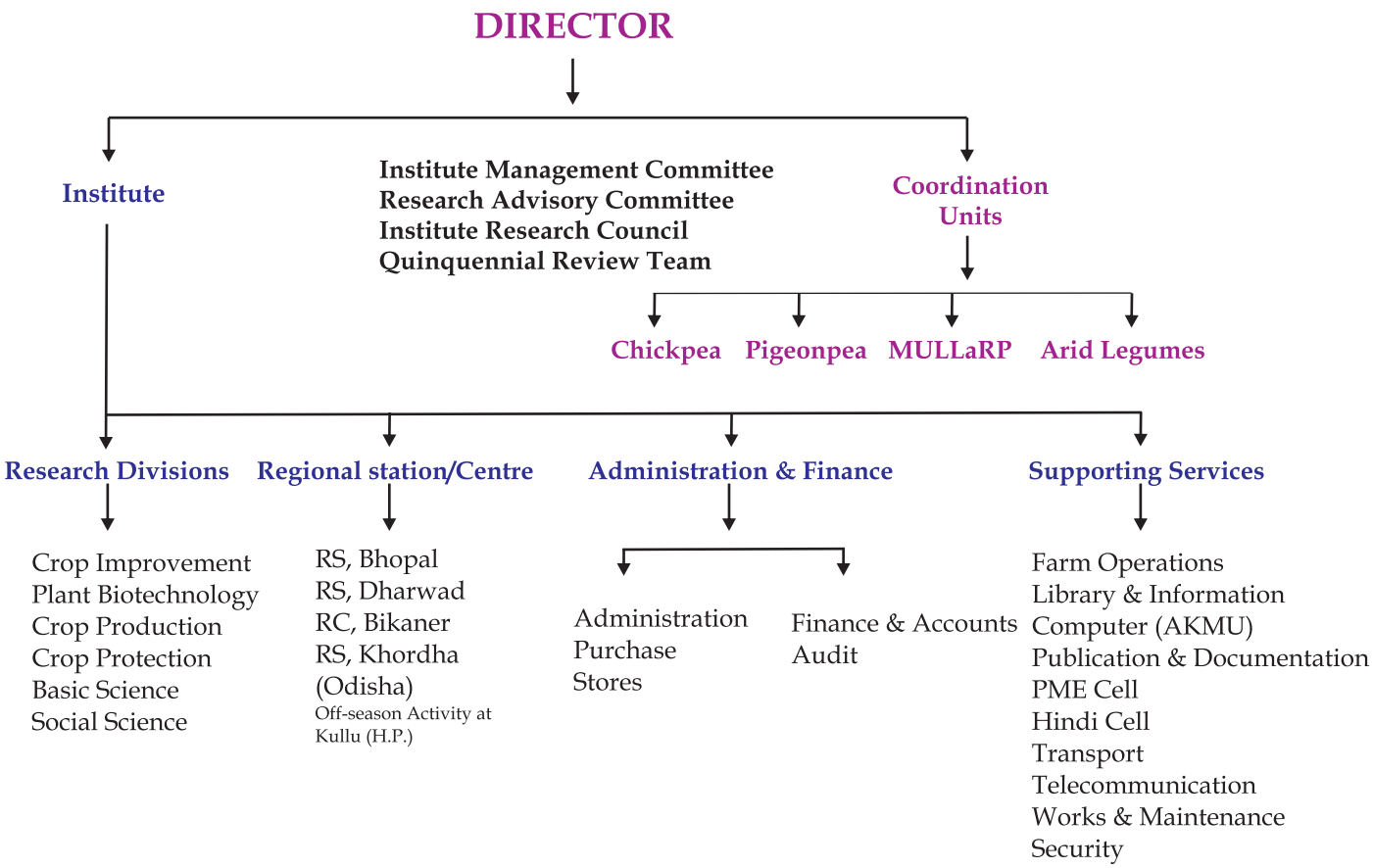
The Institute is located at Kanpur, Uttar Pradesh at $26^0 27'$N latitude, $80^0 14'$E longitude and 152.4 meter above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central Railway Station towards New Delhi.

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 3.4^0C 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 recently 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, 62 technical, 63 administrative and 31 supporting personnel.

Organizational Set-up



Staff Strength

As on 31.12.2021

Category	Sanctioned	In position	Vacant Post
RMP	01	-	01
Scientist	100	74	26
Technical	62	38	24
Administrative	63	21	42
Skilled Support Staff	31	17	14
Total	**257**	**150**	**107**

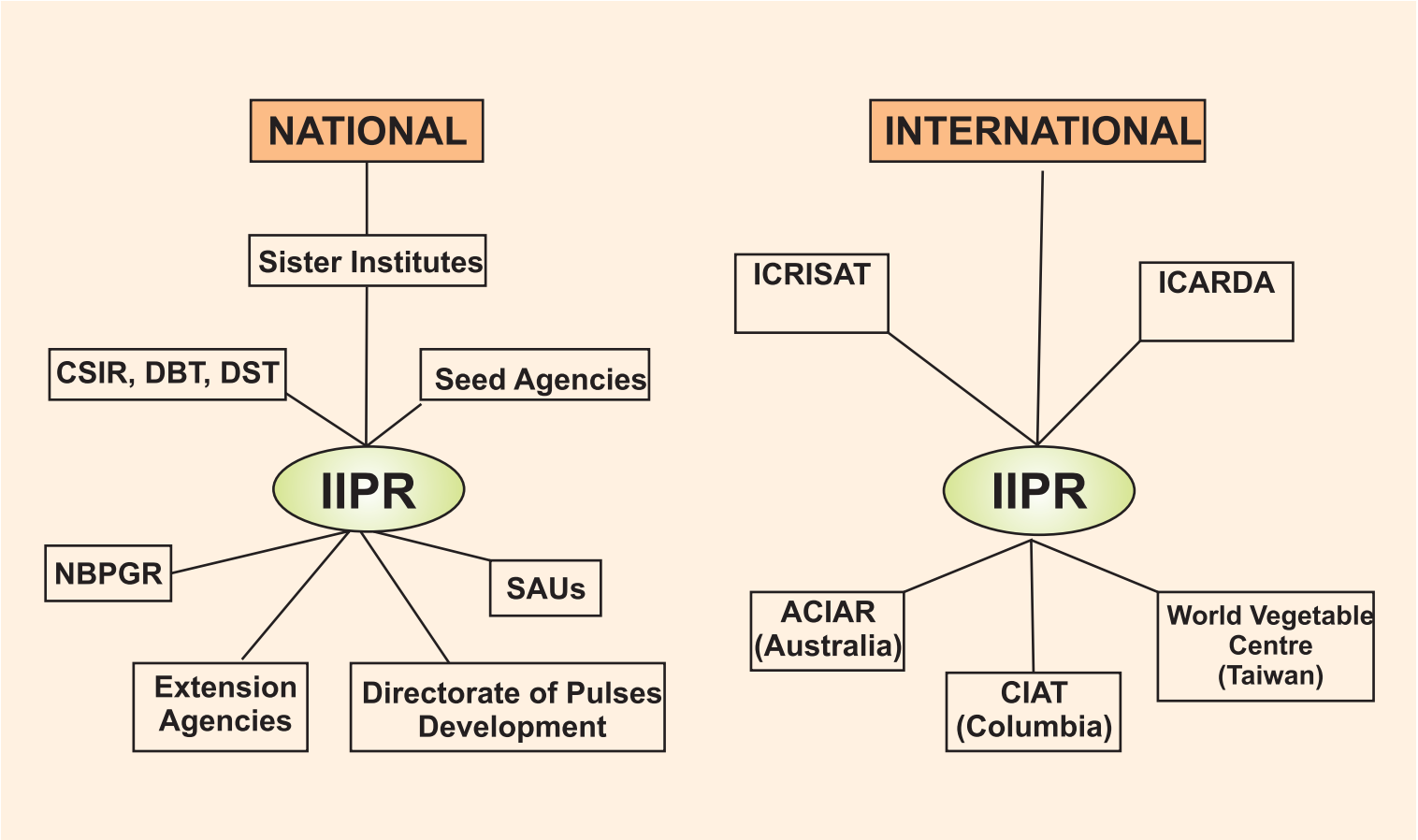
Mandate

- 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 2020-21

(As on 01.04.2020 to 31.03.2021)

		₹ in lakh
A.	**Receipt**	3956.10
B.	**Expenditure**	**3956.10**
	Plan	3956.10
C.	**Pension and other retirement benefits**	224.27
D.	**AICRP**	
	Chickpea	
	a. Coordination Unit	221.00
	b. Grant-in-aid	1042.04
	Pigeonpea	
	a. Coordination Unit	173.10
	b Grant-in-aid	931.15
	MULLaRP	
	a. Coordination Unit	226.50
	b. Grant-in-aid	1245.65
	AINPAL	
	a. Coordination Unit	90.00
	b. Grant-in-aid	380.14

Status of Implementation of SFC 2017-20 Three Year Plan (Upto 31.03.2021)

(₹ in lakh)

Head	**Approvd outlay (B.E.)**	**Expenditure (31.03.21)**
A. Recurring		
Pay & Allowances/Wages & Pension	2448.97	2448.97
TA	10.34	10.34
HRD	0.28	0.28
Contingency	1041.31	1041.31
Total	**3500.90**	**3500.90**
B. Non-Recurring		
Equipment, Information Technology & Furniture & Fixture	136.80	136.20
Works	288.40	288.40
Library	0.00	0.00
Total	**425.20**	**425.20**
C. TSP	**30.00**	**30.00**
TOTAL (A+B+C)	**3956.10**	**3956.10**

Crop Improvement

Programme 1: Development of biotic and abiotic stress reistant superior varieties/ hybrids through integrated conventional and modern breeding approach.

A. Chickpea

A01. Genetic enhancement of chickpea for higher grain yield and wider adaptability

1. **Varieties developed:** Three chickpea varieties including two *desi* and one *kabuli* type have been released and notified during 2021 by Competent authority for enhancing productivity of chickpea in Uttar Pradesh and North Western Plan Zone (NWPZ).

1.1. **IPCK 2013-163 (Atal):** This *kabuli* chickpea variety derived from JGK 1/Phule G 0517 cross. It has been released and notified during 2021 for cultivation in NWPZ comprising of Panjab, Haryana, Rajasthan, Delhi, Uttarakhand and West Uttar Pradesh. It produced mean yield of 1971 kg/ha and registered 11.5% and 13.6% yield superiority over national check BG 3022 (1735 kg/ha) and GLK 28127 (1778 kg/ha), respectively during three years of evaluation in NWPZ under AICRP. It matures in 130-140 days and is moderately resistant to wilt disease. It has large seed (28.7 g/100 seed wt.) with attractive creamy beige seed colour.

1.2. **IPC 2010-134 (Shiva):** It is *desi* chickpea variety derived from GNG 469/FG 711 cross. It has been released/notified during 2021 for cultivation in Western and Bundelkhand regions of Uttar Pradesh under timely sown condition. It produced mean yield of 1706 kg/ha with 13.0% yield superiority to the best check KWR108. It matures in 125-135 days with resistant to wilt, moderately resistant to DRR, AB, BGM disease. It is medium seed size (23g of 100 seed wt.).

1.3. **IPC 2007-28 (Atal):** It is desi chickpea variety derived from DCP 92-3/JG 16 cross. This variety has been released and notified during 2021 for cultivation in Eastern regions of Uttar Pradesh under late sown condition. It produced mean yield of 1683 kg/ha and registered 11.96% yield superiority over the best check KPG 59. It matures in 128 days and resistant to wilt disease. It has large seed (18.5 g/100 seed wt.) with brown seed coat colour and semi-erect growth.

2. **Proposal invited for release in Uttar Pradesh:** Two chickpea varieties namely, IPC 10-142 (*desi*) and IPCK 09-145 (*Kabuli*) were identified and recommended for release in Uttar Pradesh

2.1. **IPC 2010-142 (Kuber):** It is a *desi* chickpea genotype derived from RSG 143-1/IPC 94-94 cross and recommended for release in Western and Eastern region of Uttar Pradesh. The SATs were conducted under timely sown during 2016-19 at 9 locations represented all zones over state. This is high yielding genotype produced mean yield of 1598 kg/ha with 10.44% superiority to the best check KWR 108 (1447 kg/ha). It matures in 130-140 days, and is resistant to wilt and moderately resistant to DRR, Ascochyta blight and BGM diseases. It has medium seed size (29.1 g of 100 seed weight) and semi-erect growth (65-75 cm PH) habit.

2.2. **IPCK 2009-145 (Kanchan):** This is a kabuli chickpea genotype derived from JGK 1/ICC 17109 cross and found promising based on SATs conducted at 9 locations of Uttar Pradesh during 2018-20. The proposal has been invited for release in Western, Central & Eastern regions of UP by *Rajya Beej Vimochan Samiti*. It produced mean yield of 1203 kg/ha with registered 15.23% yield superiority to best check K 3256 (1044 kg/ha). It matures in 130-135 days and is moderately resistant to wilt. It has large seed size (32.2 g of 100 seed wt.) with creamy white seed colour.

3. **Performance of breeding lines in AICRP trials:** Five chickpea entries, IPC 16-25-Timely Sown (ECZ) & IPC 17-292- Rainfed (CZ) were promoted to AVT-1. Similarly, three chickpea entries of machine harvest, IPC 17-253, IPC 15-132, IPC 17-141 were promoted to AVT-1 (NEPZ). Sixteen entries, IPC 18-131, IPC 18-38, IPC 16-127 (TS); IPC 17-373, IPC 16-231, IPC 14-88 (LS); IPC 17-361, IPC 19-222, IPC 17-04 (Rainfed); IPC 18-59, IPC 17-351, IPC 18-39 (MHT); IPCK 10-124, IPCK 16-12, IPCK 16-

133, IPCK 16-149 (*Kabuli*) are being evaluated in IVT during 2021-22.

4. **Performance of breeding lines in UP SATs:** Total 15 advanced lines *viz*., IPC 16-44, IPC 15-123 (new lines), IPC 14-10, IPC 15-12, IPC 15-17, IPC 15-116, IPC 15-123, IPC 15-165, IPC 15-267, IPCK 11-37, IPC 11-28, IPC 11-30, IPC 12-108, IPC 14-51, IPC 14-120 (old entries) were evaluated in UPSAT for different ecologies (TS, LS, *Kabuli*). Eight lines were evaluated in Jharkhand and IPC 10-62 produced more yield (2330 kg/ha) followed by IPC 09-21 (2140 kg/ha), IPC 07-28 (2110 kg/ha) and check BG 372 (1767 kg/ha) and registered 31.9% yield superiority. Similarly, 28 lines also evaluated in MP (8), Bihar (3), Jharkhand (9), Chhattisgarh (8).

5. **Evaluation of trait specific germplasm/wild relatives:** Total 337 chickpea germplasm lines (released varieties, trait specific donor) were evaluated for hybridization and shared with NARS partners. Total 113 wild lines from 7 *Cicer* species including *C. reticulatum* (42), *C. pinnatifidum* (27), *C. echinospermum* (6), *C. yamashitae* (2), *C bijugum* (1), *C. cuneatum* (3), *C. judaicum* (32) are maintained. *C. reticulatum* & *C. pinnatifidum* used as donor to enhance traits, heat/ drought tolerance, yield, plant architecture, seed/pod, protein content

6. **Generation of breeding material:** Chickpea breeding material including donor/breeding lines utilized in crossing. **Agronomic base** (BG 3043, GNG 1581, GNG 2207, GG 2, GJG 0814, IPC 05-62, IPC 06-77, IPC 10-62, IPC 17-351, JAKI 9218, JG 16, Vijay, RVG 202), **wilt** (GJG 0814, IPC 07-28, IPC 12-100, IPC 07-56, IPC 10-134, ICC 12237, SA1, JG 315), **DRR** (IPC 10-134, JSC 37), **AB** (ICC 3935, ICC 8933, ICC 9001, ICC 111321), **earliness** (IPC 08-83, ICC 96029, BGD 9971), **drought** (ICC 4958, RSG 888), **heat** (JG 14, ICC 1205, ICC 15614), **salinity** (CSG 8962),**MHT** (HC 5, IPC 17-351, NBeG 47), **herbicide** (IPC 18-186, ICC 11101, ICC 12315), **Zn/Fe** (ILWC 257), ***protein*** (T 39-1, T 1-A), ***wildlines*** (ILWC 21, ILWC 142, ILWC 263) were used to broaden genetic base.Total 30 chickpea crosses including 16 & 14 were made during *Rabi* and *Kharif* 2020-21 at Kanpur and Off-season nursery Dharwad, respectively to develop breeding lines for yield, biotic/ abiotic stresses resistance, earliness, tall/erect, suitable for different agro-ecology

7. **Generation advancement:** The generations were advanced during *Kharif* 2020 and *Rabi* 2020-21 at Dharwad & Kanpur, respectively. $\mathbf{F_1}$ populations from 54 crosses were raised for generation advancement and 450 F_1 plants harvested separately during *Rabi* 2020-21. Altogether, 1331 SPS in various generations (F_2 to F_7 populations) derived from 239 crosses including 59 $\mathbf{F_2}$**:** 153 SPS + 50 Plot Bulk (PB), 25 $\mathbf{F_3}$**:** 258 SPS, 44 $\mathbf{F_4}$**:** 545 SPS + 12 Line Bulk (LB), 25 $\mathbf{F_5}$**:** 192 SPS + 3 LB, 32 $\mathbf{F_6}$**:** 233 SPS + 94 LB were harvested separately. The segregating material of different generations as line bulk (LB), plot bulk (PB) will be shared among the NARS partners

8. **Evaluation of advance breeding lines:** Total 325 breeding lines including 140 and 185 entries were evaluated as station trials (ST), preliminary yield trials (PYTs), respectively under timely sown (TS), late sown (LS), rainfed (RF), pre-breeding (PB), mechanical harvesting (MHT) *kabuli* and trait specific. Total 140 entries were evaluated as ST-1 (**MHT**), ST-2 (**PB**), ST-3 (**TS**), ST-4 (**RF**), ST-5 (**LS**), ST-6 (**K**) & ST-7 (Trait specific) at Kanpur, Bhopal, Dharwad. Similarly, 191 lines with 6 PYT were evaluated as PYT-1 (MHT), PYT-2A (PB), PYT-2B (Nutrition), PYT-3 (TS), PYT-4 (RF), PYT-5 (LS). The trial-wise entries are given below:

8.1. **ST-1 (MHT):** Twenty lines were evaluated for machine harvest. Entry IPC 16-53 (2594 kg/ha, 73 cm) was top yielder followed by IPC 16-15 (2378 kg/ha, 75.4 cm), IPC 18-59 (2322 kg/ha, 68.2 cm), IPC 18-136 (2289 kg/ha, 63.7 cm) and check GNG 2207 (2078 kg/ha, 46.2 cm) & HC 5 (1767 kg/ha, 62.8 cm) and registered 4.8% & 46.7% yield superiority over both checks, respectively at Kanpur. Entry IPC 18-59 (2215 kg/ha, 58.3 cm) was top yielder at Kanpur, Bhopal, Dharwad followed by IPC 16-53 (2178 kg/ha, 60.2 cm) and check Phule Vikram (2409 kg/ha, 56.8 cm).

8.2. **ST-3 (TS):** Total 20 breeding lines were tested. Entry IPC 17-358 (2772 kg/ha) was found top yielder followed by IPC 18-121 (2478 kg/ha), IPC 18-117 (2456 kg/ha), IPC 19-19 (2322 kg/ha) and checks IPC 11-112 (2217 kg/ha), GNG 2207 (1572 kg/ha) & BG 3043 (1117 kg/ha) was registered with 25.0%, 76.3% & 148.2% yield superiority over checks,

respectively.

8.3. **ST-4 (RF):** Total 20 lines with check were evaluated under rainfed at Kanpur, Bhopal, and Dharwad. In Kanpur, IPC 18-111 (3221 kg/ha) was found top yielder followed by IPC 17-04 (2888 kg/ha), IPC 19-139 (2877 kg/ha), the best check RSG 888 (2529 kg/ha) and registered with 27.4% yield superiority over check. Based on mean yield over 3 locations, IPC 17-361 (2342 kg/ha) was found top yielder followed by IPC 19-139 (2285 kg/ha) and best check JAKI 9218 (2290 kg/ha).

8.4. **ST-5 (LS):** Total 20 breeding lines were evaluated under late sown. Entry IPC 17-10 (2517 kg/ha) was found top yielder followed by IPC 15-57 (2472 kg/ha), IPC 19-277 (2317 kg/ha), IPC 19-142 (2278 kg/ha), IPC 17-166 (2267 kg/ha), IPC 19-126 (2239 kg/ha), IPC 19-67 (2217 kg/ha) and best check BG 372 (1933 kg/ha) and registered with 30.2% yield superiority.

8.5. **ST-6 (*Kabuli*):** Total 20 *kabuli* lines were evaluated at Dharwad. Entry IPC K20-190 (2130 kg/ha, 38.2g HSW) was found top yielder followed by IPCK 18-184 (2095 kg/ha, 32.5 g HSW), IPCK 18-185 (2030 kg/ha, 35.8 g HSW), IPCK 20-189 (1850 kg/ha, 39.0 g HSW) and check MNK1 (1989 kg/ha, 36.9 g HSW) and registered with 7.1% yield superiority over check MNK 1.

8.6. **ST-7 (Trait specific):** Total 20 breeding lines with checks were tested at Dharwad during 2020-21. Entry IPC 19-41 (2669 kg/ha) was top yielder followed by IPC 17-139 (2387 kg/ha), IPC 19-152 (2364 kg/ha), check JG 11 (2309 kg/ha) with 15.6% yield superiority over check.

8.7. **PYT–1 (MHT):** Total 16 tall/erect lines were evaluated under machine harvest. Entry IPC 20-08 (2592 kg/ha & 64.7 cm) was found top yielder followed by IPC 20-111 (2443 kg/ha & 77.7 cm), IPC 20-120 (2402 kg/ha & 87.0 cm), IPC 20-97 (2388 kg/ha & 74.3 cm) and the best check HC 5 (2367 kg/ha & 82.0 cm) and registered 9.5% yield superiority over the best check.

8.8. **PYT–3 (TS):** A total of 21 advance lines were tested during 2020-21. Entry IPC 20-63 (2920 kg/ha) was found top yielder followed by IPC 20-196 (2602 kg/ha), IPC 20-48 (2472 kg/ha), IPC 20-104 (2362 kg/ha) and check IPC 11-112 (2228 kg/ha) with 31.1% yield superiority.

8.9. **PYT–4 (RF):** Total 50 advance breeding lines were evaluated. Entry IPC 20-143 (3733 kg/ha) was found top yielder followed by IPC 20-94 (3310 kg/ha), IPC 20-51 (3212 kg/ha), IPC 20-134 (2953 kg/ha) and check BG 3043 (2833 kg/ha) and registered 31.8% yield superiority.

8.10. **PYT–5 (LS):** Total 42 lines with checks were evaluated under late sown condition. Entry IPC 20-115 (2883 kg/ha) was top yielder followed by IPC 20-176 (2733 kg/ha), IPC 20-88 (2700 kg/ha), IPC 20-42 (2650 kg/ha), IPC 20-94 (2617 kg/ha) and the best check IPC 05-62 (1983 kg/ha) with 45.4% yield superiority.

9. **Phenotyping against biotic stresses:** One hundred sixty eight lines were screened in sick plot at Kanpur and 18 lines (IPC 97-29, IPC 20-12, IPC 20-47, IPC 20-58, IPC 20-59, IPC 20-61, IPC 20-70, IPC 20-115, IPC 20-123, IPC 20-124, IPC 20-134, IPC 20-135, IPC 20-146, IPC 20-147, IPC 20-148, IPC 20-153, IPC 20-155, IPC 20-167, IPC 20-181) showed resistance reaction to wilt, while seven lines (IPC 16-31, IPC 07-56, IPC 97-29, IPC 13-209, IPC 11-31, IPCK 12-306, IPCK 11-31) showed stable resistance under AICRP. Ten lines/wild *Cicer,* ICC 17164, ICC 17151, ICC 182, ILWC 30, ILWC 95, ILWC 50, ILWC 182, ILWC 188, ILWC 223, ILWC 185 showed resistance to A. blight, while six lines, ICC 17155, ICC 17116, ICC 17150, ILWC 238, EC 600099, EC 6000100 exhibited moderate resistance to *A rabiei*. In DRR, 4 lines (IPC 12-98, IPC 13-33, IPC 11-85, IPC 10-219) exhibited moderately resistance to DRR in AICRP

10. **Phenotyping against abiotic stresses (heat):** Eighty breeding lines of chickpea and checks were raised on January 5, 2020 for screening to heat (>35°C). Five plants were selected from each line and screened based on semi-erect plant, high podding, seed setting in terminal pods of plant >35^{0}C and yield. Total 25 lines were found promising and tolerant to heat (IPC 19-79, IPC 19-216, IPC 19-93, IPC 19-136, IPC 19-188, IPC 19-173, IPC 19-177, IPC 19-24, IPC 19-104, IPC 19-102, IPC 19-179, IPC 19-192, IPC 19-26, IPC 19-199, IPC 19-175, IPC 19-34, IPC 19-216, IPC 19-157, IPC 19-153, IPC 19-74, IPC 19-37, IPC 19-217, IPC 19-144, IPC 19-119, IPC 19-19)

11. **Evaluation of International Nurseries and Elite Breeding Lines:** Total three trials including two ICVTs (*desi* & MHT) and EBLs of *desi* chickpea were evaluated during *Rabi* 2020-21.

11.1. **ICVT (*Desi*):** Twenty entries with checks were evaluated and entry ICCV 201201 (2052 kg/ha) was found top yielder followed by ICCV 201206 (2039 kg/ha), ICCV 201210 (1484 kg/ha), the best check IPC 11-112 (1397 kg/ha) and registered with 46.9% yield superiority.

11.2. **ICVT-*Desi* (MHT):** Twenty entries were evaluated and entry ICCV 201115 (2202 kg/ha) was found top yielder followed by ICCV 201116 (2081 kg/ha), ICCV 201101 (2063 kg/ha) best check IPCHC 5 (1677 kg/ha) and registered 31.3% yield superiority over best check.

11.3. **EBL (*Desi*):** Seventy EBLs were evaluated during 2020-21. Entry JG 16-141611 (1832 kg/ha) was found top yielder followed by IPC 08-11 (1732 kg/ha), JG 16-1206301 (1668 kg/ha), IPC 05-62 (1632 kg/ha), IPC 10-142 (1599 kg/ha) and check DCP 92-3 (1248 kg/ha). Based on 4 years (2017-21) mean yield, IPC 10-142 was found top yielder (1722 kg/ha) followed by IPC 08-11 (1628 kg/ha), IPC 12-98 (1595 kg/ha), IPC 12-31 (1583 kg/ha), best check DCP 92-3 (1509 kg/ha) and registered 14.1% & 25.8% yield superiority to DCP 92-3 & JAKI 9218, respectively.

12. **Maintenance breeding:** One thousand Single Plant Selections (SPS) were harvested from eight varieties for maintaining genetic purity. Total 2086 kg nucleus seed of chickpea varieties, DCP 92-3 (21.6 kg), IPCK 02-29 (103.6 kg), IPCK 04-29 (62.5 kg), IPC 06-77 (514.8 kg), IPC 04-98 (212.2 kg), IPC 05-62 (317.4 kg), IPC 04-01 (273.1 kg) and IPC 11-112 (581.5 kg) was produced based on single plant *progenies* method and supplied to seed production unit for enhancing breeder seed.

A02. Breeding for high yielding chickpea with multiple biotic stress resistance

1. **Generated breeding material:** Total 25 crosses ((AKG 1303/SGPWR 30)//(JAKI 9218/GJG 904), (AKG 1303/SGPWR 28)//(PG 0405/SA 1), CSJ 515/DKG 964, GNG 2171/IPC 08-69, CSJ 515/IC 248147, GNG 2171/IC 275447, GL 13001/IPC 07-28, GNG 2207/DKG 964, GNG 2207/IPC 08-11, GNG 2264/DKG 964, GNG 2264/IPC 08-11, GNG 2299/DKG 964, (AKG 1303/GJG 814)//(PG 0405/SGPWR 30), IPC 16-44//(T39-1/T1-A), IPC10-121//(CSJ515/IPC08-69), JAKI 9218/BGM 20212, AKG 1303/BGM 20213, (PG 0405/GJG 0904)//(JAKI 9218/SGPWR 30), (PG 0405/SGPWR 28)//(JAKI 9218/GJG 0921), JAKI 9218/BGM 20213, PG 0405/BGM 20211, PG 0405/ BGM 20212, PG 0405/GJG 0921, JG 24/ICC 14340, JG 24/ICC 144872 were made for DRR/wilt

2. **Generation advancement:** Total 37 F_1s' were advanced to F_2 and SPS from each cross harvested separately. Total 1850 SPS including 42 F_2: 800 SPS, 34 F_3: 450 SPS, 31 F_4: 600 SPS, harvested separately during *Rabi* 2020-21.

3. **Evaluation of advance breeding lines:** Two Station trials were conducted over three locations *viz*., Kanpur, Bhopal & Dharwad during *Rabi* 2020-21 and contributed five promising entries namely, IPC 19-219, IPC 19-220, IPC 19-221, IPC 19-222 and IPC 19-223.

4. **Mapping population development:** Two crosses namely, IPC 05-28/BG 212 & JSC 37/BG 212 utilizing IPC 05-28 & JSC 37 as resistant and BG 212 as susceptible parent were advanced to F_5 for developing mapping populations for dry root rot resistance

5. **Screening for Fusarium wilt resistance (race 2):** Ninety four wilt resistant plants from 11 crosses in F_3 (GNG 1958/IPC 05-28)//DKG 964, (IPC 10-134/DKG 964)//(IPC 05-28/JSC 37), (IPC 10-134/JG 24)//IPC 07-28, DKG 964//(GNG 1958/JSC 37), IPC 07-28//(IPC 10-134/DKG 964), IPC 007-28// (IPC 10-134/JG 24), JG 37//(IPC 06-88/ILWC 179), IPC 10-134/GNG 2226, IPC 10-134/IPC 07-28, JG 315/ RSG 888, IPC 05-28/JSC 37 were selected from wilt sick plot at IIPR

A03. Development of high yielding genotypes of chickpea having combined resistance against drought and heat stress

1. **Genetic stock registered:** Germplasm line, **ICC 15925 (INGR 21144)** has been identified as heat tolerant donor and registered with ICAR-NBPGR, New Delhi as unique trait. Besides this, 250 lines including germplasms,

improved breeding lines are characterized for various phenological, physiological and yield related traits under normal and late sown condition.

2. **Generated breeding material:** Total 16 crosses (BG 372/ICC 92944, BG 372/JG 11, BG 372/PG 0405, ICC 92944/GNG 2207, ICC 92944/BG 372, ICCV 92944/PG 0405, IPC 06-77/ICC 92944, IPC 06-77/GNG 2207, GNG 2207/Vijay, JG 11/ICC 07110, JG 11/ICC 15925, Vijay/ICC 92944, KWR 108/ILWC 36, KWR 108/ILWC 121, KWR 108/GNG 2207, KWR 108/PG 0405) and a multiparent cross [{(JG 130/ICC 92944)//(JG 11/ICC 96029)}///(ICC 07110/RVG 203)//(GG 2/GNG 2144)}] for MAGIC Population were made during *Rabi* 2020-21.

3. **Generation advancement:** F_1 populations derived from 19 crosses were advanced to F_2 and SPS were harvested separately. The generation advancement of F_2, F_3, F_4, F_5, F_6& F_7 population derived from 26, 49, 12, 8, 3 & 13 crosses and SPS & line bulk were harvested.

4. **Evaluation of advance breeding lines:** Total 27 lines were evaluated under normal & late sown for heat tolerance. Entry IPC 15-22 (1759 kg/ha) was found top yielder followed by IPC 14-88 & IPC 14-19 (1740 kg/ha), ICC 12213 (1675 kg/ha), IPC 14-55 (1611 kg/ha), over the checks KPG 59 (1453 kg/ha), ICC 92944 (1398 kg/ha), BG 372 (1240 kg/ha), KWR 108 (1124 kg/ha) under normal condition. Similarly, entry IPC 11-92 (1601 kg/ha), ICC 12213 (1481 kg/ha), IPC 15-22 (1458 kg/ha), IPC 11-78 (1398 kg/ha) showed superior yield over the checks KWR 108 (1286 kg/ha), ICC 92944 (1275 kg/ha), KPG 59 (1053 kg/ha) & BG 372 (1039 kg/ha). Physiological/ phenological traits were also recorded under late sown. ***In PYT:*** an early line, IPC 2019-5 (I^{st}flowering - 34 days) in comparison to check ICC 96029 (I^{st} flowering- 36 days), was identified it could be used for transfer of earliness trait in chickpea cultivars

5. **Development of mapping population:** Seven populations, DCP 92-3/ICC 92944 (F_8, 220 SPS), JG 315/ICC 92944 (F_6: 221 SPS), JG 11/ICC 1205 (F_6: 211 SPS), DCP 92-3/ICC 96030 (F_6: 219 SPS), DCP 92-3/ICC 1205 (F_6: 215 SPS), DCP 92-3/ICC 4958 (F_6: 201 SPS), DCP 92-3/ICC 1205 (F_7: 198 SPS) for heat tolerant were advanced. Three populations (JG 11/ICC 1205, DCP 92-3/ICC 1205, JG 315/ICCV 92944) were characterized under normal/heat condition. The mapping population DCP 92-3/ICCV 92944 has been characterized for various traits. Total 37 major QTLs were obtained for various heat tolerant traits during genotyping through GBS technology. QTLseq of 10 heat tolerant and sensitive lines uncovered three major heat tolerant QTLs *CaqH 5.1, CaqH 5.2, CaqH 6.1* were uncovered. Selected underlying candidate genes (*Ca_02170, Ca_16631, Ca_23016, Ca_09743, Ca_25602, Ca_08536, Ca_17680*) were validated through RT-PCR for expression of genes under normal/late sown. The genes showed up-regulation under heat stress condition suggesting their important role in controlling heat stress tolerance.

A04. Genetic enhancement for grain quality and milling attributes in chickpea

1. **Generation of breeding material:** Six crosses, IPC 17-351/T 1-A, GNG 2207/T 1-A, PG 0405/T 1-A, IPC 06-77/T 1-A, (IPC 05-62/ILWC 257)//(Vijay/IPC 97-29), (IPC 17-49/IPC 18-166)//(T 1-A/ILWC 257) were made during 2020-21 under grain and milling quality.

2. **Generation advancement:** Handling advance generation segregation in F_4 to F_5 breeding lines derived from crosses with high protein donor (Landrace T 39-1) was developed. Selection was carried based on protein content (≥25%) and grain parameters, yield and filled/unfilled pods ratio. F_1 population from 8 crosses was advanced. The generation advancement of F_2, F_3, F_4, F_5& F_6 population derived from 3, 4, 10, 12 & 3 crosses and SPS & line bulk were harvested.

3. **Evaluation of advanced breeding lines:** Fifty advanced breeding lines (ABL, F_6) evaluated for yield derived from crosses involving high protein donor. A PYT was conducted with 28 ABLs derived from crosses involving donor for high protein, Fe and Zn content.

3.1. **ST-2 (PB):** Total 20 breeding lines and check were tested. Entry IPC 19-246 (2694 kg/ha) was found top yielder followed by IPC 19-173 (2578 kg/ha), IPC 19-250 (2461 kg/ha), IPC 19-

249 (2444 kg/ha), IPC 19-177 (2394 kg/ha), IPC 19-48 (2378 kg/ha) and checks IPC 11-112 (2294 kg/ha), GNG 2207 (1694 kg/ha) & BG 3043 (1561 kg/ha) ands registered 17.4%, 59.0% & 72.6% yield superiority over checks IPC 11-112, GNG 2207 & BG 3043, respectively.

3.2. **PYT–2A (PB):** Total 31 breeding lines were evaluated. Entry IPC 19-251 (2715 kg/ha) was found top yielder followed by IPC 20-72 (2387 kg/ha), IPC 20-192 (2102 kg/ha), IPC 20-136 (1978 kg/ha) and best check IPC 11-112 (1810 kg/ha) and registered 50.0% yield superiority.

3.3. **PYT–2B (Nutrition):** Total 28 advance breeding lines and check were evaluated. Entry IPC 20-86 (2532 kg/ha) was found top yielder followed by IPC 20-29 (2202 kg/ha), IPC 20-20 (2153 kg/ha), IPC 20-93 (2128 kg/ha), IPC 20-15 (2108 kg/ha) and the best check IPC 05-62 (2083 kg/ha) and registered 21.6% yield superiority over the best check.

4. **Development of mapping population:** Five mapping populations, IPC 04-98/T 39-1 (F_6, 200), JAKI 9218/T 39-1 (F_5, 200), JG 16/T 39-1 (F_5, 180), DCP 92-3/T 39-1 (F_5, 160) & ICC 4958/T 39-1 (F_5, 190) were advanced. All the populations are segregating for protein content.

B. Pigeonpea

B01. Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance: Long duration pigeonpea

1. **Performance of breeding lines under AICRP:** IPA 15-21 (2521 kg/ha) showed 16.16% yield superiority over check IPA 203 and promoted to AVT-2. Similarly, entry IPA 19-26 (2631 kg/ha) registered 11.56% yield superiority over check IPA 203 and promoted to AVT-1. Four entries, IPAL 20-1, IPAL 20-5, IPAL 20-11, IPAL 20-24 were nominated for IVT for NWPZ.

2. **Evaluation of promising lines in station trials and PYT:** Total 26 entries with checks were evaluated as station trial and IPA 20-11 (4217 kg/ha) was found top yielder followed by IPA 20-5 (4094 kg/ha), IPA 20-1 (3967 kg/ha) and checks IPA 203 (3750 kg/ha), Bahar (2983 kg/ha), NDA 1 (2817 kg/ha) registering with of 12.4%, 41.3% & 49.9% yield superiority over check, IPA 203, Bahar & NDA 1, respectively. Similarly, 27 entries were evaluated as PYT and entry IPA 20-24 (4450 kg/ha) was found top yielder registered with 38.9%, 74.7% & 85.3% yield superiority against IPA 203 (3750 kg/ha), Bahar (2983 kg/ha), NDA 1 (2817 kg/ha), respectively.

3. **Generation advancement:** F_1 populations derived from 13 crosses were advanced to F_2 and SPS were harvested. Total 3944 SPS including 10 $\mathbf{F_2}$: 290 SPS, 13 $\mathbf{F_3}$: 405 SPS, 23 $\mathbf{F_4}$: 500 SPS, 49 $\mathbf{F_5}$: 2500 SPS, 9 $\mathbf{F_6}$: 200 SPS, 7 $\mathbf{F_7}$: 49 SPS were harvested separately during *Rabi* 2020-21.

4. **Evaluation of high selfing advanced generation for complete selfing and yield triats:** Characterized a set of 14 advanced cliestogamous breeding lines (IPAcliesto 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,14) and their male and female parents' *viz.*, IPA 203 & ICPL 87154, respectively along with check IPA 206 & IPAV 16-1 for extent of out crossing and yield attributes during *Kharif* 2021. Current study is the validation of identified aforementioned advanced indeterminate long duration breeding lines which were identified in 2018-19 and 2019-20.



Fig 1: Female (IPA 203) and male (ICPL 87154) parents and their derived indeterminate high selfing advanced generation long duration breeding lines along with flower photos

The study revealed that all the breeding lines were indeterminate in growth habit and having the plant height range from 158-218 cm with the mean of 19 primary branches/plants. The genotype ICPL 87154 had 13 flower/cluster whereas; line IPAcliesto 1 had 10 flowers/cluster. IPAcliesto 14 recorded the longest flower bearing raceme of 29.33 cm. The absolute selfing was recorded in 9 lines, IPAcliesto 3, 5, 6, 7, 8, 10, 12, 13, 14 lines and these lines having good yield attributing and high selfing trait holds immense scope to breeders during the course of varietal development

5 **Identification of a low chlorophyll content long duration pigeonpea genotype:** Identified a long duration breeding line IPAL 21-15 with low chlorophyll content (SPAD) reading of 4th fully developed leaf was 34.66 in leaf as compared to high chlorophyll accumulation breeding line IPAL 21-33. The recorded SPAD reading for IPAL 21.33 was 65.56. The chlorophyll present in the plant is closely related to the nitrogen status of the plant as can be seen from the photos given here under.

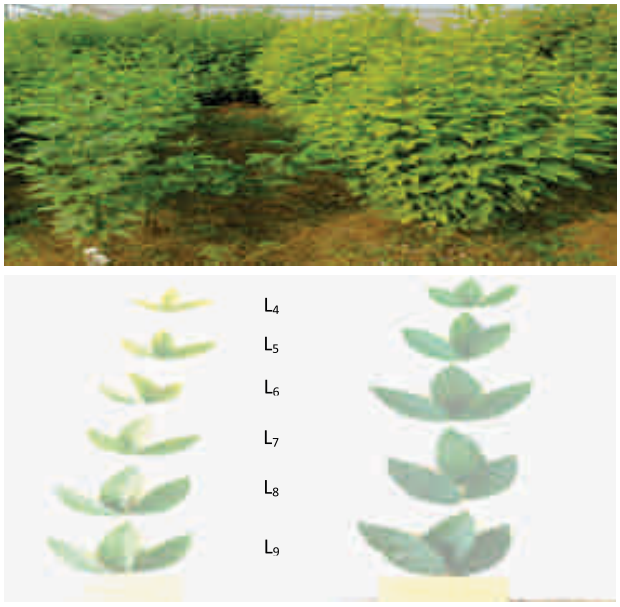


Fig 2: Low (IPAL21-15) and high (IPAL21-33) chlorophyll genotypes (left) and leaf arrangement from L4 to L9 from the single branch (right)

6. **Maintenance breeding:** A total of 490 kg nucleus seed was produced during *khairf* 2020 for varieties namely IPA 203 (250 kg) and IPA 206 (240 kg).

B02. Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance: short duration pigoenpea

1. **Performance of breeding lines in AICRP trials:** IPAE 15-08 is a unique early maturing genotype resistant to PSB for two consecutive years in sick plot, outperformed best check of CZ & SZ, promoted to AVT-I for CZ & SZ. IPAE 15-05 outperformed best check of CZ promoted to AVT-I for CZ. IPAE 15-07, IPAE 19-04, IPAE 20-3, IPAE 20-11 were included in IVT.

2. **Evaluation of promising lines in station trials:** Total 34 entries were conducted as station trial-1, 2 & 3, respectively at Kanpur. Entries IPAE 19-04, IPAE 19-23, IPAE 19-16, IPAE 19-15, IPAE 20-1 & IPAE 20-10 were shown 25% yield advantage over the best check of respective trials. The maturity ranged from 130-160 days and 100 seed weight from 8.3-10.2 g were recorded. An extra early maturing genotype IPAE 19-23 was found top yielder over the best check at IIPR-RRS, Bikaner. Similarly, extra early maturing lines, IPAE 15-05 and IPAE 15-06 were outperformed the best check with registered with >60% yield superiority over the best check at IIPR-RRS, Bhopal.

3. **Generation of breeding material:** Five crosses (IPAE 19-19/IPAE 19-21, IPAE 19-19/ICPL 20333, IPAE 15-6/IPAE 19-21, AK 250189/PA 163, AK 250204/PA 163) were generated. F_2 seeds were obtained from 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/Manakcrosses. SPS from F_2 derived from ICPL 11298/ICP 6992, ICPL 11298/ICP 7130, ICPL 11285/ICP 14459, ICPL 11285/ICP 7148, ICPL 11279/ICP 13193, ICPL 11279/ICP 14440, ICPL 11301/ICP 10908 ICPL 20325/ICP 13193, ICPL 11301/ICP 10905, ICPL 20325/ICP 709 crosses and F_3 seeds were obtained. Selection from AL 15/ICPL 84023, AL 15/D 20, AL 15/DSLR 129, AL 15/CORG 9701, Prabhat/ICPL 91045, Prabhat/ICPL 84023, Prabhat/UPAS 120, AL 201/ICPL 84023, ICPL 88039/CORG 9701, CORG 9701/ICPL 88039, CORG 9701/AL 15, ICPL 88039/AL 201, ICPL 88039/AL 15, UPAS 120/AL 15, Manak/AL 15, CORG 9701/Prabhat, AL 201/D 20, Manak/CORG 9701, Manak/ICPL 88039, UPAS 120/ICPL 84023, NA1/(NA1/ICPL 20338) cosses have been advanced. SPS were made from F_5 derived 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, NA1//(NA 1/ICPL 20338) were advanced. F_6

progenies from CORG 9701/Pusa 992, CORG 9701/ICPL 88039, CORG 9701/AL 201, UPAS 120/Pusa 992, Pusa 2002-2/UPAS 120, Pusa 2002-2/MN 5, Pusa 2002-2/ICPL 88039, MN 5/AL 201, MN 5/UPAS 120, MN 5/Pusa 992, ICPL 88039/Pusa 992, AL 201/ICPL 88039, AL 201/UPAS 120, Pusa 992/ICPL 87154, ICPL 7124/Pusa 992 Prabhat/ICPL 87154, AL 201/Pusa 992 crosses were selected to constitute F_7. (Progeny selections were made from 8 crosses (ICPL 87154/ICPL 88039, ICPL 88039/UPAS 120, ICPL 20335/ICPL 87154, 67 B/UPAS 120, ICPL 87154/Pusa 992, ICPL 20330/Pusa 992, CORG 9701/Pusa 992, Pusa 992/CORG 9701) derived from fixed lines).

4. **Maintenance breeding:** Nucleus seed of IPA 15-06 was produced for breeder seed production. Sufficient quantity of genetically pure seed of entries in station trial and AICRP trials were produced. The elite patents of extra early and early genotypes were maintained through selfing.

B03. Harnessing CMS-based hybrid technology for yield stability and stress tolerance in pigeonpea

1. **Evaluation of hybrids in station and multi-location trials:** Total 5 pigeonpea hybrids and checks were evaluated during 2020-21. The hybrid IPH19-05 (2122 kg/ha) was found top yielder followed by check, PAU 881 (1758 kg/ha), Pusa 992 (1360 kg/ha). The seed size of IPH 19-05 (10.44 g/100 seed wt.) is higher than IPH 15-03 (8.84 g/100 seed wt) and matures in 155 days.

2. **Development of CMS lines:** The first set of conversion has reached BC_7 $F_1$with parents (AL 15, ICP 7148, AL 201, Pusa 2002-2, MN5) and other set of CMS conversion has reached $BC_5F_1$with parents (ICP 88034, ICP 20338, ICP 11255, ICP 20340, PAU 881). CMS was introduced into several desirable lines through recurrent backcrossing in BC_4F_1 with parents (ICPL 11244, ICPL 11301, ICPL 11326, ICPL 20325, ICPL 20326, ICPL 20327, ICPL 20329). Seven crosses [(GT 288A/ICPL 11244)//ICPL 11244,(GT 288^a/ICPL 11301)//ICPL 11301,(GT 288^a/ICPL 11326)//ICPL 11326, (GT 288^a/ICPL 20325)//ICPL 20325,(GT 288^a/ICPL 20326)//ICPL 20326,(GT 288^a/ICPL 20327)//ICPL 20327,(GT 288^a/ICPL 20329)//ICPL 20329)] made for conversion in extra-early background.

3. **Maintenance of A, B and R lines:** Thirty cytoplasmic male sterile lines (A lines) and their corresponding maintainer (B lines) were maintained through controlled pollination under netting. In addition, 80 restorer (R) lines are also being maintained through controlled selfing under net.

C. Genetic enhancement in lentil

1. **Variety Developed:** The lentil variety IPL230 has been released for cultivation in Uttar Pradesh. It has been developed through hybridization (IPL 522/DPL 62). It has yield superiority of 19.5% over the check KLS 218 in UP under normal sown conditions with mean yield 1320 kg/ha. This is early maturing variety (110-115 days maturity) with small seed size (2.4g/100 seed weight) and red cotyledons. This variety has resistance to rust and tolerance to wilt diseases.

2. **Performance of breeding lines in AICRP trials**: Eight entries, IPL 241, IPL 242 IPL 347 (small seeded), IPL 348, IPL 542, IPL 605 (large seeded), IPL 606, IPL 543 (rice fallow) were evaluated in regular trial, while 12 entries IPL 801, IPL 802, IPLB 703 (drought), IPL 803, IPL 804, IPLB 704 (heat), IPL 805, IPL 806, IPLB 705 (salinity), IPL 807, IPL 808, IPLB 706 (acidity) were evaluated in special trial under AICRP during 2020-21. Six entries (IPL 242-small seeded (NEPZ), IPL 801 (D)-large seeded (NWPZ, CZ), IPL 808 (A)-large seeded (NHZ), IPL 542-large seeded (NHZ), IPLB 702-large seeded (NHZ), IPL 347-large seeded (NHZ) were promoted to AVT-1. Eight entries, IPL 243, IPL 244 (small seeded), IPL 349, IPL 350, IPLRS 703, IPLRS 704 (large seeded), IPL 607, IPL 608 (rice fallow) have been submitted for evaluation in IVT AICRP during 2021-22.

3. **Performance of entries in UP State Trials (SAT):** Total 16 entries were evaluated in UPSAT. Among these, one small seeded (IPLS 238), four large seeded (IPL341, IPL342, IPL343& IPL344) and two late sown (IPL540 & IPL538) entries have been promoted to SAT-1. Two small seeded genotypes IPLS233 & IPLS234 performed well and recommended for release in Uttar Pradesh. In addition, six new entries have also been submitted for evaluating during *Rabi* season 2021-22.

4. **Evaluation of promising breeding lines:** Two station trials (ST) with 15 entries each and one PYT (60 entries) were sown during 2020-21. In *ST-I,* eight entries (IPL 1936201, IPL 181591,

IPL 14977, IPL 131225, IPL 1946104, IPL 191520, IPL 141563, IPL 11718) produced yield ranging from 1434 to1681 kg/ha were found promising over check IPL 534 (1422 kg/ha). IPL 181591 showed early flowering (57 days) with early maturity (115 days), while IPL 141563 had high harvest index (0.39). In *ST-II*, 7 small seeded entries IPL 141570, IPL 131053, IPL 11671, IPL 171392, IPL 10834, IPL 141550, IPL 191498 were found promising with mean yield ranging from 1306 to 1442 kg/ha over check IPL 220 (1300 kg/ha). In *PYT*, 18 entries (IPL 19-35, IPL 19-02, IPL 19-258, IPL 19-139, IPL 19-131, IPL 19-22, IPL 19-132, IPL 19-256, IPL 19-50, IPL 19-171, IPL 19-25, IPL 19-181, IPL 19-105, IPL 19-76, IPL 19-57, IPL 19-74, IPL 19-45, IPL 19-83) were found promising over check IPL 220 with mean yield range from 1714 to 1984 kg/ha. Six entries (IPL 171398, IPL 19-04, IPL 19-131, IPL 11718, IPL 19-03, IPL 141159) were found promising at RS Bhopal. These large seeded entries (>3.0 g/100 seeds) had maturity 112 to 116 days.

5. **Generation of breeding material:** Twenty Six crosses, IPL 315//(IPL 98/193), IPL 220//(IPL 98/193), IG 54/IPL 329, IPL 230/IPL 406, IPL 230/IPL 62, IG 54/IPL 321, IPL 315/IG 4258, IPL 316/IG 4258, IPL 316/IG 54//IPL 316/DPL 58, IPL 316//IPL 98/193, IPL 316/IPLPBR-1, IPL 316/PL 7//IPL 316/IG 54, IPL 316/SLLOPFL, IPL 329/DPL 62, IPL 329/IPL 406, IPL 329//IPL 98/193, IPL 329/IG 4258, IPL 329/IPLPBR-1, IPL 406/IG 4258, IPL 406//IPL 98/193, IPL 406/IPLPBR-1, IPL 406/SLLOPFL, IPL 406/MH 36119, IPL 220/IG 4258, IPL 220/IPLPBR-1, L 9-12/IPLPBR-1 were made for wilt resistance, drought/heat tolerance, seed size, lodging tolerance. F_1 seed from 31 crosses and multi-parents (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/PL 7, IPL 316/IPL 321, IPL 316/DPL 58, IPL 220/SLLOPFL, IPL 316/ILL 1114, ICARDA 1946133/IPL 406, IPL 316/ILL 1203, [(IPL 539/IPL 534)//(IPL 321/IPL 220)], IPL 406/LIENMH 36119, LIENMH 36119/IPL 406, [(IPL 316/IPL 534)//(IPL 316/L 4710], [(IP 225/IPL 220)//(IPL 534/IPL 321)], [(IPL 534/IPL 321)//(IPL 225/IPL 220)], [(IPL 321/IPL 220)//(IPL 539/IPL 534)], [(IPL 316/IG 136607)//IPL 534/L 4710], [(IPL 316/L 4710)//(IPL 316/IPL 534)], [(IPL 11702/IPL 10820)//(IPL 316/IPL 10820)], [(IPL 11702/IPL 10820)//(IPL 316/IPL 10820)]. Total 296F_1 plants were evaluated. Total 1234 SPS from 25 F_2 (596 SPS+ 1 LB), 27F_3 (261 SPS), 9F_4 (119 SPS) and 21 F_5 (258 SPS) were harvested. Total 259 line bulks from 21 F_6 were harvested and these lines were advanced.

6. **Development of mapping population:** Trait specific AB QTL mapping population with >500 BC_2F_4 plants for yield traits (ILWL 118/IPL 220) has been advanced to F_5 for developing NILs. A RIL population for root traits (IPL 98/193/EC 208362) with 200 RIL has also been maintained.

7. **Nucleus seed production:** Total 614 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, IPL 329) were produced and 7800 SPS of above varieties were selected for next year nucleus seed production.

8. **Validation of genes expressed under heat stress in lentil:** RNAseq analysis between IG 4258 (heat tolerant) and IG 3973 (heat sensitive) lentil lines at reproductive stage under both normal and heat conditions was done. It resulted in 2,09,549 assembled transcripts and among these 1,61,809 transcripts had coding regions of 94,437 transcripts were annotated. The differential gene expression analysis showed upregulation of 678 transcripts and downregulation of 680 transcripts between tolerant and susceptible lines at early, While 76 transcripts were upregulated and 47 transcripts were downregulated at late

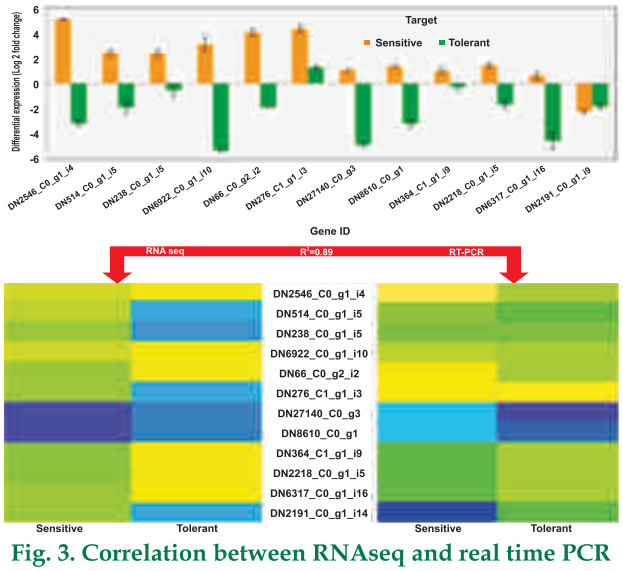


Fig. 3. Correlation between RNAseq and real time PCR

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

9. **Phenotyping for drought tolerance:** A mapping population comprising 200 RILs derived from cross (IPL 98/193//EC 208362) for root traits were evaluated for agro-physiological traits under drought conditions in dug-out pots and a range of variability has been observed among these RILs for studied traits, which is given in following table.

	Characters								
	NDVI (F)	NDVI (P)	NBI (P)	Chl (P)	Flav (P)	Anth (P)	Yield (kg/ha)	100-SW (g)	Maturity
Range	0.2-0.5	0.4-0.6	10.1-58.2	10.2-73.4	0.9-1.5	0.0-0.4	32-1284	1.7-3.4	96-131
Mean	0.3	0.5	24.6	30.2	1.2	0.1	619.5	2.5	107

Note: F= Flowering stage; P= Podding stage

D. Urdbean

D01. Genetic enhancement in Urdbean

1. **Variety developed:** Urdbean variety IPU 17-1 has been developed from PGRU 95027/DPU 88-31 cross and released/notified for cultivation in Madhya Pradesh. It has been tested in different agro-climatic regions of MP with check KU 96-3 and showed 13.1% yield superiority over check. It is an early maturing (73 days) with attractive black seed colour, medium large seeds (3.35 g/100 seed wt.) with high seed protein content (24%). It is also highly resistant to MYMV and resistant to ULCV, LCV, Web Blight, BLB, Powdery Mildew and CLS diseases. It is resistant to white fly, pod borer and pod bug insects under field conditions. It is moderately resistant to root knot nematodes, *Meloidogyne javanica* and *Meloidogyne incognita*

2. **Hybridization and generation advancement:** Twenty four crosses (IPU 12-05/IPU 13-1, IPU 17-1/IPU 13-1, Shekhar-3/IPU 94-1, KU 96-3/IPU 17-1, IPU 19-27/IPU 17-1, ADT 3/IPU 94-1, NUL 7/Uttara, MASH 114/IPU 17-1, LBG 752/IPU 94-1, TU 94-2/IPU 10-30, KU 96-3/IPU 13-1, IPU 13-1/IPU 17-1, IPU 02-43/IPU 13-1, PU 31/LBG-752, IPU 94-1/IPU 13-1, IPU 02-43/IPU 17-1, IPU 02-43/Shekhar-3, IPU 02-43/KU 96-3, Uttara/IPU 17-1, Uttara/IPU 19-27, (BDU-1/*V sylvestris*)/Uttara, (BM 4/BWM 29)//Uttara, (BM 4/BWM 29)//IPU 02-43, IPU 02-43/PM 6) were made with diverse lines and harvested. F_1's of 31 crosses were harvested during *Kharif* 2021. Twenty advanced breeding lines, and segregating generation (F_2-F_6) were advanced as following:

Generation	Families	Crosses	SPS made
F6	20	20	20 bulks
F5	40	40	140+19 bulks
F4	209	21	200+ 178 bulks
F3	-	12	150+12 bulks
F2	-	10	10 bulks

3. **Preliminary Yield Trial (PYT):** A set of 67 urdbean entries were tested under preliminary yield trial where yield of two rows of four-meter lengths ranged from 120 gm to 310 gm. The high performing entries will be promoted to station trials in the next *Kharif* season.

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

1. **Generation of breeding materials and generation advancement:** Total 35 including 20 for photo-thermo insensitivity (IPU 11-02/PKGU 03, IPU 11-02/IPU 99-247, IPU 11-02/IPU 99-189, IPU 11-02/IPU 99-123, IPU 11-02/IPU 99-213, IPU 11-02/UH 8515, IPU 11-02/IPU 99-79, IPU 10-26/IPU 99-79, IPU 10-

26/LBG 787, IPU 10-26/IPU 99-247, IPU 10-26/PKGU 03, IPU 10-26/UH 8515, IPU 13-01/PKGU 03, IPU 13-01/IPU 99-79, IPU 13-01/IPU 99-213, PDU 1/IPU 99-79, PDU 1/LBG 787, PU 19/LBG 787, PU 19/IPU 99-79, PU 19/PKGU 03) and 15 crosses for heat & drought (IPU 11-02/IPU 99-189, IPU 11-02/LBG 20, IPU 11-02/PGRU 95016, IPU 11-02/IPU 94-2, PDU 1/PGRU 95016, PDU 1/LBG 20, PDU 1/STY 2289, IPU 10-26/VBG 04-008, IPU 10-26/STY 2289, IPU 13-01/STY 2289, IPU 13-01/UH 855, IPU 13-01/VBN 04-008, IPU 13-01/PGRU 95016, IPU 13-01/LBG 20 & IPU 13-01/IPU 99-189) were attempted to develop of genetically improved breeding lines for new niches of different agro-ecological conditions during *Kharif* 2021.

2. **Evaluation of segregating generations for abiotic stresses:** The segregating generations (F_1 & F_2) were advanced during *kharif* 2021 at IIPR Kanpur. Total 43 F_1 being raised at IIPR, Kanpur during *kharif* 2021 for generation advancement to F_2. Total 36 F_2 are advanced to F_3, while 24 F_3 progenies are advanced to F_4 during *kharif* 2021. A total of 523 and 320 SPS were taken from F_3 and F_4 segregating generations, respectively. All segregating generations were advanced through SPS. The breeding lines and segregating generation (F_1–F_5) were advanced as following;

Generation	Crosses	SPS made
F_5	31	465 + 31 bulks
F_4	28	523 + 28 bulks
F_3	31	320 + 28 bulks
F_2	36	36 bulks
F_1	43	43 bulks
G_3	09 Multiline cross	53 SPS + 9 bulks

E. Mungbean

E01. Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance in Mungbean

1. **Registration of unique germplasm:**

1.1. **IPM 604-1-7 (IINGR 21104):** The genotype IPM 604-1-7 is a unique line derived from IPM 99-125/Sona Mung cross and registered for golden yellow seed coat. Besides, this genotype also performed significantly better than the best check in PYT and station trials, also nominated for evaluation under AICRP during 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.

1.2. ***V glabrescens* (IC 251372/INGR 21143) & *V umbellata* (IC 251442/INGR 21226):** Two lines, one each of *V. glabrescens* (IC 251372/INGR 21143) & *V. umbellata* (IC 251442/INGR 21226) were registered as a unique germplasms for photo- and thermo-period insensitivity. Both lines were observed to have normal flower and pod set at temperatures as high as 42.4°C during summer and as low as 6°C during *Rabi* over the years while pollen viability studies also supported the results. >70% viable pollen and normal pollen tube formation were observed at both extremes of temperatures. Both, *V. glabrescens* & *V. umbellata* have semi-erect growth habit, indeterminate growth pattern and dark green leaves. *V. glabrescens* has yellow flowers, long & constricted pods with dark green, mottled, drum shaped seeds. *V. umbellata* has light yellow flowers, smooth, curved and semi flat pods, shiny, beige, oval and large seeds. Both genotypes also exhibited resistant to major diseases including MYMV, powdery mildew and can be utilized to develop photo-thermo insensitive lines in *Vigna* crops including mungbean and urdbean



Fig. 4: Unique germplasm registered with NBPGR: IPM604-1-2 (top), *V. glabrescens* (IC 251372) (bottom left) and *V. umbellata* (IC 251442) (bottom right)

2. **Performance of breeding lines in AICRP/Adaptive trials**: Fifteen mungbean genotypes were evaluated under AICRP (MULLaRP) during 2021. Genotype IPM 1604-1 was promoted to AVT-1 in Central Zone during *Kharif* 2021 with a yield superiority of 16.28% over the best check. The genotype IPM 20-1 was promoted to AVT-1 in NEPZ & CZ with yield superiority of 8.90 and 6.84% over

the best checks in respective zones. Another genotype IPM 20-2 was promoted to AVT-1 (NEPZ, NHZ) with a yield superiority of 15.38 and 20.63%, respectively.

The genotypes IPM 1603-1 & IPM 1610-1 were promoted to AVT-I (NHZ) with yield superiority of 25.38 & 5.02% over the best check IPM 99-125 during spring 2021. Another genotype IPM 604-16 was retained in AVT-I (NWPZ). Two genotypes (IPM 1603-1 & IPM 1610-1) were promoted to AVT-I (NWPZ) during summer 2021. Both genotypes recorded a yield superiority of 15.15 & 5.13% over best check, Virat. Entry IPM 1103-1 & IPM 1610-1 were promoted to AVT-1 (NEPZ) recording a yield superiority of 7.40 and 5.29 %, respectively over the best check.

Ten new genotypes were also entered in AICRP trials for their multilocation evaluation in different seasons. These included three genotypes viz., IPM 1205-2, IPM 1704-14 and IPMD 1202-1 for evaluation during Spring and Summer season. Likewise, the genotypes IPM 1603-3, IPM 13-6 and IPMD 1603-7 were entered for their multilocation evaluation during *kharif* season.

Table 1: Multilocation evaluation of superior fixed lines of mungbean in AICRP trials

SL	Entry	Pedigree	Stage/Season	Zone/State	% Superioty
1.	IPM 1604-1	PDM139/EC369223	AVT-I, *Kharif*	CZ	16.24
2.	IIPM 20-2	NM 94/ML 1628	AVT-I, *Kharif* AVT-I, Spring	NEPZ, NHZ, NEPZ	15.38, 20.36 20.49
3.	IIPM 20-1	NM 94/ML 1628	AVT-I, *Kharif*	NEPZ, CZ	8.90, 6.84
4.	IPM 604-16	Sona Mung/IPM 99-125	AVT-I, Spring	NEPZ	11.15
5.	IPM 1603-3	MH 3-18/EC 369223	IVT *Kharif/Rabi*	All Zones	
6.	IPM 13-6	IPM 6-5/IPM 409-4	IVT *Kharif/Rabi*	All Zones	
7.	IPMD1603-7	MH 3-18/EC 369223	IVT Kharif/*Rabi*	All Zones	
8.	IPM 1103-1	IPM 06-5/IPM 409-4	IVT Spring/Summer/Rice Fallow	All Zones	
9.	IPM 1610-1	EC 391178/IPM 99-125	IVT Spring/Summer/Rice Fallow	All Zones	
10.	IPM 1603-1	MH 3-18/EC 369223	IVT Spring/Summer/Rice Fallow	All Zones	
11.	IPMD 1604	IPM 2-23/DMG 1045	IVT Spring/Summer	All Zones	
12.	IPMD 101-2	IPM 99-125//(IPM 03-1/SPS5)	IVT Spring/Summer	All Zones	
13.	IPMD 14-6	IPM 99-125/Co 5	IVT *Kharif*	Karnataka	
14.	IPMD 14-10	PDM 139/ML 729	*Kharif*	Karnataka	

3. **National crossing programme:** Seven promising genotypes *viz.,* IPM 409-4 (extra early + synchronous maturity), IPM 410-3 (more cluster/plant + pod nos. + YMV), EC 398889 (heat/drought tolerance), IC 2527442 *(V umbellata*) (photo-thermo insensitivity), RBL 50 (*V. umbellata*, long pod, YMD resistance), IC 277021-IIPR *(V. sylvestris)* (YMD resistance, pod nos /plant) and IPM 512-1 (pod nos./plant, plant type) were included in National Crossing Programme during *kharif* across the country to generate fresh breeding materials.

4. **Evaluation of elite breeding lines:** During 2021, two demonstrations, six station trials (ST) and three PYTs were conducted at IIPR, Kanpur during spring, summer and *kharif*. During spring, 2 ST with 28 entries each with five checks were conducted. In *ST-1*, ten genotypes were found to be either better or at par with best check IPM 02-3 (1344 kg/ha), these included IPM 604-1-6 (1411 kg/ha), IPM 9901-6-1 (1528 kg/ha), IPM1603-7 (1377 kg/ha), IPM 312-18 (1370 kg/ha), IPM 409-4 (1320 kg/ha), IPM 302-2 (1336 kg/ha) IPM 9-43K/IPM 02-3 (1511 kg/ha), IPM 312-18 (1518 kg/ha) and IPM 02-3/SPS 5 (1553 kg/ha). In *ST II*, six genotypes were observed to be better or at par with the best check, IPM 410-3 (1545 kg/ha), these included IPM 1707-1 (1670 kg/ha), IPM 1703-1 (1711 kg/ha), IPM 1704-14 (1670.00 kg/ha), IPM 312-18 (1511.35 kg/ha), IPM 1732-1 (1578.15 kg/ha) and IPM 14-17-4 (1545 kg/ha).

During summer, two STs with 28 entries each with five checks were conducted. In *ST-1*, genotypes IPM 1604-1 (1528 kg/ha), IPM 1620-5 (1553 kg/ha), IPM 604-1-6 (1628

kg/ha), IPM 312-18-1 (1578 kg/ha), IPM 101-102-1 (1570 kg/ha), IPM 1604-3 (1528 kg/ha), IPM 1620-6 (1520 kg/ha), IPM 1205-2 (1687 kg/ha), IPM 1604-5 (1595), IPM 1202-1 (1611 kg/ha) and IPM 701-704 (1570 kg/ha) were better than the best check IPM 409-4 (1528 kg/ha). In *ST-2*, seven genotypes were observed to be either at par or superior to the best check, IPM 409-4 (1494 kg/ha). These included IPM 1718-3 (1787 kg/ha), IPM 1711-1 (1487 kg/ha), IPM 1732-2 (1495 kg/ha), IPM 03-1/SPS 5 (1444 kg/ha), Kanika (1486 kg/ha), Virat (1419 kg/ha) and IPM 312-18 (1461 kg/ha).

During *Kharif*, three STs were conducted with 18 genotypes with four checks each. The yield was affected to some extent in station trials due to terminal rains. Nevertheless, it was observed that in *ST-1*, three genotypes, IPM 312-18 (1008 kg/ha), IPM 1718-3 (1146 kg/ha) and IPM 312-18-1 (891.6 kg/h) were either at a par or better than the best check IPM 410-3 (904 kg/ha). In *ST-2*, six genotypes including IPM 1604-1 (945 kg/ha), IPM 312-18 (787 kg/ha), IPM 101-102-1 (791 kg/ha), IPM 1604-3 (817 kg/ha), IPM 1620-6 (942 kg/ha) and IPM 1604-1 (904 kg/ha) were better than best check IPM 410-3 (766 kg/ha). In *ST-3*, six genotypes viz., IPM 1704-14 (1000 kg/ha), IPM 1722-1 (1288 kg/ha), IPM 701-704 (1033 kg/ha), IPM 312-18 (912 kg/ha), IPM 6-5/IPM 409-4 (971 kg/ha) and IPM 1707-1 (976 kg/ha) were either better than or at par with the best check variety IPM 512-1 (996 kg/ha). Two PYTs were also conducted during *kharif* 2021 with 36 entries including four checks each. In ***PYT-1***, genotypes IPM 21-13-7 (1206 kg/ha), IPM 21-15-1 (1310 kg/ha), IPM 21-15-2 (1456 kg/ha), IPM 21-15-5 (1456 kg/ha), IPM 21-15-7 (1726 kg/ha), IPM 21-20-3 (1206 kg/ha), PDM 139/DGG5 (1186 kg/ha), PDM 139/TMB 37 (1418 kg/ha), IPM 21-22-11 (1186 kg/ha), IPM 21-23-1 (1248 kg/ha), IPM 21-23-5 (1227 kg/ha) and IPM 21-23-13 (1268 kg/ha) yielded better than the best check IPM 512-1 (1019 kg/ha). In *PYT-2*, three genotypes viz., IPM 1704-13 (2017 kg/ha), IPM 1718-2 (1560 kg/ha) and the derivative of cross MH 3-18/EC 369223 (1290 kg/ha) yielded better than the best check IPM 512-1 (1268 kg/ha).

5. **Generation and advancement of breeding materials**: During *kharif* 2021, 30 intra-and inter-specific crosses were generated using 10 mungbean cultivars (IPM 410-3, IPM 02-3, IPM 409-4, IPM 2-14, IPM 2K14-9, IPM 302-2, IPM 99-125, PDM 139 & IPM 205-7) as recipient and nine donor lines (ML1808, SPS 5, CoGG 8, LGG 460, ML 1808, PDM 54, Co 6, ML 2479 and MH 421). Besides this, eight multi-parent crosses were developed for several traits including yellow mosaic disease resistance, yield related traits, early maturity and bruchid resistance.

6. **Advancement of breeding materials:** The breeding materials in different segregating generations were advanced. Total 642 superior SPSs were isolated from different generations in 89 inter- and intra-specific crosses. These included F_2 (66SPS), F_3 (106 SPS), F_4 (170 SPS), F_5 (42 SPS), F_6 (28 SPS), F_7 (10 SPS) and 11 SPS in F_8 generation in mungbean x mungbean intra-specific crosses. Besides this, 68 outstanding lines were also bulked in different generations in mungbean x mungbean crosses. In the inter-specific crosses involving urdbean, *V. umbellata, V. unguiculata, V. glabrescens, V. sylvestris* as donors in mungbean background and total 267 SPSs were selected in different segregating generations including 41 SPS in F_3, 198 SPS in F_4 and 28SPS in F_5 generations. Besides, 22 outstanding single lines were bulked for their evaluation in preliminary yield trials. Eleven superior bulks were also isolated for sharing with NARS partners.

7. **Maintenance breeding:** Total 750 kg nucleus seed of nine mungbean varieties developed by IIPR was produced. This included 150 kg seed in Soorya (IPM 512-1), 172kg. in Virat (IPM 205-7), 78 kg in IPM 02-3, 130 kg in Shikha (IPM 410-3), 105 kg in IPM 2-14, 45 kg in Kanika (IPM 302-2), 25 kg in Versha (IPM 2K14-9), 82 kg in Heera (IPM 409-4) and 24 kg in Heera (Vasudha (IPM 312-20). Besides the above, >3500 single plant selections of the above nine varieties were also taken during *kharif* 2021 for growing single plant progeny rows for nucleus seed production.

8. **Genetic diversity and population genetic structure analysis of wild and cultivated *Vigna* accessions**

An experiment was undertaken with 119 lines including 99 wild *Vigna*lines belonging to 19 different species and 18 cultivated genotypes of *Vigna* and 2 of *Phaseolus*. 102 polymorphic SSRs were deployed to characterize the material at molecular level which produced

1758 alleles. The genotypes under study were grouped into four major clusters which further sub-divided in 9 sub-clusters. Interestingly, all cultivated species shared a single cluster while no such similarities were observed for wild accessions as these were distributed in different groups of sub-clusters. The co-dominant allelic data of 114 accessions were then utilized for obtaining status of lines and their hybrid forms. The model-based population structure analysis categorized 114 lines of *Vigna* into six genetically distinct sub-populations (K = 6) following admixture-model based simulation with varying levels of admixture. 91 (79.82%) lines resembled their hierarchy and 23 (20.18%) lines were observed as the admixture forms. Maximum number of lines (25) were grouped in sub-population (SP) 6 and the least accessions were grouped in SP3 & SP5 (11 each).

9. **Genome wide association mapping for agronomic traits in wild and cultivated *Vigna***

This study was conducted with an objective to detect the genomic regions associated with various yield attributing traits by genome-wide association mapping. A diverse panel of 98 wild and cultivated *Vigna* accessions (acc.) belonging to 13 different species was evaluated for yield and related traits. Simultaneously, the panel was genotyped using 92 cross genera and cross species simple sequence repeat (SSR) polymorphic markers to study population genetic structure and work out the useful market-trait associations. The principal component analysis and trait correlation established relationships amongst the traits during both the seasons while 100-seed weight (HSW) had positive correlation with pod length (PL), days to first flowering (DFF) and days to maturity (DM). The population genetic structure analysis grouped different acc. into three genetically distinct sub-populations with SP-1 comprising 34 acc., SP-2 (24 acc.), SP-3 (33 acc.) and one admixture group (7 acc.). MLM analysis revealed association of 13 markers namely VR 018, VR 039, VR 022, CEDG 033, GMES 0337, MBSSR 008, CEDG 220, VM 27, CP 1225, CP 08695, CEDG 100, CEDG 008 & CEDG 096A with 9 traits. Furthermore, 7 of the above markers *viz*., VR 018 for plant height (PH) & terminal leaflet length (TLL), VR 022 for HSW & PL, CEDG 033 for DFF & days to maturity (DM), MBSSR 008 for DFF & DM, CP 1225 for chlorophyll content at 30 days (CC 30), DFF & DM, CEDG 100 for PH & TL and CEDG 096A for CC 30 and chlorophyll content at 45 days were pleiotropic in nature. The marker CEDG 100 associated with HSW, PH & TLL is co-localized in gene encoding histone-lysine N-methyltransferase *ATX 5*. Similarly, VR 22 associated with PL & HSW is co-located in gene encoding *SHOOT GRAVITROPISM 5* in mungbean. These associations may be highly useful for marker-assisted genetic improvement of mungbean and other related *Vigna* species.

E02. Breeding for high yield, wider adaptability, multiple stress resistance and quality in pulses-Mungbean (Drought & Heat)

1. **Screening of mungbean genotypes for drought stress under rainout shelter condition:** A set of 34 mungbean genotypes were evaluated by using drought sensitive (ML 5 & IPM 99-125) and drought tolerant checks (IPM 2-14/IPM 2-3) under rainout shelter condition during *Kharif* 2020. The experiment was done at 3 levels of treatment: no stress, stress at vegetative stage (25 DAS) and stress at reproductive stage (35 DAS) by withdrawal of irrigation for 15 days. The observation was recorded on soil moisture status of agronomic and physiological traits at various stages. Based on two year pooled mean value and comparative studies of four genotypes, IPM 06-5, MH 421, BIG 0068-1, MH 03-18 showed higher value of photosynthetic efficiency, photosynthetic electron transport (ETR), SPAD, relative leaf water content, 100-seed wt. (>4.5 g) with enhanced seed yield. In addition, these genotypes maintained high RWC produced higher seed yield under drought stress condition. Hence, these genotypes will be used as a potential source for development of drought tolerant varieties in mungbean breeding.

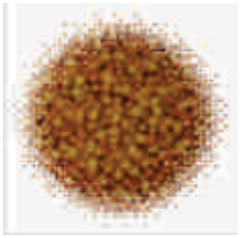
2. **Breeding material:** Total 6 F_4 seggregating material, PM 5/EC 398889, HUM 12/EC 398889, SML 668/EC 426841, Pusa Vishal/EC 426841, HUM 12/PM 2 & SML 668/PM 2 adavanced during summer 2021 and made 11 fresh hybrids for heat & drought tolerance during *Kharif* 2020.

F. Fieldpea

F01. Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance in fieldpea

1. Variety developed:

IPFD 16-3: This elite genotype registered >10% yield superiority over the best check variety under state adaptive trials conducted during 2017-18 to 2019-20. It was found resistant to powdery mildew, rust and ascochyta blight disease. Hence, this variety has been released for entire UP state.

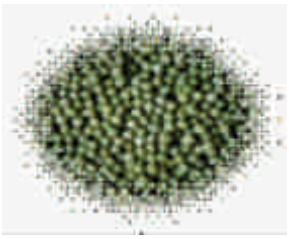



2. Genetic stock:

2.1 IPFD 18-14: The extra early fieldpea genotype has been developed from DDR 23/VRP 22 cross followed by pedigree method. This is dwarf and white seeded fieldpea genotype which flowered and matured in less than 36 days and 85 days, respectively. Therefore, this extra-early fieldpea genotype has been registered with ICAR-NBPGR, New Delhi.




2.2 IPFD 18-26: This extra early field pea genotype is derived from DDR 23/VRP 22 cross through pedigree breeding method. It is a dwarf and green seeded genotype which matures in less than 100 days. Hence, this extra early type field pea genotype has been recommended by Institute GGIC for registration with ICAR-NBPGR, New Delhi and proposal will be submitted soon



2.3 IPF 2014-13: This genotype is developed from EC 538005/IPFD 1-10 cross. Based on multi-location assessment for rust disease showed tolerant reaction and it has been recommended by Institute GGIC for registration with ICAR-NBPGR, New Delhi and proposal has been submitted.

2.4 IPF 2014-16: This genotype is derived from IPF 99-25/Arkel cross. Based on multi-location assessment for rust disease, genotypes found tolerant to rust disease. It has been recommended by Institute GGIC for registration with ICAR-NBPGR, New Delhi and proposal has been submitted.

3. Generation of breeding material: Total 30 crosses [(IPF 5-19/DDR 17, HFP 9907B/IPFD 12-2, IPFD 12-8/EC 384275, IPF 13-14/P 1075, IPFD 12-8/EC 502159, IPFD 13-2/EC 502159, HFP 8909/EC 534807, IPFD 9-2/P 1046, IPF 99-25/EC 324113, IPF 99-25/EC 894778, KPMR 522/IPFD 10-12, IPFD 1-10/EC 398597, IPFD 9-2/EC 56770, IPF 99-25/P 1062, PP 42/EC 502159, HFP 529/DDR 13, HFP 529/IPFD 13-2, HFP 529/IPF 16-13, IPF 99-25/EC 598644, HUDP 15/IPFD 18-14, IPFD 99-13/P 637, (IPFD 18-14/IPF 16-13)//IPF 5-19, IPFD 12-2/EC-564816, IPFD 6-3/EC 564814, IPF 5-19/IPFD 18-14, IPFD 10-12/IC 0220286, IPFD 12-2/EC 328778, IPFD 6-3/EC-328778, IPFD 6-3/EC 414479, IPFD 6-3/EC 414486)] were made during 2020-21 with trait specific donors. In addition, crosses also were made to develop MAGIC population and genetics of various traits were worked out. Similarly, during 2021-22 crosses will be made with specific donors.

4. Evaluation of advance breeding lines: In station trial (Dwarf), 10 lines were evaluated and entry IPFD 2021-7 (4278 kg/ha) and IPFD 2021-5 (4378 kg/ha) were performed better than check IPFD 12-2 (3875 kg/ha). In station trial (Tall), 12 lines were evaluated with check and entry IPF 2021-13 (2958 kg/ha), IPF 2021-21 (2847 kg/ha) & IPF 2021-16 (2875 kg/ha) were portrayed superiority over the best check IPF 16-13 (2701 kg/ha). In PYT (Tall), overall 37 lines were evaluated and 16 entries demonstrated yield superiority over check IPF 16-13. PYT (Dwarf), 30 entries were tested and 12 entries registered yield advantage over check IPFD 12-2. In PYT (extra early), 32 entries were tested and 21 entries portrayed yield superiority over check IPFD 99-13.

Sixteen lines in dwarf and tall categories of station trial are being evaluated during 2021-22. In PYT(dwarf, tall and extra early), total 32, 39, 35 genotypes, respectively are being evaluated with three checks.

5. **Selections of promising genotypes from segregating population:** Total 40 crosses were raised in F_1. SPS was done considering targeted traits (earliness, seed size, pod length, resistant to powdery mildew, rust and yield) in segregating generations. 40 F_2 (387 SPS), 38 F_3 (514 SPS), 62 F_4 (743 SPS), 43 F_5 (739 SPS), 25 F_6 (250 lines) and F_7 (40 lines) were selected. Similarly, total 49 F_1 including 4 crosses of MAGIC population are being raised during 2021-22. 40 F_2, 38 F_3, 32 F_4, 61 F_5 (743 lines), 43 F_6 (739 lines) and 40 F_7 generations have been planted for advancement.

6. **Development of mapping population:** $F_{8'S}$ harvested (310) derived from HFP 4(S) x FC1(R) for rust resistance has been harvested and single plant progeny has been raised for advancement.

7. **Nucleus seed production of released variety of fieldpea:** As per DAC indent, nucleus seed of fieldpea varieties,Adarsh (6 kg), Aman (127 kg), Vikas (8.5 kg), Prakash (12 kg), IPFD 10-12 (200 kg), IPF 4-9 (33 kg), IPFD 6-3 (92 kg), IPFD 11-5 (174 kg) and IPFD 12-2 (381 kg). IPFD 9-2 (217 kg), IPFD 2014-2 (99 kg), IPF 16-13 (197 kg), IPFD 12-8 (104 kg), IPFD 13-2 (127 kg) was produced during 2020-21.

8. **Promising entries in AICRP trials:** Total six entries IPF 20-11, IPF 20-21, IPF 20-17, IPFD 20-3, IPFD 20-9, IPFD 20-8, IPF 20-20 & IPFD 20-2 were evaluated in IVT (tall, dwarf &rice fallow) under AICRP during 2020-21. Two dwarf entries, IPFD 19-1 & IPFD 19-3 were evaluated AVT-1 in NEPZ. In addition, six dwarf entries IPFD 19-9, IPFD 18-2, IPFD 18-10, IPF 18-17, IPF 19-15 & IPF 18-14 were tested in UPSAT. Total 13 new entries IPF 21-13, IPF 21-16, IPF 21-21, IPFD 18-3, IPFD 21-5, IPFD 21-7 & IPFD 21-4 (dwarf/tall) were evaluated. Six new entries IPFD 21-2, IPFD 20-8 (AVT-1), IPFD 21-6, IPFD 21-10, IPF 21-14, IPF 21-17, IPF 21-20 evaluated in rice fallow.Five new entries IPF 19-18, IPF 19-11, IPF 20-20, IPFD 18-1 & IPFD 18-9 were submitted for testing in UPSAT. Total 10 entries have been contributed for testing in north eastern hill zones.

9. **Screening of fieldpea advanced breeding lines to leaf miner:** Total 28 lines comprised of 22 advanced breeding lines (ABLs) with six checks were screened for pea leaf miner infestation under timely and late sown conditions. The leaf infestation (%) in late sown ranged from 25.67 to 61.17, whereas it was 3.44 to 49.44 for timely sown crops. Among 28 lines, 8 lines categorized under susceptible category, 2 lines under moderately resistant, 3 lines under intermediate and 15 lines were categorized as moderately susceptible under late sown. None of the lines could be categorized as very highly resistant, highly resistant, resistant, highly susceptible and very highly susceptible under late sown. Only nine lines were categorized under moderately susceptible under timely sown. Seven lines each under moderately resistant and intermediate and 5 lines grouped under highly resistant category. None of the lines categorized as susceptible. Most of lines showed susceptibility under late sown had expressed comparatively resistance under timely sown. Twolines, IPF2021-8 & IPFD12-2 could demonstrate good level of resistance in both late and timely sown and these lines after further validation can be used as donor in resistance breeding program.

10. **Standardization of colour traps for Pea leaf miner:** To understand the preference of colour by the pea leaf miner, a study was conducted using different coloured traps (Fig 1). The yellow coloured sticky trap attracted more number of pea leaf miner over the crop growth period than other sticky traps. Blue coloured sticky trap attracted significantly higher number of unidentified Dipterans. The yellow trap can be used for relative estimate of leaf miner population and also for monitoring and mass trapping as a component of IPM programme.

G. Biofortification in mungbean and urdbean

A set of urdbean genotypes with diverse origins to validate high sources for iron (Fe) and zinc (Zn) concentrations based on replicated field trials to determine effect of growing environment on Fe & Zn concentrations. Quantify phytic acid in urdbean lines grown over multi-environment to quantify fats, carbohydrate, dietary fibre, protein content and to generate Fourier Transformed Infrared Spectroscopy profile. Analysis of variance showed that genotypic

effects were significant ($p<0.05$) at all locations for iron concentration. Genotypic effects were larger in Kanpur followed by those at Dharwad and Bhopal ranging from 81.55-153.95 mg/kg with mean value of 102.16 mg/kg at Kanpur. Fe ranged from 63.95-118.17 mg/kg with mean value of 97.75 mg/kg at Dharwad. Fe ranged from 65.25-109.81 mg/kg with mean value of 91.46 mg/kg at Bhopal.

Analysis of variance showed genotypic effects were significant ($p<0.05$) at all locations for Zn. Genotypic effects were larger in Bhopal followed by Kanpur and Dharwad. Zn concentration ranges from 6.66-18.05 mg/kg with mean value of 9.97 mg/kg at Kanpur. Zn ranged from 11.39-19.67 mg/kg with mean value of 15.93 mg/kg at Dharwad. Zn ranged from 8.58-20.63 mg/kg with mean value of 16.03 mg/kg at Bhopal.

Moisture (%) ranged from 10.40 (NO. 5-31) to 12.80 (PLU 429) with mean value of 11.48 in urdbean flour. Total protein content (%) ranged from 20.40 (LBG 787) to 29.20 (SPS 28) with mean value of 25.32. Total fat content (%) ranged from 0.66 (IPU 99-209) to 1.41 (Shekhar 2) with mean value of 1.10. Total ash content (%) ranged from 2.50 (IPU 02-43) to 3.65 (U 3108) with mean value of 2.95. Total fiber content (%) ranged from 13.20 (IPU 99-79) to 15.10 (IPU 99-209) with mean value of 13.92 in urdbean. Total carbohydrate content (%) ranged from 55.7 (PU-30) to 58.7 (NO. 5-31) with mean value of 57.50. The mean value of PA was stable over locations ranged from 13.66-13.92 mg/g for 20 tested lines. PA content was highest in WBU 108 and lowest in PLU 429 over the locations.

In GGE Biplot analysis it was found most stable lines with high Fe were PU 30 & Shekhar 2 and Zn concentration, WBU 137-2 & UH 85-5 having high concentration and comparatively higher stability. It was clear from biplot analysis that Kanpur was closer to ideal environment for Fe and Dharwad was closer to ideal environment for Zn. FTIR analysis showed that PLU 429 was having the lowest concentration of different chemicals. This unique lines also had Fe ranging between 81.55 and 93.49 mg/kg is a better genotype with lower PA content over 3 locations. These identified high sources of Fe & Zn concentration along with lower concentration anti-nutrients may help to breed for nutrient-dense urdbean cultivar.

- Total 21 F_2 population derived from 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/*V. sylvestris*, IPU 19-53/IPU 19-27, LBG 787/ LBG 17, IPU 19-53/Mukundra Urd 2, DPU 88-31/GP 20, IPU 02-43/*V. sylvestris*, IPU 11-02/*V. sylvestris*, GP 20/IPU 94-1, IPU 94-1/IPU 19-53, IPU 94-1/*V. 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/ *V. umbellata* crosses were grown under biofortification programme.
- Mapping populations available in biofortification programme for iron and zinc concentration are as following: HPU 120 x IC560408 (F_4), WBU 108 x Shekhar-2 (F_4), Azad-3 x T-9 (F_4)

Programme 2: Plant genetic resource management and its utilization through pre-breeding

1. Chickpea

1.1. Maintenance of wild *Cicer*: Total 337 chickpea germplasm lines were evaluated and 113 lines from 7 species, 42 *C. reticulatum*, 32 *C. judaicum*, 27 *C. pinnatifidum*, 6 *C. echinospermum*, 3 *C. cuneatum*, 2 *C. yamashitae*, 1 *C. bijugum* were maintained. *C. reticulatum* & *C. pinnatifidum* with donor to enhance drought/heat tolerance, plant architecture, seed/pod, protein content and 11 wild lines (ICC 17123, ILWC 237, ILWC 115, ILWC 257, ILWC 21, ILWC 179, ILWC 245, ILWC 141, ILWC 142, ILWC 148, T 39-1) were used to broaden genetic base.

1.2. Breeding material generated: Six wide crosses with *C. reticulatum*, *C. judaicum*, *C. bijugum* as donors were generated in chickpea cultivar background. 5 F_1, 11 F_2, 8 F_3, 25 F_4, 14 F_5 & 17 F_6 segregating populations were derived from wide cross and pre-breeding hybridization.

1.3. Evaluation of breeding lines: A station trial conducted with ABLs derived from wide cross and prebreeding hybridization IPC 19-246 (CA/CE, 2694 kg/ha), IPC 19-173 (ABL/Landrace, 2578 kg/ha), IPC 19-250 (CA/CE, 2461 kg/ha), IPC 19-249 (CA/CE, 2444 kg/ha), IPC 19-177 (ABL/Landrace, 2394

kg/ha) and IPC 19-48 173 (ABL/Landrace, 2378 kg/ha) performed better than the best check IPC 11-112. PYT conducted with ABLs derived from wide cross and prebreeding hybridization IPC 19-251 (CA/CE, 2715 kg/ha), IPC 20-72 (Var/Landrace, 2387 kg/ha), IPC 20-192 (double cross with CR & CB donors, 2102 kg/ha), IPC 20-136 (CA/CR, 1978 kg/ha), IPC 20-96 (double cross with CR donor, 1940 kg/ha) outperformed the best check IPC 11-112.

1.4. Identification of distinct genotypes: Morphologically distinct lines identified in the landrace T 39-1 (ICC 5912), a high protein containing line with heat susceptibility were evaluated. Those selected lines that had improved seed setting under heat, (their protein content) are yet to be tested for 113 wild germplasm accessions belonging to seven *Cicer* spp. was maintained in the wild garden and 250 accessions comprising of landraces, trait specific donors, exotic lines *etc.* were rejuvenated.

1.5. Genetic stocks registered: An advanced breeding line **IPC 20-198** (**INGR 21141**) derived from wide cross with *C echinospermum* was confirmed with 3-4 seeds/pod in ~40% pods/plant and germplasm line **ICC 12315** (**INGR 21142**) was confirmed with post emergence herbicide tolerance (Imazethapyr @ 120 g/ha) and registered as donor with ICAR-NBPGR New Delhi. Morphologically distinct lines identified in landrace T39-1 (ICC5912), a high protein line with heat susceptibility were evaluated and selected lines to be tested for protein content.

1.6. Screening against post emergence herbicide: Thirty chickpea genotypes varying for tolerance to post emergence systemic herbicide imazethapyr @ 150g a.i/ha with respect to recommended dose of 75 g/ha were evaluated during *Rabi* 2020-21 for confirmation. All the entries had 100% plant survival following treatment. Five entries performed better (ICC 12337, ICCIL 04004, ICCV 92504, ICC 91902, ICC 12315) to check IPC 18-186. The panel comprised of released varieties (JG 16, JG 14, JSC 37, JG 11) which showed resilience with lower seed yield.

2. Pigeonpea

2.1. Germplasm conservation: Total 2535 pigeonpea germplasm lines including 1022 of *C. cajan*, 160 collected through exploration, 1280 new augmentation through procurement and 73 wild relatives are being rejuvenated on regular interval and conserved in the cold module repository.

2.2. Maintenance of wild relatives of pigeonpea: Twelve wild species belonging to three genera, *Cajanus 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 *Rhynchosia aurea* (ICP 15809, ICP 15810).

2.3. Generation advancement of pre-breeding materials: Six F_1's were made, Ac 2881/*C. cajanifolius* (ICP15630), Ac 2881/*C. cajanifolius* (ICP 15632), Pusa arhar 16/ICP 15630, Pusa 992/*C. cajanifolius* (ICP 15631), Pusa 992/ICP 15630, Pusa 992/*C. scarabaeoides* (ICP 15739). F_2 was derived from Pusa992/ICP15630 cross. F_3 progenies were raised from ICPL 20325/IPAB 70, ICPL 20325//Pusa 992/ICP 15731(C. *scarabaeoides*) F_3 early selection-1 crosses, Manak//Pusa 992/ICP 15731 F_3 early selection-2, ICPL 20325//Pusa 992/ICP 15731 F_3 early selection-3, VL Arhar 1//Pusa 992/ICP 15731 F_3 early selection-4, Pusa 992/ICP 15731 F_3 early selection-5//Pusa 992/ICP 15731 F_3 early selection-1, Pusa 992/ICP 15731 F_3 early selection-6//Pusa 992/ICP 15731 F_3 early selection-2. SPS were made in F_3 progenies of crosses, PKV Tara/*C. scarabaeoides* (ICP15739), Manak/ICP 15731, Asha/ICP 15739, UPAS 120/ICPL 20340//ICP 15739, Bahar/Maruthi (wilt R)//IPAC 68 wilt R, Bahar/Maruthi (wilt R)//(IPA8F/IPAC 68) wilt R line, IPAC 3 (resistant to phythopthora)/IPAC 68 (wilt R) and advanced to F_4. F_5 were obtained from UPAS 120/*C. scarabaeoides* (ICP 15685), UPAS 120/ICP 15685, UPAS 120/ICP 15642 crosses.

Intermated F_5 progenies were derived from (UPAS 120/*C. scarabaeoides*) WD5-1//(UAS 120/*C. scarabaeoides*) WD 6-6, (UPAS 120/*C. scarabaeoides*)//UPAS 120, WDBCU 9/(UAS 120/*C scarabaeoides*) WD5-2, (UPAS 120/*C. scarabaeoides*)//(UPAS 120, WDBCU 9/UPAS 120/Asha)/WD 19-IPAWD, (UAS 120/*C. scarabaeoides*) WD5-2//(UAS 120/*C. scarabaeoides*) WD 19-2 crosses. F_6 progenies were obtained from Pusa 992/ICP 15731 cross. Fixed lines were obtained from crosses UPAS 120/ICP 15685 and Early 3/ICP 15761 designated as IPAWD & WDBCU.

2.4. Efforts made in deriving early and photo insensitive genotypes: The breeding materials that emanated from extra mural project on identification of photo-insensitive genotypes were infused into pre-breeding project. F_2 segregant derived from AL 2091/ICPL 113529, Maruti/ Bahar, ICPL 11258/UPAS 120, ICPL 11273-B/ICPL 11301-3, IPAV 16-1/ICPL 113529, IPAM 16/ BRG-2, ICPL 113529/ICPL 1134, ICPL 11273A/VKS 11-24-2, ICPL 113529/ICPL 1134 crosses involve photoinsensitve genotypes were selected and advanced to F_3. The segregants from UPAS 120/ICPL 11263, UPAS 120/ICP 15685-2 (*scaraboides*), UPAS 120/ICP 15763 (*C. sericius*), Pusa 992/ICP 15642 (*C. lineatus*), Pusa 992/ICP 15663, Pusa 992/ICP 15685-2 (*scarabaeoides*), Pusa 992/ICPL 11263, IPAC 438/Pusa 992, WDBCE-6-6-1A/IPA 203, Pusa 992/ICP 15763 & WDBCE-6-3-7/IPA 203 crosses have reached F_4. SPS were made from three way crosses, UPAS 120//[ICPL 20340/ICP 15739] and Pusa 992//[ICPL 20340/ICP 15739] for advancing it to F_4 stage.

2.5. Screening of genotypes for *Fusarium* wilt resistance: One hundred five fixed lines derived through pre-breeding were screened in the wilt sick plot. Fifteen lines were found to be non-segregating for wilt resistance, whereas 10 were segregating for resistance, and therefore, single plant selection was made for fixing the resistance. Eight lines namely, IPA 12W 19, IPA 12W 18, IPA 10W 16, IPA 10W 20-1, IPA 12W 39, IPA 12W 41, IPA 12W 45, IPA 12W 61 were resistant for 3 consecutive years. These lines will be proposed for registration with ICAR-NBPGR

2.6. Validations of wilt resistance in 7 genetic stocks developed through pre-breeding: Seven genetic stocks developed through pre-breeding activities were sown with susceptible check after every four rows of test entries. The final observations were recorded in the second fortnight of March, 2021. These entries were inspected in the wilt sick plot by the IGIC and found to be highly resistant, and hence, approved for registration with ICAR-NBPGR

SL	Entry Name	Status of Resistance in wilt sick plot	Average disease incidence over years
1	IPAC 66	Resistant for last 7 years	< 5 %
2	IPAC 68	Resistant for last 7 years	< 5 %
3	IPAC 67	Resistant for last 7 years	< 5 %
4	IPA 10W12	Resistant for last 4 years	<10 %
5	IPA 20-2	Resistant for last 4 years	<10 %
6	IPA 10W1-8	Resistant for last 4 years	<10 %
7	IPA 12W26-1	Resistant for last 3 years	<15 %

2.7. Development of wilt resistant lines involving multi-parents: A population was reconstituted from intermating among IPAC 68, BSMR 853, BSMR 736, Maruthi, WRP1, KPL 43, IPAC 66, C11 followed by open pollination and selection for three generations. One hundred resistant plants were selected for advancing the generation. These lines will be stabilized through single plant selection under wilt sick plot and selfing.

2.8. Validation of *Phythopthora* stem blight (PSB) tolerant lines: The advance generation wild derivatives of C. *scarabeoides* were screened for *PSB* in the sick plot for identification of PSB resistant genotypes. The incidence of disease was less than 20% in candidate lines, IPAC 2, IPAE 15-08, SPD/DD-2 and SPD/DD-3 and hence, PSB resistances of these lines were validated

2.9. Evaluation of pod borer tolerance in wild derivatives: Fourty two advance lines derived from *C. scarabaeoides* are being screened for tolerance to *Helicoverpa armigera* and *Maruca vitrata* for two years. This trial was conducted by entomologist using standard procedure for tolerance to insect damage. Two lines IPAWD 28-1 & WDBCE 6-3-4-6 were putatively identified as tolerant to pod borer. No-choice assay will be done for validating pod borer tolerance of these two lines

3. Mungbean

3.1. Germplasm resources and wild accessions: During *kharif* 2021, 1067 germplasm accessions were rejuvenated. This included 314 active germplasm collections, 21 landraces and farmers' materials, one IMIN minicore set comprising 296 accessions, 90 AVMU advanced breeding lines supplied by the World Vegetable Centre (advanced breeding materials as well released cultivars of Australia, Myanmar and Bangladesh), 96 lines for resequencing were supplied under DBT-minor pulses project and 250 wild *Vigna* accessions. The 296 minicore accessions were raised during *Kharif* at IIPR, Kanpur and during summer at RS, Dharwad. Data were recorded on 24 morpho-physiological parameters besides disease incidence at IIPR, Kanpur. Among the wild genetic resources, 250 accessions of 21 *Vigna* species as described in the Table below were rejuvenated during *Kharif* 2021. These were also evaluated for morpho-physiological traits following IBPGR descriptors

***Vigna* Germplasm maintenance during 2021**

Germplasm Set	No. of accessions
Active germplasm collection	314
Landraces and Farmers' materials	21
Miniore set	296
AVMU advanced lines	90
Wild accessions	250
DBT resequencing set	96
Total	**1067**

Table 2: Maintenance and evaluation of wild *Vigna* accessions during 2021

Name of species	No. of accession	Name of species	No. of accession
Vigna radiata	15	*V. hainiana*	04
V. trilobata	108	*V. trinernia* var. *bournei*	03
Vigna mungo	12	*V. glabrescens*	01
V. umbellata	18	*V. pilosa*	03
V. sublobata	08	*V. trinernia*	01
V. aconitifolia	08	*V. dalzelliana*	03
V. sylvestris	08	*V. unguiculata*	10
V. stipulaceae	35	*V. vexillata*	02
V. radiata var. *setulosa*	02	*V. khandalensis*	01
V. *unguiculata* ssp. *cylindrica*	04	V. *unguiculata* ssp. *unguiculata*	04
V. sinensis	08	**Total**	**250**

4. LENTIL

4.1. Evaluation of trait specific Germplasm: Two hundred six accessions of active lentil germplasm were maintained and 94 accessions were multiplied over two locations (Kanpur and RS-IIPR, Bhopal) for evaluating the concentration of Fe and Zn in their seeds.

4.2. Generation of breeding materials: Four wide crosses made between cultivated and wild species (*Lens orientalis*) including ILWL 118/DPL 58; ILWL 189/DPL 62; ILWL 425/DPL 62 and ILEL 366/DPL 58 were evaluated for heat stress tolerance under late sown conditions.

4.3. Evaluation of breeding lines: Seventy two prebreeding lines were evaluated. Among these lines, a range of variability for yield was seen that varied from 0.18–570 kg/ha and on the basis of higher yield one pre-breeding line ILWL 425 DPL 62-20 has been identified for heat tolerance. Another set of 149 pre-breeding lines derived from 31 crosses made between wild (*Lens curlinaris* subsp. *orientalis* and *L. curlinaris* subsp. *tomentosus*) and cultivated species were evaluated for drought tolerance in dugout plots and wilt resistance under wilt sick plot; identified line IPLPBR-1 from cross between IPL406 (*L. culinaris* subsp. *culinaris*) × IG 136667 (ILWL 44; *L. curlinaris* subsp. *tomentosus*) for wilt resistance having high level of resistance (8.57%). This line was used in crossing programme. Under drought conditions, yield varied from 47 to 1710 kg/ha and 100 seed weight from 1.6-3.7 g among

these lines. Based on higher yield potential two lines namely IPLPBR-81and IPLPBR-82 derived from cross ILWL118/DPL58) having 1710 kg/ha and 1587 kg/ha yield, respectively, have been identified as drought tolerant pre-breeding lines.

5. Urdbean

5.1. Maintenance of urdbean germplasm: Three hundred ten and 98 germplasm lines were evaluated during *Kharif* 2021 and summer 2020, respectively for characterization and maintenance and further utilization in the future breeding programme. Also 150 germplasm lines were evaluated and maintained at IIPR-Regional Station, Dharwad during *Rabi* 2020.

5.2. Screening of urdbean germplasm lines for abiotic stresses: A set of 326 urdbean germplasm lines were raised during *Kharif* 2021 for screening and evaluation for biotic and abiotic stress resistant 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.

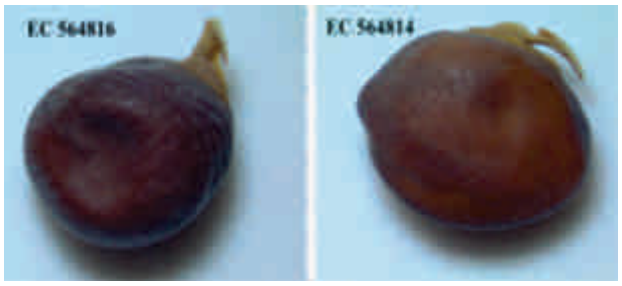
5.3. Pre-breeding: Eleven crosses (IPU 11-02/IPU 99-141, IPU 10-26/IPU 99-141, IPU 10-26/*V. mungo,* IPU 94-1/IPU 99-141, IPU 10-26/*V. sylvestris,* IPU 02-43/ IPU 99-95, IPU 02-43/*V. unguiculata,* IPU 02-43/*V. sylvestris,* IPU 02-43/*V. mungo,* PU 30/*V. mungo,* Shekhar-2/IPU 99-141) were made with diverse parents focussing with abiotic stress tolerance, new plant type during *Kharif* 2021 for development of genetically improved pre-breeding lines of urdbean for new niches,.

6. Fieldpea

6.1. Genetic stock identified:

6.1.1. EC 564816: This is tall and tendril type that fieldpea genotype has intact funiculus in matur and harvested seeds. Intact funiculus is not a common trait in fieldpea and may serve as a unique morphological marker in seed production. This line was recommended by GIC for registration.

6.1.2. EC 564814: This is a dwarf and leafy type fieldpea genotype that has intact funiculus in mature and harvested seed. Intact funiculus is not a common trait observed in fieldpea and may serve as a unique morphological marker in seed production programme. Subsequently, these accessions were recommended by GIC for registration.



6.2. Germplasm rejuvenation and evaluation: Total 315 lines of fieldpea were rejuvenated during 2020-21 for different traits (days to 50% flowering, anthocynin, leaf size, foliage colour, leaf axil colour, plant height, petal colour, pods/plants, pod length, seeds/pod, seed colour, 100-seed wt., days to maturity, powdery mildew and rust). Ample amount of variability was noticed for all the traits that witnessed by descriptive statistics (Table 2.1) and two way clustering (Fig 2.1).

Table 2.1: Descriptive statistics for various quantitative traits

Characters	Descriptive statistics				
	Mean	Min	Max	SD	CV
50% flowering	73.54	55.00	89.00	9.93	13.51
Plant height(cm)	105.82	34.00	192.67	32.77	30.97
Pod/axil	1.70	1.00	2.00	0.46	27.03
Maturity days	122.36	100.00	130.00	5.01	4.10
FPBN	12.24	4.67	18.00	2.52	20.59
LPBN	19.56	10.67	28.67	3.25	16.62
BN	1.09	1.00	8.00	0.63	57.85
PPP	14.44	3.00	41.33	6.22	43.10
PL	5.03	3.16	6.83	0.49	9.66
SPP	4.16	2.83	7.00	0.64	15.37

6.3. **Variability for qualitative traits:** To understand variability for qualitative traits like anthocynin, foliage colour, leaf axil colour, petal colour, pod no./axil, pod curvature, pod beak, pod colour and seed shape is also calculated.

6.4. **Identification of trait specific donors:** On the basis of 315 accessions evaluated for different traits, some of the trait specific donor has been identified for important traits. The trait specific donors are mentioned below in Table 4.1.

Table 3: Trait specific donors of field pea

Characters	Trait specific genotypes
50% flow, (<55)	JPBATRI, EC 398590, EC 398593, EC 398602, EC 398612, EC 322144, EC 324131, EC 324133, EC 324107, EC 324109, EC 324108, IVD 99-5
Plant height (<40cm)	ET 5107, EC 564805, IMD 25, EC 564811, EC 13052, EC 385246, KPMR 385, JP BATRI, S 143, EC 414481, L 118-II, EC 344890, ET 5101, JP 67
Plant height (>160)	P 1176-1, TRAPPAR, EC 324133, HUP 37, ET 45190, P3, T 10, IP2K 112, IP2K 111
Maturity (110 day)	EC 564817, EC 564811, ET 45169, JP BATRI, EC 329568
FPBN (<6.0)	EC 322144, JP 1144, ET 5102, EC 564806, DPFPD 20, KSP 26, DPFPD 2, JP 1193, IMD 83, EC 398594, EC 6620
LPBN (>26.0)	ET 5117, IP2K 110, IVD 99-1, IP2K 105, EC 381858, P 6586, PM 5, IP2K 111, IP2K 59
PPP (>28.0)	JP 292175, IP2K 56, IP2K 81, JP 2901, JP 141, JP 67, JPBATRI, BR 3, JP 333 , IP2K 72, ET 5107, T 163
PL (>6.0)	L 118-II , DPFPD 2, EC 15066, EC 381857, ET 5106, IP2K 58, EC 344890, KSP 10, KSP 21
SPP (>6.0)	DPFPD 20, IMD 51, IMD 41, IVD 99-8
TPBN (>12)	R 41, IP2K 110, T 163, IVD 99-1, T 10, JP 141, HUP 37

6.5. **Herbicide tolerance in fieldpea against topramezone:** Due to intensive cropping system, weeds are become a menace in case of winter season and fieldpea is also affected by weed incidence. During 2020-21, 315 genotypes were screened to topramezone @ 20.6 ml a.i./ha (60 ml/ha). Based on visual phytoxicity the following lines KPMR 4, KPMR 13, KPMR 14, KSP 6, JP 9, JP 56, AR 12, IVD 99-4, IVD 99-5, IVD 99-11, EC 414481, EC 414483, EC 414487, ET 5126, IP2K 61, IP2K 76 (16) were found promising with minimal phytotoxicity .

6.6. **Screening for rust resistance:** Total 315 accessions were screened for rust severity under field conditions during reporting period and sufficient disease incidence was noticed for disease due to congenial conditions (Fig.6.1). To assess diseases severity of rust, 1-9 scale was used. Based on disease severity, ten resistance and ten susceptible genotypes have been identified (Table 6.1) The identified genotypes for further confirmation will be screened for diseases in next winter season.

Table 4: Resistant and susceptible genotypes for rust

Resistant	Susceptible
KPMR 9	EC 342002
KPMR 145	PUSA 10
S 143	EC 564808
KSP 9	IP2K 107
KFPD 10	IP2K 89
EC 385245	IP2K 71
EC 398612	IP2K 91
EC 324125	KPSD 1
JP 885	JP 67
JP 628	KSP 17

7. Cowpea

7.1. **Generation of breeding materials:** Total 25 crosses were made with trait specific donors (determinate plant type, YMV, powdery mildew, bruchid tolerance, pod length, number of pods, grain size and color) and seeds from 10 crosses were successfully harvested during *Kharif* 2021.

7.2. **Selection and generation advancement:** Total 19 F_3, 10 F_5 (100 bulk lines) and 2 F_6 (13 lines) were raised during summer 2021 and superior single plants/lines were selected based on plant type, growth habit and disease reaction for further advancement. Total 20 crosses were raised in F_1 during *kharif* 2021. Based on desirable traits, superior SPS were selected. Altogether, 1548 SPS and 175 line bulk in various generations (F_2 to F_5) derived from 45 crosses including 13 **F_2:** 700 SPS, 10 **F_3:** 548 SPS, 5 **F_4:** 300 SPS, 5 **F_5:** 100 Line Bulk, 12 **F_6:** 75 Line bulk were harvested.

7.3. **Sharing of materials**: Total 140 superior single plants selected from 7 F_3 were supplied to be planted in *Kharif* 2021 at ICAR-IIPR, RRS Off-Season Nursery, Dharwad.

8. Rajmash

8.1. **Germplasm conservation:** Total 1946 germplasm accessions were maintained in medium term cold storage module of IIPR pulses gene bank unit. In addition, few valuable trait specific accessions/donors and advanced breeding material at various stages were maintained at institute. A thirty per cent of total germpalsm accessions were utilized in evaluation and characterization and rejuvenation of common bean germplam during *Rabi* 2021-22.

Table 5: Common bean genetic resource maintained at ICAR-IIPR, Kanpur

Time line	Germplasm collection	Botanical name	Source of Collection
---	52	*Phaseolus vulgaris*	IIPR, Kanpur
2016	270	*Phaseolus vulgaris*	NBPGR-RS, Bhowali
2017	9	*Phaseolus vulgaris*	SeKU, Jammu
2017	176	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2018	73	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2018	620	*Phaseolus vulgaris*	CIAT, Colombia
2019	113	*Phaseolus vulgaris*	NBPGR-RS, Shimla
2019	512	*Phaseolus vulgaris*	CIAT, Colombia
2019	20	Wild germplasm	NBPGR-RS, Shimla
2020	101	Biofortifed lines	CIAT, Colombia
Total	1946		

8.2. **Germplasm characterization:** Total 631 lines were evaluated for morphological and agronomic traits with three checks (Uday, Utkarsh, Arun). 22 morpho-agronomic characters were measured based on NBPGR Standard Descriptors for Common Bean. Data on growth habit, seed and pod traits obtained from field evaluations showed wide range variability. Few valuable traits in specific accessions were identified that could be utilised in common bean improvement programme.

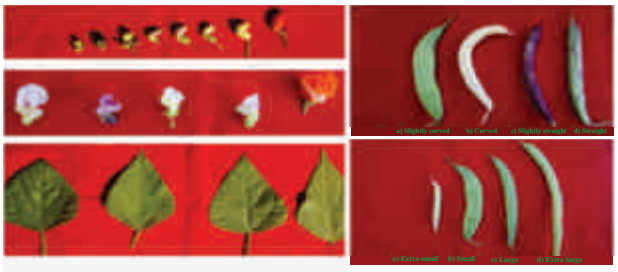


Fig. 5. Phenotypic variation for various traits (colour, shape, size of flower bud, flower, leaf, pod in common bean line

Table 6: Identified trait specific germplasm accessions for breeding programme

SL	Traits	Accession no.	Promising accessions
I	**Days 50% Flowering**		
a)	Early (< 50)	94	EC 931101, EC 931102, EC 931970, EC 931971 & EC 932047
b)	Medium (50-75)	444	EC 931103, EC 931106, EC 931107, EC 931111 & EC 931112
c)	Late (> 76)	56	EC 931138, EC 931141, EC 931150, EC 931158 & EC 931163
II	**Days to maturity**		
a)	Early (< 100)	44	EC 931126, EC 931127, EC 932189, EC 932021 & EC 931971
b)	Medium (101-120)	419	EC 931101, EC 931102, EC 931103, EC 931105 & EC 931106
c)	Late (>120)	131	EC 931138, EC 931144, EC 931148, EC 931159 & EC 931161
III	**Pod length (cm)**		
a)	Small (< 10cm)	391	EC 931106, EC 931107, EC 931108, EC 931109 & EC 931110
b)	Medium (11-15cm)	184	EC 931101, EC 931102, EC 931103, EC 931105 & EC 931111
c)	Long (> 16 cm)	19	EC 931347, EC 931358, EC 931374, EC 932047 & EC 932060
IV	**Pods/plant**		
a)	Few (< 10)	394	EC 931104, EC 931107, EC 931108, EC 931111 & EC 931112
b)	Average (15-20)	182	EC 931101, EC 931102, EC 931105, EC 931113 & EC 931114
c)	High (> 20)	18	EC 931103, EC 931106, EC 931109, EC 931111& EC 931149
V	**Hundred Seed Wt (g)**		
a)	Extra Small (< 15)	36	EC 931132, EC 931110, EC 931121, EC 931152 & EC 931154
b)	Small (16-25)	308	EC 931103, EC 931108, EC 931109, EC 931113 & EC 931114
c)	Medium (26-35)	119	EC 931104, EC 931105, EC 931112 & EC 931118
d)	Large (36-45)	91	EC 931101, EC 931107, EC 931924 & EC 931925
e)	Extra Large (> 46)	50	EC 931102, EC 931111, EC 931119 & EC 931374
VI	**Seeds/pod (> 7)**	12	EC 931121, EC 931237, EC 931385 & EC 931481
VII	**Upright plant canopy**	02	EC 931895 & EC 932091

8.3. Breeding material: Crosses were made for development of biotic/abiotic stress tolerance, micronutrient (Fe & Zn), cooking quality and other traits (early, erect/upright canopy, high pods/plant, yield). 14 crosses (EC 1038024/Amber, Uday/EC 1038024, Uday/EC 932030, Uday/IC 340947, Uday/Amber, Uday/IC 360831, Uday/EC 1037931, EC 1038024/Uday, Araka bold/Uday, Amber/EC 931971, Amber/EC 932030, Uday/IC 340947, Uday/EC 931194, Amber/EC 1037931 were harvested during **Rabi** 2020-21 and raised at Shimla during **kharif** 2021 for advancement. Similarly, 3 F_3 from Amber/Kailash, Uday/Amber, Uday/EC 931194 crosses, 4 F_4 derived from Uday/EC 931194, Amber/Uday, Uday/Arka bold, Kanchan/EC 931194 crosses and 2 F_6 from Kailash/Amber, Amber/Uday crosses were advanced at Dharwad. F_4 from Amber/Kailash, Uday/Amber, Uday/EC 931194 crosses, 4 F_5 from Uday/EC 931194, Amber/Uday, Uday/Arka bold, Kanchan/EC 931194, crosses and 2 F_7 from Kailash/Amber & Amber/Uday crosses. A mapping population from Uday/EC 931194 cross (F_3: 210) for anthracnose resistant trait has been developed.

8.4. Evaluation of promising entries in station trial: Total 12 entries with 4 checks (Uday, Arun, Utkarsh and HUR 15) were evaluated in replicated station trial. Out of 12 entries tested for agronomic performance and yield traits, there were two entries IPR 242-20 (1768 kg/ha) & IPR 236-20 (1720 kg/ha) showed high yield superiority over the best check,Uday (1544 kg/ha) & Utkarsh (1569 kg/ha) in terms of high yield, pods/plant, plant type and BCMV disease resistance and these entries were currently evaluated in IVT trial under AICRP on MULLaRP crops.

8.5. Evaluation of biofortified lines (CIAT, Colombia) for enhanced grain micronutrient: Total 101 biofortifed lines and 9 Indian cultivars were evaluated for agronomic performance and micronutrient concentration (Fe & Zn) during Rabi 2020-21. Atomic absorption spectroscopies (AAS) were applied for estimation of micronutrient concentration (Fe & Zn) at IIPR, Kanpur. The wide range of variability for agronomic traits

and high Fe and Zn concentration of common bean grain. Mean iron concentration of 122.5 ppm was found, with a range of 62.3 to 185.2 ppm. Zinc concentrations ranged between 24.1 to 84.32 ppm, with an average value of 60.22 ppm. From this study, we identified few high micronutrient bean lines (Table.3), these lines could be validate under multi-location environoment for stable grain micronutrient concentration.

Table 7: High micronutrient (Fe & Zn) bean lines identified

Lines	Fe(ppm)	Seed yield(kg/ha)	Lines	Zn (ppm)	Seed yield(kg)
EC 1037935	168.9	850	EC 1037935	52.63	850
EC 1037957	134.5	650	EC 1037948	52.09	1028
EC 1037975	139.5	600	EC 1037996	84.35	800
EC 1037996	185.1	800	EC 1037999	49.63	600
Arun	65.2	1800	Arun	23.6	1800
Utkarsh	56.3	1752	Utkarsh	18.36	1752

8.6. Identification of extra early maturing lines: Twenty nine accessions with checks (Uday, HUR 15 & Arun) were evaluated at two diverse zones during *Rabi* 2019-20 & 2020-21 at Kanpur and during *Kharif* 2021 at RS Shimla. The significant genotypic differences of agronomic and yield traits were observed with estimated of correlation coefficients. Super early flowering accessions like EC 931970, EC 931971, EC 932047, EC 932167 (super early flowering <50 days) and super early maturing accessions like EC 932189, EC 932021, EC 931971, EC 931833 (super early <110 days) were identified. These promising accessions and the information generated would be useful for breeding extra-early cultivars in common bean improvement programme.

Programme 3: High Value seed Production and quality control

1. Seed Technological Studies in Pulses

1.1 Variation of hardseededness in *Kharif* and summer grown mungbean and urdbean genotypes

Hardseededness refers to the development of water impermeable seed coat that does not allow seed to imbibe water. To understand the effect of growing season on occurrence of hardseededness, the freshly harvested seeds of 131 urdbean lines and 107 lines of mungbean produced during *kharif* and *summer* 2021 were subjected to germination assay for 4 days. The hard seeds in *kharif* grown urdbean lines ranged between 10 and 88% with mean of 56%, the value ranged from 0-40% with mean of 10% in summer grown urdbean. The hardseed in *kharif* grown mungbean lines (107) ranged between 14 and 82% with mean of 47%, while in summer mungbean lines, the value ranged from 0-24% with mean of 6%. The occurrence of hardseededness in freshly harvested seeds of mungbean and urdbean was more in *kharif* as compared to summer.

1.2. Seed longevity of rajmash cultivars: An experiment was conducted to study the longevity of 14 rajmash cultivars stored in ambient room temperature for 4 years. In all tested varieties, the mean viability was 93, 93, 73, 3 & 0.9% when stored for 0, 1, 2, 3 & 4 years, respectively. All varieties could be safely stored for a minimum period of one year at ambient condition. 7 varieties, Arka Komal, IPR 98-5, IPR 98-3-1, HUR 137, HUR 203, HPR 35, Gujarat Rajmash 1 could be stored for two years as they demonstrated more than minimum germination requirement (75%) of Indian Minimum Seed Certification Standard. Storing seeds for extended period not only decreased final germination percentage but also increase time for initiation of germination, time to achieve 50% germination and uniformity of germination, suggesting that use of aged seeds could result into poor field establishment coupled with delayed and non-uniform germination.



Storage period (years)

c. Influence of seed and pod traits on pre harvest sprouting (PHS) tolerance in

urdbean: A panel of 140 diverse urdbean genotypes was tested for seed and pod physical and physiological traits such as seed length, seed width, seed thickness, seed weight, pod length, pod wall thickness, rate of water uptake, seed germination, mean germination time and physical dormancy or hardseededness to understand the associations of these traits with PHS tolerance. The genotypes recorded a significant variation for PHS, which ranged from 3–94%. The genotypes with low PHS (< 10%) had a mean hard seed of 77% (n = 13) while, the genotypes with higher PHS (> 70%) recorded a mean hard seed of 7% (n = 7). The PHS exhibited positive correlations with seed weight (r = 0.184), seed length (r = 0.172), pod water uptake (r = 0.339), seed water uptake (r = 0.332), mean germination time (r = 0.362) and fresh seed germination (r = 0.666).



Fig. 6. PHS tolerant genotype (No 7668-43) showing no germination in pods, while the susceptible genotypes (KUG 479 and Him Mash 1) recorded profused germination of seeds inside pod.

EXTERNALLY FUNDED PROJECTS

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

Variety developed: The *desi* chickpea variety 'Samriddhi (IPCMB 19-3)' was released and notified for cultivation during 2021. This variety developed through MABC approach was identified for release in Central Zone (Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh) of India. With an average yield of 2.5 tones/ha over locations in CZ and an exhibited yield potential of >3.5 tones/ha, this variety has been developed n the background of Pusa 256, a popular pan-India variety with the *Fusarium* wilt resistance locus transferred from another popular chickpea cultivar Vijay. Besides its >30.50% yield superiority over the recurrent parent, its yield surpassed even that of the other commercial checks for CZ, JAKI 9218 (31.80%), JG 11 (26.96%), Vijay 20.21% and Phule G 0405 (14.27%) in AVT-2. This variety is expected to fill the void created after the popular variety Pusa 256 becoming old and FW susceptible.



Fig. 7. Field and seed view of chickpea variety IPCMB 19-3 (Samriddhi)

This project was undertaken with an objective to introgress multiple race resistance to *Fusarium* wilt caused by races 1, 2 3 & 4 of *Fusarium oxysporum* f.sp. *ciceri* in chickpea cultivar JG 16. Two elite chickpea genotypes, Vijay & WR 315 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 to *Fusarium* wilt.

During 2020-21, the third and fourth rounds of backcrossing were undertaken in the crosses JG 16/WR 315 and JG 16/Vijay in those BC_3F_1 and 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 (JG 16/WR 315)//(JG 16/Vijay) cross in order to pyramid multiple race resistance to Fusarium wilt. In the cross JG 16/WR 315, 41 BC_3F_1 & 19 BC_2F_1 seeds were obtained. Likewise, in the cross JG 16/Vijay, 11 $BC4F_1$ seeds were harvested. These are being subjected to

foreground and background selection 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 2019-20 in order to maintain continuity in the programme. For introgression of drought tolerance fresh F_1 crosses were attempted between JG 16 (recipient) and ICC 4958 (donor) and 52 F_1 seeds were obtained. These seeds have been sown during *Rabi* 2021-22 to attempt first round of backcrossing.

Seed multiplication: The nucleus seed production plots of IPCMB 19-3, the newly released varietiy of chickpea have been raised during 2021-22. Simultaneously, 12 superior fixed lines in the background of JG 16 developed through MABC have been sown during this season to multiply their seed and evaluate their yield performance.

2. Application of next-generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops (ICAR-BMGF)

Product profiles of *desi* chickpea across different ecologies for future breeding programme were finalized and weightages were assigned to the traits for development of breeding materials in consultation with the PC (Chikpea) unit. One hundred fifteen Advanced Breeding Lines (ABL) of *desi* chickpea subjected of 5 Station trials during *Rabi* 2019-20 were digitalized in the breeding management system.105 ABLs of *desi* chickpea have been subjected to 5 Station trials during ongoing *Rabi* 2020-21, were digitalized in the Breeding management system. In the IIPR Chickpea BMS account till March, 2021; 191 germplasm lists and 178 nurseries have been uploaded. The breeding pipelines are duly advanced in the *Rabi* season 2020-21.

3. Establishing International Mungbean Improvement Network (IMIN)

A replicated trial of mungbean minicore collection (MCC) comprising 296 was conducted during *kharif* 2021 at IIPR Kanpur and other trial was conducted at RS Dharwad during *Kharif*. Based on observations at both the locations during last three years, five accessions, VI 004957AG, VI 004934AG, VI 004973B-BLM, VI 004937AG & VI 002190BG were found highly resistant to MYMV disease. Another set of 90 lines comprising advance line and released varieties of Australia, Bangladesh and Myanmar was also raised at both locations for morho-physiological characters and disease resistance. 16 promising lines for yield and quality parameters were identified.

Identification of new sources for yellow mosaic disease resistance

During the last five years (2017-21), intensive efforts were made to develop and screen a large number of mungbean advanced breeding materials, germplasm lines and mini core accessions developed by World Vegetable Centre to MYMV disease. The identity of YMD causing virus was ascertained by PCR assay using specific primers as *Mungbean yellow mosaic India virus*. Among >450 genotypes that were screened to MYMV disease during last five years. Three breeding lines (IPM 526-11, IPM 08-1,IPM 312-17) developed at IIPR and 7 lines (IC 616147, IC 616220, IC 616116, EC 862645, IC 616208, IC 16266 and IC 616194) from World Veg minicore collection have been found resistant. These genotypes recorded 0 to 3.1% YMD incidence and <1% disease severity over the five years' (2017-2021) period as well as multiple seasons (Monsoon and Spring/Summer) as against 61.1 to 100% YMD incidence and >70% disease severity in the susceptible check (DGGV 2) under field conditions. All resistant genotypes recorded a score of 1 or 2 on YMD rating scale (1-9) exhibiting their resistance superiority over the other genotypes. The identified YMD resistant lines will be tremendously useful as donors in introgression breeding programme for developing superior resistant cultivars of mungbean. These can be used for development of mapping populations to map genomic regions conferring the resistance to MYMIV.

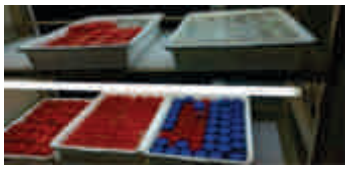
4. Genetic enhancement of minor pulses: Cowpea (DBT project)

Generation advancement: Total 22 F_1 were raised along with parents during *Kharif* 2021 for generation advancement. Superior SPS were selected based on desirable traits to develop superior genotypes. Total 13 F_2 (821

SPS), 9 F_3 (500 SPS), 6 F_4 (485 SPS) and 5 F_5 (100 lines) were evaluated. Two mapping population of crosses, Goa cowpea 3/RC 101 and RC 101/Palm yard bean were planted in F_3 for advancement in *kharif* 2021. In case of first mapping population (Goa cowpea 3/RC 101), total 194 SPSs were planted, of them, only 105 harvested and remaining were vitiated due to heavy rains after two days of sowing. Similarly, in second mapping population (RC 101/Palm yard bean), total 120 SPSs were planted and of them only 64 single plant progenies could harvested and remaining were vitiated due to heavy rains after two days of sowing. In addition, 4 mapping populations, PL-4/PL-1, PL-4/RC-19, PL-4/RC101 & PL-4/Goa Cowpea-3 were planted in F_2 for further advancement using single seed descent method.

Identification of trait specific donors through germplasm evaluation: Total 130 lines were evaluated during *Kharif* 2021 for desired traits (growth habit, days to 50% flowering, pod length, days to pod maturity, testa texture, eye colour, 100-seed weight, seed colour, flower colour, pod nos., pod colour and yield/plant). Ample amount of variability was there for different above mentioned traits such as days to maturity, seed size, pod length, seed coat color. Total 24 lines of wild *Vigna* species of cowpea were maintained and evaluated in vigna garden of IIPR.

Screening for bruchid tolerance: Total 22 lines belonging to four wild species were screened for two Bruchids species: *Callosobruchus maculates; C. chinensis* under Bruchid screening laboratory of IIPR. Two accessions EC 0390282 (*V. Unguiculata sub sp. Cylindrical)* and EC 0012059 (*V. Unguiculata)* showed moderately resistant reaction to *C. chinensis*. 3 acc, EC 0390282 (*V. Unguiculata sub sp. Cylindrical);* EC0098680 (*V. Sinensis)and* EC0099573 (*V. Unguiculata)* demonstrated moderately resistance reaction to *C. maculates.* The other remaining genotypes were found susceptible to highly-susceptible to both bruchid species





Sharing of materials: Total 50 germplasm accessions, 10 F_3 (190 SPS) and 10 F_5 (200 lines) were supplied to RRS, Bikaner, Rajasthan for evaluation and selection of superior SPS & lines suitable for arid ecology and their further advancement. Advanced breeding material was supplied at ICAR-IIPR Regional station, Bikaner for evaluation in arid conditions.



Fig. 8. Field View at ICAR-IIPR, Kanpur

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

Backcross breeding: Uday is a well-adapted anthracnose and BCMV susceptible IIPR variety suitable for NEPZs was chosen as recurrent parent for introgression of resistance to anthracnose and BCMV from common bean landrace EC931194 (CIAT, as it Colombia genotype ID-G2333) carries a three gene pyramid for anthracnose resistance gene: Co-4^2, Co-5 & Co-7. This landrace selected as donor parent for introgression of genomic segment carrying Co-4^2 and Co-5 gene. Previously described Sequence Characterized Amplified Region (SCAR) markers were used to discriminate between resistant and susceptible cultivars and to identify targeted genes introgressed for anthracnose resistance in dry bean cultivars. There are two tightly linked molecular markers such as SCAR molecular markers (SAS13/950c for Co-4 & SAB3/400c for Co-5 gene). During*rabi* 2021, total 26F_1 hybrids were confirmed for true hybrids and presence of targeted locus, sufficient backcrosses were attempted by using Uday as recurrent parent.

6. Mega Project : Creation of seed hubs for increasing indigenous production of pulses in India

Quality seed production of high yielding varieties of different pulse crops namely, mungbean (Shikha & Virat) & urdbean (IPU13-1) during *Kharif* 2021 and pigeonpea (IPA 203) during 2020-21 were conducted at

farmers' field of Kanpur Dehat and at IIPR Kanpur. The seed production of pigeonpea (IPA 203) was also conducted through NGO (FAARD, Foundation) in 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 farmers'. While, quality seed production of chickpea, fieldpea and lentil during 2020-21 were taken and realized in June 2021, following the mandate of project through Farmer's Participatory seed production on framers field of Kanpur Dehat, Hamirpur, Jalaun districts and Sonbhadra, Ghazipur, Varanasi, Chandauli districts through FAARD Foundation. Total of 106 qtls mungbean (foundation & certified seed of 2 varieties (Virat & Shikha) and 58 qtls urdbean varieties (IPU 13-1 & IPU 10-26) were produced. However, during 2019-20 chickpea variety (IPC 06-77 with 8.80 qtls), fieldpea varieties (IPFD 10-12, IPFD 12-2, IPF 14-2 & IPF 4-9 with yield to 456.52 qtls), lentil (IPL220, IPL315, IPL316 with yield 96.69qtls) and pigeonpea (IPA 203 with yield 78.50 qtls) were produced on farmers field. Total quality seed produced under Creation of Seed Hubs for increasing indigenous production of pulses in India is 861.51 qtls during year 2020-21.

Table 8: Quality Seed Production of Pulse crops during the year 2021

Crop	Variety	Category of quality seed produced (qtls)	
		Foundation Seed (qtls)	CS/ TL Seed (qtls)
Chickpea	IPC 2006-77	52.00	
	GNG 2207	-	16.80
Fieldpea	IPF 4-9	13.80	
	IPF 2014-2	5.70	
	IPF 10-12	168.72	
	IPFD 12-2	268.3	
Lentil	IPL 316	47.49	
	IPL 315	10.50	
	IPL 220	38.70	
Mungbean	Shikha	66.80	
	Virat	44.60	
Urdbean	IPU 13-1	26.00	
	IPU 10-26	23.60	
Pigeonpea	IPA 203	23.50	55.00
Total		**789.71**	**71.80**

AICRP on Seed (crops)

During kharif 2021, 87 q foundation seed and 331 q certified seed of mungben and urdbean were produced. In *Rabi* 2021-22, 79 q of foundation seed and 252 q of certified seed of lentil and fieldpea were produced. During the year four trainings were also organized which are as under-

Title of training	Date	Kind of Stakeholders	No. of Beneficiaries
Maintenance breeding in Pulse Crops	January 2425, 2022	Technicals & SRF	35
Seed quality parameters and production technology of pulse crops	February 39, 2022	Farmers, Technicals & SRF	75
Participatory Seed Production Techniques in Summer / Spring Pulse Crops	February 28 & March 1, 2022	Farmers	15
Management of stored grain pests in pulses		Farmers, Technicals & SRF	15

Project Title: CRP on Hybrid Technology in Pigeonpea (Funded By ICAR, New Delhi)

To develop new heterotic hybrids, a set of 92 new hybrid combinations was generated by crossing CMS lines with different restorers. Second backcross of the BC_1F_1s was accomplished with the corresponding recurrent extra-short duration parents (ICPL 11244, ICPL 11276, ICPL 11301, ICPL 11326, ICPL 20325, ICPL 20326, ICPL 20327 and ICPL 20329) for developing new CMS lines. The eight CMS lines have been converted in the background of early pigeonpea lines/varieties (ICPL 88034, ICPL 88039, ICPL 7148, PAU 881, AL 15, AL 201, Pusa 2002-2, MN 5). All these have now reached the stage of homozygosity, producing completely non-functional pollen grains. The CMS lines have been converted using standard backcross technique with A_2 cytoplasmic donors.

Table 9: The details of the new CMS lines with respect to sterility status areas follows.

S N	CMS lines	2020-21				2019-20		2018-19		2017-18	
		Main farm		New Research Campus							
		No. of plants		No. of plants		No. of plants		No. of plants		No. of plants	
		F	S	F	S	F	S	F	S	F	S
1	ICPL 88039	0	7	0	5	2	25	0	18	0	72
2	PAU 881	0	6	0	3	0	35	3	6	13	19
3	ICPL 7148	0	10	0	4	1	26	5	12	15	22
4	ICPL 88034	0	4	0	3	8	21	3	10	3	16
5	AL 201	0	7	0	5	0	2	4	8	5	11
6	Pusa 2002-2	0	7	0	5	-	7	3	5	8	15
7	MN 5	0	1	0	4	2	14	2	9	3	7
8	AL 15	0	8	0	4	0	26	4	16	9	14

During Kharif 2021, in multi-location trial under CRPHT on pigeonpea, ten hybrid entries were tested using three check varieties Pusa 992, BDN 711 and ICPL 88039. Concerning yield superiority, two hybrids BDNPH 12-03(1647.92 kg/ha) and IPH 18-05 (1259.38 kg/ha) showed 73% and 32% yield superiority, respectively over the best check i.e. Pusa 992 (952.08 kg/ha).

Project Title: Genetic enhancement in pigeonpea (Cajanuscajan L. Millsp.) through pre-breeding efforts for developing phytophthora stem blight resistant/tolerant and photo-thermal insensitive early genotypes (Funded by DST-SERB) Project ended on 12/03/2021.

Under this project we have screened a total of 500 extra early and early germplasm lines including 50 wild accessions under field conditions for initial two years and generated a total of 4213 advanced generation F4 breeding lines involving different trait specific parents. Three staggered planting was followed with minimum of 20-25 day interval in each planting, which helped us to estimate the effect of photo-period on different yield and yield attributing parameters. This project led to the identification of set of 27 cultivated and 15 wild accessions belonging to five different species which could be classified as less-responsive to photo-thermal regimes. The cultivated genotypes are ICPL 2287, PusaArhar 16, ICPL 11326-2, ICPL 11326-1, DSLR 43, ICP 3800B, ICPL 85010, ICPL 20325-1, ICPL 11318-1, ICPL 11273A-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 and 15 wild accessions belonging to *C. scarabaeoides* Acc. No. ICP 15683, ICP 15690, ICP 15699, ICP 15710; *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. aureaAcc, No.ICP 15819 and ICP 15809. The project was successful in development of 1600 pre-breeding lines involving different wild species for widening the genetic base in pigeonpea; most of these lines are in extra early maturing group 120 days. During the course of screening against Phytophthora stem blight resistance under national sick field we have identified 11 promising breeding lines for use in pigoenpea PSB resistance breeding proramme and further use as varieties. Under this project a trait specific donor IPAC 79 with INGR20023 was registered with ICAR-NBPGR, New Delhi. The controlled PSB screening technique developed under this project is highly promising to scale up the screening of pigeonpea germplasm and breeding

lines. Overall the project yielded two research articles, a screening protocol for PSB, 11 resistance advanced generation breeding lines, 27 extra early maturing potential cultivated genotypes and 1600 pre-breeding and 4213 advanced generation breeding lines.

Project Title: ICAR-BMGF Collaborative Project on application of next generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian staple crops on Pigeonpea.

As a means to focus pigeonpea breeding activities to replace the established varieties in different zones, four product profiles were developed in pigeonpea. The designing of these product profiles was performed in such a way that the profiles retained all the Basic traits/ Unique Selling Prepositionsof the existing varieties in addition to impart a suite of value-added traits defined here as 'comittement'. The four commercial products targetted for replace in next 5-6 years are PAU 881, TJT 501, Maruti and Bahar released for the North-wester plain zone (NWPZ), Central zone (CZ), South zone (SZ) and north-eastern plain zone (NEPZ), respectively. Benchmark variety were also finalized that will be compared with the final products with respect to the corresponding value-added traits. Similarly, three product profiles of chickpea (ICAR-IIPR, Kanpur and Regional Research Station, Bhopal) have been finalized and submitted. Concerning digitalizaton of breeding data, data of more than 50 pigeonpea nurseries have been migrated to BMS. In parallel, data of 24 trials of pigeonpea have been migrated to BMS including the latest trials conducted during 2021.

Plant Biotechnology

Programme: Genomics, Genetic Engineering and New Breeding Technologies for Pulses Improvement

SP 1: Marker-assisted gene introgression for abiotic stress tolerance and their effect on primary metabolites in chickpea

Moisture stress is major constraint for chickpea. It affects the plant growth, total biomass, reproductive phase and ultimately yield. Marker aided gene introgression for biotic and abiotic stress management is crucial. Here, we report the development, identification; notification & release of marker assisted backcrossing breeding (MABC) derived improved drought tolerant introgressed line IPCL 4-14 (IPCMAS-1) in genetic background of DCP 92-3. This variety was identified on August 17, 2021 in the AICRP Virtual Workshop Meeting and released and notified for North Western Plain Zone of India (Punjab, Haryana, Plains of Jammu &

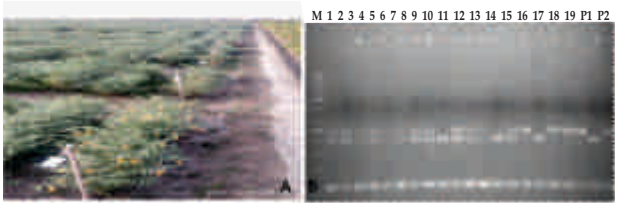


Fig. 1: Field view showing hybridization programme (A), whereas (B) shows the foreground testing result where P1=ICC 4958; P2=KWR 108.

Kashmir, part of Rajasthan and Western Uttar Pradesh) in 87th CVRC meeting held on September 23, 2021. The IPCMAS-1 gave an average yield of 1664 kg/ha under stress condition which is more than 24% over the base parent DCP 92-3. It has potential yield of 2272 kg/ha compared to the recurrent parent DCP 92-3 which yielded 1563 kg/ha.

Three more improved MABC lines (IPC L4-25, IPC L4-7 and IPC L22-33-2) have also shown > 16% yield and have yield advantage over the recurrent parent in station trials also been submitted for AVT 1 in AICRP Chickpea during 2019-20.

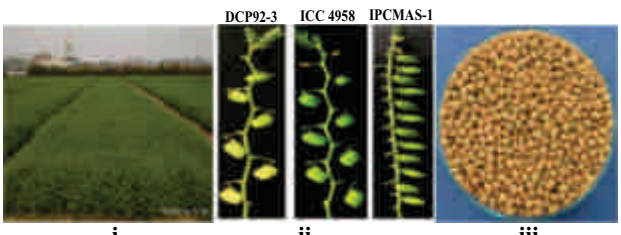


Fig. 2: Different growth stages of crop (i) Vegetative stage (ii) Podding and (iii) Seed view

Efforts were also made to transfer "*QTL hotspot*" in genetic background of KWR 108 and GNG 1581, respectively and materials are at different stages of development (BC_2F_1, BC_2F_2, and BC_3F_1). Last year, 43 BC_3F_1 plants in genetic background of KWR 108 were analyzed for foreground marker of QTL hotspot and found 21 heterozygote plants which were allowed for selfing. However, 5 BC_2F_1 heterozygotes were found positive in genetic background of GNG 1581 & 7 fresh F_1 were obtained.

SP2: Molecular mapping of heat stress tolerance QTLs and understanding heat stress induced transcriptome dynamics in chickpea

In this project, QTL mapping for heat stress tolerance in chickpea has been proposed with use of the immortal segregating mapping population phenotyped at different environments. Six such immortal mapping populations involving heat stress susceptible and tolerant genotypes are developed and are currently at F_6 stage (Table 1). These 6 populations are being advanced to F_7 stage during *Rabi* season 2021-2022 at ICAR-IIPR main field. F_6 population developed from BG 256 x EC 556270 will be phenotyped at late sown condition at ICAR-IIPR, main farm, Kanpur and ICAR-IIPR RRC, Bikaner during January-April, 2022. Paul *et al* 2018 mapped QTLs for heat stress tolerance using RIL population derived from ICC 4567 and ICC 15614 on Chromosome 5 and 6 at the interval of 2.28 Mb and 6.5 Mb, respectively. The same intervals were also identified in our earlier study using F_2 mapping population. In order to fine map these QTL intervals, 4500 and 22500 SNPs in the QTL intervals on chromosome 5 and 6, respectively were identified from re-sequencing data of 195 mini-core lines of chickpea following GATK tools. This SNP information will be utilized in fine mapping the QTLs associated with heat stress tolerance.

Table 1: Chickpea mapping populations segregating for heat stress

S. No.	Cross	Population stage	Population size
1	BG 256 x EC 556270	F_6	233
2	BG 256 x ICC 12155	F_6	155
3	ICC V2 x ICC 9942	F_6	187
4	ICC V2 x ICC 12155	F_6	190
5	ICC 5912 x ILWC 141	F_6	170
6	ICC 12155 x ICC 15614	F_6	191

SP3: Molecular diagnosis of *Fusarium* sp. infecting chickpea and pigeonpea

Pathogens possess different effectors including secreted in xylem (SIX) which are released into the xylem sap during infection to facilitate successful infection and the colonization process. The *secreted in xylem* (*SIX*) genes are majorly present on pathogenicity chromosome and encode small, cysteine-rich, secreted proteins which are reported to be involved in manipulation of the host's defense responses by specific *Fusarium* species. Such *Six* effectors coding genes were identified from refined genome assembly of *Fusarium udum* developed by us and *Fusarium o.f.sp. ciceris* genome assembly following homology based search approach. 5 (*SIX4* (1), *SIX8*, (2), *SIX9* (1) and *SIX13*(1)) and 19 (*SIX1*(2), *SIX4* (6), *SIX5*(1), *SIX8*(1), *SIX11*(1), *SIX13*(6) and *SIX14*(2)). *SIX* coding genes were identified in *Fusarium udum* and *Fusarium o. f.sp. ciceris* genome assembly. Besides *SIX* coding genes, miniature impala (MIMP) transposable elements were searched in these genome assemblies. MIMP transposable elements are reported to be flanking many effector genes in *Fusarium o. f. sp. lycopersici* and other *Fusarium* species. 4 such MIMPs were identified in *Fusarium udum* genome flanking genes coding for SED1 glycoprotein, glycoside hydrolase, transmembrane 66 and pectate lyase (Figure 3). Similarly, 39 such MIMPs were identified in *Fusarium o. f. sp. ciceris* genome and of these, 2 MIMPs were flanking gene coding for *SIX5* and *SIX14*.

SP 4: Molecular Dissection of loci for 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, photo thermo sensitivity *etc*. 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.

A panel of 96 contrasting urdbean genotypes were sown at RRS, Dharwad in *Rabi* 2020 for phenotyping against powdery mildew, but germination was very low due to the heavy rainfall. Again in *Rabi* 2021, the same panel of 96 urdbean genotypes have been sown at RRS, Dharwad and RC, Khordha (Odisha) for phenotyping against powdery mildew. Parental polymorphism screening of DPU 88-31 X LBG 17 population against powdery mildew is being done using SSR markers.

In order to perform candidate gene based association mapping, orthologous and heterologous gene(s) providing resistance to powdery mildew were searched for further genotyping. Homology based study has revealed MLO (Mildew Locus O) genes/domains in blackgram genome. Based on the MLO domain information, sequence alignment and protein prediction, four SSR markers have been designed from two different chromosomes for candidate gene based association mapping against powdery mildew in blackgram.

In order to understand the photo and thermo sensitivity/insensitivity nature of different urdbean genotypes, a panel of 96 genotypes was sown at different time intervals in *Kharif* and *Rabi* 2021, and data was recorded for further study and analysis. Further, an attempt was made to establish a cross between PGRU 95016 and IPU 94-1 for molecular mapping of the loci imparting insensitivity to photoperiod and/or temperature.

SP 5: Precision Plant Breeding and Rapid Generation Advancement in Chickpea

The Project envisages development of protocols for rapid generation advancement in chickpea. Chickpea genotypes JG 14, JG 11, JAK I9218, KWR 108, KPG 59, GNG 1581, JG 16, RVG 202, JGK 5, GCP 105, RSG 888, HC 5, ICC 96029, BGD 9971, ICC 96030, SA-1, BG 3043 of varying maturity duration, were tested under LED light *viz*. Red (625-700 nm); Blue (450-485 nm) and White (380-700 nm), with photoperiod 22h/2h and 60-70% RH. Overall, LED light has positive impact on reducing growth stages of chickpea, as compared to fluorescent/PAR lights. Effect of spectrum on days to first flowering was highest for red followed by white. Similar observation was also found in terms of filled/unfilled pods whereby LED (red and white) were better compared to fluorescent lights.

SP 6: Molecular approaches for improving the nutritional quality of grasspea (*Lathyrus sativus* L.) and field pea (*Pisum sativum* L.)

Grasspea (*Lathyrus sativus*) is a protein-rich, climate-smart grain legume. However, the presence of neurotoxin β-ODAP in its seeds and other plant parts hinders widespread cultivation of grasspea. CRISPR/Cas-based gene-editing technology offers a promising platform to develop low/zero-ODAP

grasspea by creating targeted knockout of the genes encoding key enzymes of the β-ODAP biosynthesis pathway. Therefore, aim of this project is to develop and optimise CRISPR/Cas based gene editing system in grasspea. In this direction, identification and characterization of the candidate genes encoding the key enzymes of the ODAP biosynthesis pathway and employing them to optimise CRISPR/Cas based genome editing in grasspea has been taken up. To identify the genomic sequence of grasspea ODAP synthase, four sets of overlapping primers were designed around the cDNA sequence, PCR amplified from the genomic DNA of grasspea (cv. Pusa 24 and Mahateora), sequenced, and assembled. Gene structure prediction using FGENESH and alignment of assembled genomic sequence with the transcript sequence revealed the intron-less type gene (Fig 4). The ODAP synthase gene sequence was submitted to

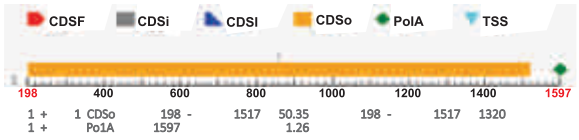


Fig 1. Gene structure prediction of ODAP synthase gene by FGENESH gene prediction program

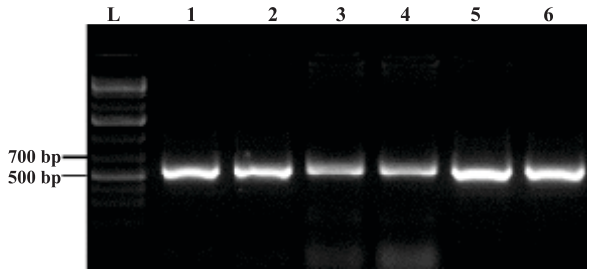


Fig 3. Gel photograph showing confirmation of different dual gRNA cloning in the pKSE401 vector

Genbank and accession number received. In addition, ODAP synthase gene was PCR amplified in a set of grasspea genotypes, sequenced and multiple sequence aligned, which revealed the presence of conserved nucleotides in and around the enzyme active site. Further, to optimise the CRISPR/Cas based genome-editing technique in grasspea and functionally characterise the candidate genes involved in ODAP biosynthesis using this technique, The Cas9 carrying binary vector pKSE401 and pCBCDT1DT2 were procured for making expression cassette with multiple sgRNAs from Addgene, USA. The three single guide RNA (sgRNA) for the oxalyl-CoA synthetase and three for ODAP synthase were designed and synthesized. Dual and single sgRNAs for different targets were cloned into the pKSE401 binary vector by golden gate cloning and confirmed by colony, plasmid PCR and sequencing. The three binary vectors carrying sgRNAs for different targets were then mobilized into *Agrobacterium* and confirmed by colony PCR. The said transformation using these vectors is in progress.

SP 7: Transforming *Vigna* for tolerance to whitefly (*Bemisia tabaci*)

In effort to genetically transform green gram for whitefly tolerance using the *tma 12*, the MTA was signed for sharing of gene with CSIR-NBRI, Lucknow.

Continuing the effforts to develop an efficient reproducible *in vitro* regeneration system in greengram in cutivars of choice, comparative assessment of multiple shoots regenerated *in vitro* using DCN (2-4/explant); embryonic axis (EA) (4-10/explant) and embryonic axis with cotyledon attached (EA-C) (10-13/explant) as explants via direct organogenesis in cultivar ML 267 revealed latter to be more efficient while using MSB5 as basal media and BAP as phytohormone. However, variation in explant response was again observed within same batch. Experiments with EA still attached to cotyledon (EA-C) as choice explant revealed higher number of shoots regenerated (7-12) *in vitro* in *cv*. Virat. Kanamycin sensitivity tests done in EA-C and in presence of BAP indicated requirement of higher doses of kanamycin (250 ppm) to achieve bleaching. The doses of kanamycin required for uniform bleaching was observed 20-30 days after inoculation and varied with explant type.



Fig. 4: *In vitro* regeneration in cv. Virat using EA as explant and hardened plantlet

However, as the tma12 gene was subcloned into choice vector pRI201AN and it was recommended to move ahead for marker free transgenics, biolistics was attempted using embryonic axis as explant in attempt to avoid issues during hardening of *in vitro* regenrated plantlets that were found to dry off gradually.

Also, two wild species of mungbean *viz. Vigna*



Fig. 5: *In vitro* regenerated wild mungbean : a) Subcultured *V. glaberescence* plantlets b) Hardened *in vitro* regenerated *V. vexillata*

glaberescence and *Vigna vexillata* could be successfully regnerated *in vitro* using embryonic axis as explants on basal media supplemented with cytokinin. An average of 1-4 shoots per explant (Fig. 6) and 2-5 shoots per explant could be regenerated in the the two species, respectively that could be successfully hardened (Fig. 7)

SP 8: Gene Identification and development of triple gene technologies for pod borer resistance in transgenic chickpea

The premise of the project is to develop triple gene constructs using multiple insecticidal genes. Two genes: cryIAc and cry2Aa were cloned under pod specific promoter and in the quest of the third gene, genomes of 5 Bt isolates: AK2.IIPR, F1.IIPR, F5.IIPR, F6.IIPR and F8.IIPR with proven insecticidal activity against *Helicoverpa* have been sequenced and insecticidal genes have been identified as listed in the Table.

Table 2: Number of insecticidal genes idnetifed in potential Bt sioaltes by genome sequencing

Name	F1.IIPR	F5.IIPR	F6.IIPR	F8.IIPR	AK2.IIPR
Cry	0	4	5	7	6
Cyt	0	0	0	0	0
Vip	0	1	1	1	1
Others	16	16	16	16	16
Ajax	0	0	0	0	0
Gapp	0	0	0	0	0
Mcf	0	0	0	0	0
Mpf	0	0	0	0	0
Mpp	1	1	1	1	1
Mte	1	1	1	1	1
Pra	0	0	0	0	0
Prb	0	0	0	0	0
Spp	1	1	1	1	1
Tpp	0	0	0	0	0
Vpa	0	2	1	2	1
Vpb	0	0	0	0	0
Xap	0	0	0	0	0
Summary	19	26	26	29	27

We have previously reported the draft genome sequencing of *Bacillus thuringiensis* isolate F6.IIPR, which is highly toxic to *Spilosoma obliqua*, possessing multiple cry genes. However, there were no details on the expression status of the multiple cry genes. LC-MS/MS, a common method for identifying *Bt* proteins in simple protein mixtures has been adopted to confirm the expression of multiple cry genes. The raw data was processed by MassLynx 4.1 WATERS. The individual peptides MS/MS spectra were matched to the database sequence for protein identification on PLGS software. A total of 76 cry peptides were found to be expressed, with approximately 42% belonging to the cry1 class and the remaining 58% to other classes. Overall, the total protein profile including the cry genes has been deciphered.

As persistent and high levels of ectopic expression of a gene can have a detrimental effect on fitness and development of the plant, employing an inducible promoter is required. For this purpose, we have tested the expression status of 11 candidate chitinase genes inducible under simulated herbivory under field conditions by *Helicoverpa* herbivory (Fig. 6). Field grown chickpea plants (ICC 86111) in flowering stage (82 days after sowing) were subjected to a three-hour pre-starved, lab-reared, third instar *H. armigera* larvae infestation (five larvae/plant). Leaf samples were excised from the 3–5 leaf positions at 0, 30 min, 1h, 2h, 4h, 8h, 24h, and 48h time points for RNA extraction and cDNA synthesis. Differentially expressed chitinase genes under simulated herbivory were identified from the transcriptome data (SRA Accession ID: SRP078184) and qRT-PCR was performed for differentially expressed genes using 18s rRNA as internal control. The relative expression values were calculated an internal standard.



Fig. 6: Chickpea plants subjected to *Helicoverpa* herbivory in field

The expression levels of eleven differentially expressed chitinase genes validated by qRT-PCR in chickpea were significantly different under *Helicoverpa armigera* infestation. One gene (Car_Chit-17) is significantly up-regulated in response to *Helicoverpa* infestation at all time points up to 48 hours post infestation except at 24 hpi, whereas Car_Chit 13 was up-regulated until 4 hpi and then down-regulated. Car_Chit-2 expression levels increased significantly at 0.5 hpi, declined at 1 hpi and 2 hpi, increased at 4 hpi, and then decreased at 8 hpi and 24 hpi before increasing at 48 hpi. The expression of four genes (Car_Chit-4,-15,-16, and 23) increased, then decreased. Car_Chit-11 expression levels, on the other hand, decreased at first and subsequently increased only 48 hours after infection. Car_Chit-25 expression was steady until 2hpi, then increased at 2hpi and 4hpi, then decreased at 8hpi, then peaked at 24hpi and 48hpi. Overall, nine genes (Car_Chit-2,-10,-11,-13,-15,-16,-17,-23, and-25) were continuously up-regulated, and two genes (Car_Chit-1,-12) were constantly down-regulated.

Six herbivore chitinases and one hormone-inducible chitinase were modelled and docked with the chitin ligand, and the docked ligands were simulated for 100 ns. RMSD, RMSF and RoG values for chitinase-$(NAG)_4$ complexes: (a) Car_Chit-1, (b) Car_Chit-10, (c) Car_Chit-13, (d) Car_Chit-15, (e) Car_Chit-16, (f) Car_Chit-17, and (g) Car_Chit-23, ligands of complexes based on 'C-alpha' atoms were determined using the gromacs programme. Similarly, RMSD for the ligands of the complexes was also determined. The MMPBSA ligand-protein binding energy calculated after every 1 ns for complexes disclosed that all ligands exhibited a diverse binding patterns, from relatively strong to poor binding with the ligands. The promoters of the *Helicoverpa*-herbivory inducible genes and the chitinases with relatively strong binding efficiencies will be isolated and characterized in heterologous systems for further downstream applications in developing the transgene constructs.

SP 9: Identification of genes/QTLs for salinity tolerance in blackgram and earliness in lentil

Blackgram is a pulse crop that has potential to increase production on increasing acreage, especially in saline affected areas. For breeding improved lines to target theses areas, molecular breeding using salinity tolerant germplasm needs to be identified *via* accurate phenotyping.

In order to observe the differential response of different genotypes against salt treatment, a quick, cost effective and efficient hydroponics based salinity screening facility has been developed (Fig. 9) that was used to screen 96 blackgram germplasm at 100 mM Nacl as well as under control condition. Data on various parameters like root length, shoot length, fresh root weight, dry root weight as well as the number of days for complete death of plant under salt stress were noted. Based on these observations, germplasm was categorized into five categories *i.e.* highly tolerant, moderately susceptible, susceptible, moderately tolerant and highly susceptible (Fig. 10).



Before treatment | 10 days after treatment

Fig. 7: Demonstration of hydroponics based salinity screening in urdbean (plants before treatment are sown in left while 10 days after treatment in right side



Control | Treatment

Fig. 8: Pictorial depiction of plant response to control as well 10 EC salt treatment. HS (highly susceptible); MT (moderately tolerant); T (Tolerant); HR (Highly resistant and S (Susceptible)

The lines phenotypically screened as salt tolerant and susceptible may serve as material to start with for mapping of responsible QTLs, however, they still need to be revalidated before using as a parental material.

With the objective to do GWAS studies for salinity related trait, 150 SSR makers covering whole blackgram genome were designed based on the reference genome developed by NIPB, New Delhi. These primers are currently being used for genotyping of the phenotyped panel of blackgram.

EXTERNALLY FUNDED PROJECTS

Project : 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

Chickpea is highly sensitive to salinity stress during the seedling establishment phase. Salt stress is widely occurring in cultivated areas and severely affects seed germination ability and seedling establishment, which may result in a complete crop failure. Accordingly, RIL population (n=224) was evaluated under pot conditions at seedling stage at 120mM NaCl at ICAR-IIPR, Kanpur. 30 days after treatments is the ideal time zone to record morpho-physiological and biochemical data, however, upto 45 days' only highly resistant lines survived. The tissue sample was harvested for analysis, however, data analysis for morpho-physiological as well as Na^+ and K^+ accumulation in root and shoots part is under process. The QTLs mapping analysis at seedling stage is underway.

To narrow down the genomic spanning region

of the QTLs harbouring genes for salinity tolerance reported in our previous finding in Ca6 and Ca3 chromosome, extreme phenotype of RIL lines were selected for making crosses in order to develop advance intercross line (AIL) for fine mapping the genetic loci governing salinity tolerance. Two extreme susceptible (RIL 156 & RIL 168) and tolerance genotypes (RIL 169 & RIL 166) were used to generate more than 46 number of F_1s for further molecular confirmation of true hybridity in coming season.

Genome-wide identification of CaBURPs and functional characterization their structures, chromosomal localizations, cis-regulatory elements (CREs), and phylogeny

From our previous report, where we identified QTL clusters in CaLG03 and CaLG06 harbouring major QTLs for yield component traits. We retrieved 763 predicted genes from QTLs region (~3.3MB) in CaLG03 and 156 genes from ~0.1Mb QTL region in CaLG06. Based on the functional annotation of these genes, we could find 92 and 25 gene(s), respectively relevant to the traits and belong to the transcripts encoding, ion transporters family, potassium transporter family, cation/H+ exchanger 3, dehydration-responsive RD22-like protein, aquaporin genes, sugar porter (SP) family MFS transporter and MIP/aquaporin protein family.

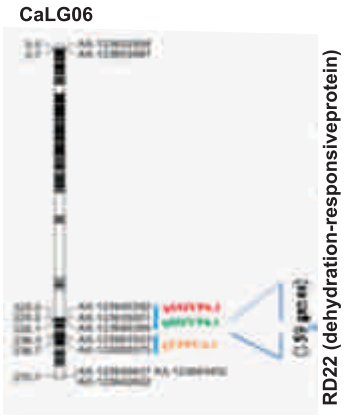


Fig. 9. Diagrammatic representation of QTLs (CaLG06) harbouring dehydration responsive RD22 protein.

The dehydration-responsive RD22-like subfamily belongs to the BURP domain protein family, which are unique to plants, have been identified. They performed diverse functions in plant development under stress response. The BURP domain-containing proteins were characterized by the conserved C-terminal domain, which was named based on four typical members: BNM2, USP, RD22 (a dehydration-responsive protein in Arabidopsis thaliana) and PG1β (a non-catalytic β-subunit of the polygalacturonase isozyme). The expression of the AtRD22 gene was found to be induced by water deficit, salinity stress and the application of abscisic acid (ABA) (Urao *et al*. 1993; Yamaguchi-Shinozaki & Shinozaki 1993; Iwasaki, Yamaguchi-Shinozaki & Shinozaki 1995; Abe *et al*. 1997). The molecular function of this gene was furthermore proved in *Glycine max* transform antes of GmRD22 gene which interacts with a putative apoplastic peroxidase, and the ectopic expression of GmRD22 in *A. thaliana* and rice could increase the lignin contents of the cell wall under salinity stress. Given the diverse function of Rd22 containing domain protein, genome wide identification of CaBURP domain and functional characterization of structure, genomic location and *cis-regulatary* elements in chickpea were done.

In this study, 15 BURP family genes (CaBURP 1–15) were identified and analyzed for diverse exon–intron structures and distinct organization of putative motifs. Based on the phylogenetic analysis of BURP protein sequences from chickpea and other legumes species, the BURP family was classified into seven subfamilies, including two subfamilies (BURP V and BURP VI) with members from rice only and one subfamily (BURP VII) with members from monocotyledons only. Two BURP gene clusters, belonging to BURP V and BURP VI, were located in the duplicated region on chromosome 5 and 6 of rice, respectively.

We investigated the expression patterns of BURP genes under different stress regimes. Promoter sequence analysis revealed an over-abundance of stress-related *cis-elements* in the stress-responsive genes. The data presented here provide important clues for elucidating the functions of genes of this family. Further, we are also identifying three Rd22 orthologues genes present in the chickpea which will be further investigated for their expression pattern under differential stress condition and accordingly validated through heterologous expression system.

ICAR-NPFGGM Project Network project on functional genomics in chickpea

Fusarium wilt in chickpea is the major soil born vascular disease limiting chickpea adaptation & production across the country. Molecular basis of resistance for early wilting in chickpea was well characterized; however, late wilting which is equally important but its resistant mechanism was still not deciphered. During last cropping season, we phenotyped 170 RIL populations (K 850 x IPC 2004-52) segregates for late wilting and 201 RIL population (WR 315 x JG 62) segregates for early wilting. This

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.

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

BC_1F_2 and $F_{2:3}$ mapping populations derived from Maruti x Bahar genotypes was phenotyped for SMD and *Fusarium* wilt incidence at ICAR-IIPR, RRC Dharwad and ICAR-IIPR wilt sick plot, respectively. Extreme segregants for SMD and *Fusarium* wilt incidence were identified from respective mapping population and used for BSA-seq analysis. Two extreme bulks each for *Fusarium* wilt and SMD were pooled (Fig. 13) and the pooled DNAs were sequenced along with one parental genotype following Illumina NGS platform and raw reads were obtained (Table 2). The reads were trimmed for low quality bases and adapter sequence contamination following Trimmomatic tools. The good quality reads were aligned on pigeonpea reference genome following BWA mem aligner and resultant ".bam" files were utilized for variant calling following GATK tool and QTL-seq analysis is in progress. Besides these, the F_3 population was advanced to F_4 stage during *kharif* 2020-2021 at IIPR main station.

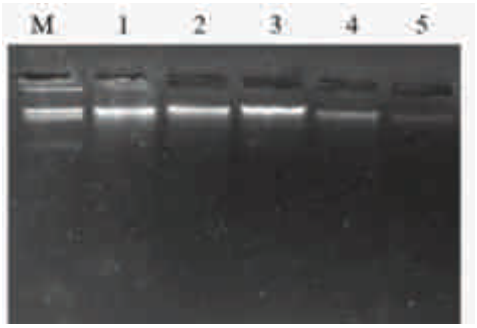


Fig. 10: Bulks and parental DNA. M- 1kb ladder; 1 and 2- Bulk1 and Bulk2 of *Fusarium* wilt incidence samples, 4 and 5- Bulk1 and Bulk2 of SMD incidence samples, 3- Parental genotype Maruti

Table 3: Sequencing of Bulks and parental DNA with NGS platform

Traits	Genotype Information	Read pairs
Fusarium	Bulk1	80872872
	Bulk2	44778078
SMD	Bulk1	117712917
	Bulk2	81017419
Parent		108054798

NPFGGM Project: Transgenic chickpea and pigeonpea for pod borer resistance

Transgenic chickpea (*cv.* DCP 92-3) lines harboring *Vip3Aa* (NCBI Accession No MZ130099) offers an alternate protection against gram pod borer (*Helicoverpa armigera* H.). Presence of Vip3Aa (2,370 bp) were confirmed in T_2 lines (from 5 independent lines) using PCR and copy number (Copy Number 1-3) using Southern blot analysis. Real Time PCR analyses indicated variable expression levels in the transgenic chickpea lines (average Cq values 15.01±0.86 to 19.32±0.10), which was absent in the non-transgenic counterpart. The presence of Vip3Aa protein (789 amino acid residues) in the leaf and pod walls of the transgenic chickpea lines were also detected in post-flowering stages. Detached leaf insect bioassay indicate larval mortality, reduced larval feeding, reduced larval weight gain, compared to control lines. Efficacious chickpea lines harboring *Vip3Aa* can be used as donor for the insect resistance trait and could be stacked with Bt-*Cry1* transgenic chickpea lines for enhancing resistance spectrum against gram pod borer

DBT Network Project on Genetic Enhancement of Minor Pulses

Genotyping of popular minor pulse cultivars

- Cowpea variety panel (21) were genotyped using 56 SSR markers that include already published cowpea specific markers and newly designed ones that were designed from chromosome / linkage groups wherein tested SSRs could not generate polymorphic amplicons. Thus, the cowpea variety panel now stands genotyped using 177 SSR markers (88 adzuki bean specific and remaining cowpea specific). Data compilation is underway for all SSR primers. Also, three diagnostic SSR markers have been identified for reproducibly discriminating amongst PL-2, PL-3 and PL-4 of the Pant Lobia series.
- Green gram variety panel (38) was genotyped using 26 green gram specific SSRs totalling the variety panel to be genotyped using 103 SSRs. Data has been compiled and analysis is underway.
- Black gram variety panel (22) genotyped using 102 SSR markers (60 adzuki bean and 42 black gram specific). Only 10 SSRs (5 adzuki bean: CEDG074, CEDG256, CEDG097, CEDG257, CEDG305 and 5 blackgram specific: VM-6,8,10,11 and 21) could generate polymorphic amplicons amongst the cultivars tested.

DST-CRG: Development of early-flowering genotype using CRISPR/Ca9 technology

The project is a proof-of-concept study for genome editing in chickpea, based on the hypothesis that mutation in early flowering 1 (*Efl1*) gene (an orthologue of *Arabidopsis* ELF3) in chickpea genome results in shorter flowering in chickpea. Genetic variation of the locus were studied in selected set of genotypes differing in maturity duration (*long duration*: C 235, C 214, GNG 1958, RSG 888; *medium duration*: Vijay, JG 16, JG 315, K 850 and *early duration*: ICCV 96030 and ICCV 96029). Sanger sequencing of PCR amplified *Efl1* locus (Ca 5) from the chickpea genotypes, indicated SNPs across the coding region and a 11-bp deletion in the first exon of the gene, resulting in premature stop codon. CRISPR/Cas9 gene construct based on p201N-Cas9 vector (Addgene, USA) targeting the deletion region were synthesized using In Fusion cloning, confirmed by restriction digestion and Sanger sequencing, and mobilized in *Agrobacterium tumefaciens* (LBA4404). In another experiment, five long duration (> 150 days) chickpea genotypes (IPC 2011-112, IPC 2004-01, GNG 2171, GNG 2207 and GNG 1958) were assessed for their responsiveness to plant tissue culture conditions, optimized from *Agrobacterium tumefaciens* based genetic transformation and regeneration employing organogenetic pathway (multiple shoots). Two chickpea genotypes (IPC 2011-112 and GNG 2171) responded well, based on multiple shoots induction (12.03±2.11) and subsequent establishment as plants, in Transgenic Containment Facility (PBSL-1).

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

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

Four new constructs (named T6, T31, T9 and T10) having 4 different sgRNAs targeting TIFY and CCT_2 domain were prepared and re-confirmed by restriction digestion and PCR. Further, three more constructs (C1, C3 and C4) developed earlier were re-confirmed. All the developed constructs were immobilized into *Agrobacterium tumefaciens* strain LBA4404.

Genetic transformation of chickpea using gene gun method

Desi chickpea (*cv*. DCP 92-3) were used for the direct delivery experiments. Embryonic axis explants were bombarded with the p201N-Cas9 vectors containing sgRNA and *nptII* gene. T_0 plants were generated using three constructs (C1, C3 and C4) targeting three different locus of BS1 gene. The independent regenerants were established based on kanamycin selection in Plant Biosafety Level 1 Facility and self seeds were harvested from the established T_0 plants. All the selfed-seeds were re-sown (96 no.) in the PBSL-1 facility and germination was observed from 72 sown seeds. DNA was isolated from all the established plants and checked for the insertion of T-DNA. Simultaneously, phenotypic data and seed weight was recorded. Further, confirmation is to be done using Sanger sequencing. In other experiments, a total of 232, 188 and 84 embryonic axis explants of chickpea were bombarded with T9, T10 and T31 constructs respectively, and putative lines were established.

Genetic transformation of chickpea using *Agrobacterium tumefaciens*

A total of 716 axillary meristem explants of desi chickpea (cv. DCP 92-3) were co-cultivated with *Agrobacterium tumefaciens* harbouring T6 construct and 95 new primary transformants were established based on kanamycin selection in PBSL-1 facility. 683 axillary meristem explants of chickpea were co-cultivated with *Agrobacterium tumefaciens* harbouring C3 construct and 132 new primary transformants were established. Further, 370 axillary meristem explants were co-cultivated with *Agrobacterium tumefaciens* harbouring T31 and 42 new primary transformants were established. Additionally, 178 axillary meristem explants were co-cultivated with *Agrobacterium* harbouring T10 construct and 28 new primary transformants were established. Seeds (53) were harvested from the established 17 To plants (Construct T6). DNA was isolated from the all the plants and checked for the insertion of T-DNA and the editing of the target locus.

Crop Production

1. Long-term effect of pulses in cereal-cereal cropping systems and nutrient management

Maize/pearl millet-based cropping systems (involving pulses)

Four cropping sequences, each maize-based *viz*., maize-wheat (MW), maize-wheat-mungbean (MWMb), maize-wheat-maize-chickpea (MWMC) and urdbean -wheat (UW) (Table 1) and pearl millet-based *viz*., pearl millet-wheat (BW), pearl millet-wheat-mungbean (BWMb), pearl millet-wheat-pearl millet-chickpea (BWBC) and urdbean -wheat (UW) were evaluated under three nutrient management practices *viz*., control (CT), integrated nutrient management-INM (crop residues + bio-fertilizers viz., *Rhizobium* for pulses and phosphate solubilizing 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 2020-2021 were MJ-4334 (maize hybrid), MP-7888 (pearl millet hybrid), Azad Urd (urdbean), HD 2967 (wheat), JG 16 (chickpea) and IPM 02-3 (mungbean). The effect of different crop rotation on wheat yield was prominent after 16 years of crop rotation. Wheat yield was higher in UW system followed by MWMb and the lowest yield was in conventional MW system. Similar was the case for pearl millet-based systems. Soil chemical study revealed that UW and INM had a higher macro- and micro-aggregated N and P compared to the remaining systems. The maize-wheat system and INM recorded a higher weed emergence in surface and sub-surface soil depth over other cropping systems and nutrient management treatments. Legume based cropping systems and INM resulted in significantly higher diversity indices (weed seed bank) compared to MWMb system and RDF at 0-7.5 cm soil depth. MWMb and INM resulted in significantly higher diversity indices compared with M-W system and RDF.

- Soil chemical study revealed that legume MWMC and INM had higher K pools at 0-20 cm and 20-40 cm soil depth. Also, MWMb 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 maize-wheat and chemical fertilizer because more accumulation of weed seeds but, an opposite result is visible in the lower depths.

The results revealed that MWMb and MWMC significantly reduced total weed density in wheat than MW and UW. Number of nodules and nodules dry weight per plant in chickpea and mungbean were the highest in INM followed by inorganic fertilizers and the least under control. Urdbean-wheat rotation with INM resulted in higher aggregated N and P than other cropping system × nutrient management treatment combinations. Similarly, UW and INM had higher aggregated N stock (Stock = weight of aggregate fraction × bulk density× nutrient concentration).

Table 1. Effect of crop rotation and nutrient management on component crop productivity (upland maize-based)

Treatment		Maize	Urdbean	Wheat	Chickpea	Mungbean
		(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
MW	CT	201		1102		
	RDF	3143		4918		
	INM	2376		4210		
MWMb	CT	357		1397		483
	RDF	2940		5090		1096
	INM	2961		4136		1282
MWMC	CT	275			1662	
	RDF	2778			1564	
	INM	2653			1726	
U-W	CT		406	1619		
	RDF		495	4996		
	INM		432	4871		

Table 2. Effect of crop rotation and nutrient management on component crop productivity (pearl millet based)

Treatment		Pearl millet	Urdbean	Wheat	Chickpea	Mungbean
		(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
BW	CT	2289		1415		
	RDF	2588		4922		
	INM	1943		4385		
BWMb	CT	2606		1110		663
	RDF	1729		4245		1206
	INM	1872		4383		1264
BWBC	CT	1874			1399	
	RDF	2224			1388	
	INM	1279			1335	
U-W	CT		495	1847		
	RDF		464	4669		
	INM		432	5529		

Rice-based cropping systems (involving pulses)

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 5 t/ha + 50% NPK) and inorganic fertilizers (RDF, recommended dose of N, P, K, S, Zn and B). Significant increase in rice yield was recorded with the diversification of rice-wheat with pulses. The yields trend of rice is RWMb> RC>RCRW>RW and Inorganic fert.>INM>CT. Further, significantly higher system productivity in terms of chickpea equivalent yield (CEY) was recorded in RWMb (5695 kg/ha) and the least under RC (3106 kg CEY/ha). On nutrient schedules, maximum system productivity was recorded in inorganic fertilizers (4663 kg CEY/ha, at par with INM with 4634 kg CEY/ha) which significantly higher over control (2059 kg CEY/ha).

Significantly higher system based net return was also recorded in RWM (₹ 158,992/ha with the least under RW with ₹ 73,446/ha), whereas BCR was maximum in RCRW (2.49) and the least in RW (1.95). Maximum system based net return was recorded in INM (₹ 1,34,280/ha) and the least in control (₹ 30,351/ha). Similarly, BCR was maximum in INM (2.63) and was the least in CTRL (1.41).

2. Conservation agriculture

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. The treatments consist of 10 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) under randomized block design with three replications. Rice yield varied between 3355 and 4407 kg/ha, maize between 6230 and 6825 kg/ha and pearlmillet 3150 kg/ha. Wheat productivity was ranged from 5637 to 5805 kg/ha and chickpea 1785 kg/ha. The summer mungbean yield ranged from 1372 to 1656 kg/ha. The system productivity in terms of mungbean equivalent yield (MbEY) was significantly highest in M-W-Mb (4747 kg/ha) followed by M+*dhaincha* (GM)-W-Mb (4479 kg/ha), R+Dh-W-Mb (4315 kg/ha) and least in Pm-L+Ls (1868 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. Net

return was maximum in M+Dh-C-Mb (₹ 2 44 600/ha) followed by M-W-Mb (₹ 2 37 065/ha) and least under Pm-L+Ls (₹ 70 987/ha) (Fig. 2). BCR also followed similar trend with the highest value in M+Dh-C-Mb (3.64) followed by M-W-Mb (2.52) and M-W (2.48), and least under Pm-L-Ls (1.20).

Production cost reduction in maize-chickpea system

A field experiment was started during *kharif* season of 2020-21 at main farm of ICAR-IIPR, Kanpur with the objective to enhance the system productivity and sustainability, and to reduce the cost of production. The study was conducted in split plot with two tillage management systems (CT-CT and ZT-ZT) in main plots and six nutrient/weed management systems [100% RDF +Manual weeding, 100% RDF + CWM (PRE+POST), 75% RDF + CWM (Pre+Post), 100% RDF + CWM (Post), 75% RDF + CWM (Post) and GM + 75% N + 50% P + CWM (Post)] in sub plots replicated thrice. Weed density was recorded at 65 DAS in chickpea. The results revealed significantly lower density of both broad leaved (BLWD) and narrow leaved (NLWD) weeds in ZT-ZT treatment than CT-CT (Table 3). The total weed density (TWD) also followed the similar trend. Whereas, in case of nutrient + weed management treatments, significantly lowest weed, the density was recorded in 100% RDF + post-emergence application of herbicide (Topramezone). The tillage practices did not influence the grain yield of maize and chickpea as well as systsem productivity, whereas, significantly higher yield of component crops as well as system productivity. The maximum yield of maize (5.88 t/ha) was recorded in 100% RDF + chemical weed management (CWM)-(Post) and chickpea (2.19 t/ha) in 75% RDF + CWM (Post). System productivity (4.33 t CEY/ha) was maximum in 100% RDF + CWM (Post) and lowest in 100% RDF + manual weeding (3.86 t CEY/ha). Net return was maximum under ZT-ZT in both the crops whereas in case of nutrient and weed management treatments, maximum net return was recorded in 75% RDF + CWM (Post) for maize (₹ 89,166/ha) and in 100% RDF + CWM (Post) for chickpea (₹ 84,861/ha). The least net return was in case of 100% RDF + manual weeding in both the crops. Similar trend was also recorded in B:C ratio.

Table 3: Weed density in chickpea at 65 *DAS* and yields of crops in system

Treatment	Weed density (Nos./m^2)			Grain yield (t/ha)		
	TWD	BLWD	NLWD	Maize	Chickpea	System*
Crop establishment practices						
CT-CT (M1)	14.2	9.82	10.1	5.70	2.02	4.08
ZT-ZT (M2)	12.1	8.03	8.9	5.72	1.92	4.00
LSD (P=0.05)	0.05	0.03	0.07	*ns*	*ns*	*ns*
Nutrient/weed control practices						
100% RDF + Manual weeding	13.0	8.66	9.6	5.31	1.94	3.86
100% RDF + CWM (Pre+Post)	14.8	10.25	10.6	5.69	1.96	4.02
75% RDF + CWM (Pre+Post)	13.1	9.29	9.1	5.79	1.85	3.95
100% RDF + CWM (Post)	11.3	8.30	7.6	5.88	2.19	4.33
75% RDF + CWM (Post)	13.5	8.04	10.5	6.01	1.94	4.12
GM + 75% N + 50% P + CWM (Post)	13.5	9.01	9.5	5.59	1.94	3.97
LSD (P=0.05)	0.07	0.04	0.08	0.87	0.22	0.49

*System productivity (chickpea equivalent yield, t/ha)

Diversified cropping systems under arid-ecosystem

A field experiment was started during *kharif* season of 2020-21 at research farm of IIPR-RC, Bikaner to identify the profitable and sustainable cropping system under CA for arid ecosystem. Total nine cropping systems viz., Clusterbean-Chickpea, Clusterbean-Mustard, Mothbean-Chickpea, Mothbean-Mustard, Mothbean- Cumin, Pearlmillet-Chickpea, Pearlmillet-Mustrad, Mungbean-Chickpea and Mungbean-Mustrad were evaluated in randomized block design with three replications. The results revealed that among the *kharif* crops, significantly higher productivity in terms of chickpea equivalent yield (CEY) was recorded in clusterbean-mustard (1295 kg CEY/ha) and the lowest in pearlmillet-chickpea (603 kg CEY/ha). Similarly in rabi crops, significantly the highest productivity was recorded in clusterbean-mustard (1596 kg CEY/ha) and the lowest in pearlmillet – chickpea (1017 kg CEY/ha). System productivity followed similar trend with maximum productivity under

clusterbean – mustard (2891 kg CEY/ha). Net return also followed a similar trend with maximum value in clusterbean-mustard (₹ 117,988/ha) followed by mungbean-musatrd (₹ 109,237/ha) and least in pearlmillet-chickpea (₹ 57,855/ha). Benefit-cost ratio also showed a similar trend.

Weed management strategies in rice-chickpea system under CA

The field experiment on effect of crop establishment techniques and weed control measures under conservation agriculture (CA) system was conducted for five years (2016-2021) in rice-chickpea cropping system. Four tillage based crop establishment methods in main-plots such as (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) and three weed control practices such as: pendimethalin – bispyribac-Na (rice) and pendimethalin – quizalop-p-ethyl (chickpea) (W1); pendimethalin – metsulfuron-methyl+chlorimuron-ethyl (rice), oxyfluorfen – propaquizafop (chickpea) (W2) pendimethalin – hand weeding (rice) and pendimethalin – hand weeding (chickpea) (W3) in sub-plots were laid out in split plot design with three replications. The treatment ZTDSR-ZTC increased rice and chickpea yields over the PTR-CTC. Pendimethalin 1 kg a.i./ha (PE) - bispyribac sodium 20 g a.i./ha at 20 DAS (POE) in rice and oxyflurofen 150 g a.i./ha (PE) – propaquizafop 100 g a.i./ha at 25 DAS (POE) in chickpea resulted in reduced weed density in system and gave significantly higher yields. ZTDSR-ZT had increasing yield trend over the years with higher SYI of rice, chickpea and system which is important in the IGP. The treatments CTDSR-CT and ZTDSR-ZT led to a significantly higher net returns and benefit-cost ratio over PTR-CTC. Additional benefit of ₹ 35,000-40,000 was achieved with the treatments ZTDSR-ZT over PTR-CTC.

Treatment ZTDSR-ZTC increased passive C pool (0.51%) in 0-20 cm soil depth by 42.3% than PTR-CTC (0.35%). The C fractions revealed that ZTDST-ZTC had a higher SOC compared to the PTR-CTC. Also, Cfrac1 (very labile pool), Cfrac3 and Cfrac4 (non-labile pools) were higher under conservation agriculture than PTR-CTC. The treatment ZTDSR-ZT resulted in a higher microbial biomass carbon at surface soil that indicated the higher microbial functions and enzymes activities under CA than CT.

3. Resource conservation and agro-technologies

Relative performance of different pulses genotypes in sorghum + pigeonpea and chickpea + mustard intercropping systems

The experiment was conducted at the main farm of ICAR-IIPR, Kanpur. The first year results revealed that the relative performance of different pigeonpea cultivars (UPAS 120, IPH 15-03 and IPH 15-09, TJT 501, IPA 203, IPA 206, JKM 189, IPA 15-02) differed markedly under intercropping and sole cropping systems. The grain yield of pigeonpea cultivars in sorghum + pigeonpea intercropping system markedly differs with reference to their sole crop performance and different intercropping indices. Among the pigeonpea genotypes, the highest intercrop pigeonpea yield was registered with the cultivar IPA 15-02 followed by IPA 203, and IPA 206. The highest land equivalent ratio, relative crowding coefficient was registered against the pigeonpea cultivar IPA 203.

The experiment on chickpea + mustard was conducted at the new research campus of the ICAR-IIPR, Kanpur. The experimental results of the year 2020-21 revealed that notable variations existed among the different released cultivars of chickpea crop productivity and intercropping yield advantage under the chickpea + mustard (Varuna) intercropping system (5:2 row ratio). The highest chickpea productivity under chickpea + mustard intercropping system was observed for the chickpea cultivar IPC 2006-77, where the productivity was the highest for cultivar IPC 2004-98 under the sole crop. Cultivars IPC 2011-112 and DCP 92-3 were the poor performers under chickpea + mustard intercropping system. The yield reduction in the side rows (adjacent to the mustard rows) from that of the middle rows were calculated the reductions ranged from 20% (cultivar IPC 2010-134) to 55% (cultivar DCP 92-3). IPC 2006-77, IPC 2004-98, IPC 2004-01 could be the potential cultivars for intercropping system, however, the results needs to be verified based on minimum of two years of field experiments.

Field efficacy of foliar spray of osmolytes to alleviate terminal stress in chickpea

The experiment was conducted to evaluate the efficacy of foliar spray of osmolytes in chickpea facing terminal stress. The treatments comprised of Irrigated Supplemental irrigation (IRR), Control (CK), Water spray (WS) 400 l/ha, Urea 2%, Neem coated urea (NCU) 2%, $MgSO_4$ 250 mM, Thiourea 500 ppm, KNO_3 1%, KCl 1%, $CaCl_2$ 20 mM at the post

flowering stage. The treatment KCl (*i.e.* foliar application 1% potassium chloride at the post flowering stage) and KNO_3 (*i.e.* foliar application 1% potassium nitrate at the post flowering stage) had a higher efficacy to alleviate stress induced grain yield loss of chickpea in the tropical environment of Kanpur. All the plant growth and yield parameters were taken at periodical intervals to interpret the results with reference to crop source-sink relation. The results needs to be validated based on two years of field experiment for a generalized recommendation.

Studies on effect of agrochemicals on mungbean varieties

A field experiment was carried out during 2020-21 to study the effect foliar supply of agrochemicals in mungbean cultivar 'Samrat, Virat, IPM 02-3' for enhancing its nutrient and water use efficiency under rainfed/ irrigated situation. The mungbean varieties are preceded with Jowar hybrid MJ 4334 during *kharif* season. Thus, above three varieties were evaluated for five other foliar supply of chemicals/nutrients at both flower initiation and pod development stages (viz., water spray as control, urea (2%), GA_3 at 100 ppm, salicylic acid at 100 ppm and NPK (19:19:19) at 0.5% in sub-plot). During 2020-21, improvement in mungbean yield and its attributes were pertinent with varieties. Accordingly, significantly higher yield was observed with mungbean IPM 02-3 (Table 4). Similarly, maximum yield was obtained with salicylic acid at 100 ppm (SA-100) followed by NPK (19:19:19) at 0.5% and GA_3 (100 ppm) applied at both flower initiation and pod development stages. Similar was the effect of these applied at both the above stages on other yield and growth attributes viz., harvest biomass, pods/plant, grain weight/plant and water saving parameters.

The effect of foliar spray of agrochemicals on cultivars revealed that there is scaling in mungbean productivity and profit following application of agrochemicals including SA and GA_3 at 100 ppm; and NPK (0.5%). SA at 100 ppm was advantageous in respect of mungbean grain yield (34.6%), PPD (34.5%), net return (49.4%), and BCR (47.7) over water spray (Control). Fertilizers, like NPK (0.5%) are also equally effective with that of SA at 100 ppm in mungbean.

Table 4. Influence of agrochemicals on mungbean (Grain yield, its attributes and growth characters)

Treatment	Grain yield (kg/ha)	Grain yield (kg/plot)	Total Biomass (kg/ha)	Straw yield (kg/ha)	HI (%)	Pods/ Plant	Seeds/ Pods	Seed Index (g)	Grain wt. per Plant (g)/ DW/Plant, (g)	Pl Ht. harvest (cm)
Varieties										
Samrat	1102	2.61	3545	2445	32.3	14.3	6.57	3.57	3.45/5.62	24.0
Virat	1184	2.80	3791	2607	32.4	14.8	6.76	4.19	3.59/6.33	23.3
IPM 02-3	1420	3.36	3956	2536	36.1	15.5	6.71	4.44	3.81/7.50	26.7
CD (p=0.05)	198	0.47	NS	NS	NS	NS	NS	0.39	NS/1.37	2.21
Foliar spray at branch & pod development										
Water	1009	2.39	3055	2046	33.7	11.8	6.47	3.80	2.97/5.13	24.7
Urea (2%)	1250	2.96	3882	2632	33.5	15.2	6.53	4.16	3.54/6.65	24.7
GA_3 (100 PPM)	1259	2.98	3909	2650	32.7	15.1	6.88	3.99	3.81/6.75	25.4
SA (100 PPM)	1358	3.21	4038	2681	34.8	16.1	6.70	4.23	3.58/7.05	23.9
NPK (0.5%) 19:19:19	1301	3.08	3939	2637	33.3	16.0	6.81	4.16	4.18/6.82	24.5
CD (p=0.05)	172	0.41	691	NS	NS	2.38	NS	0.31	0.77/0.88	NS

Interaction was not significant

Evaluation of agro-techniques in hybrid pigeonpea

An experiment was conducted at IIPR New Research Farm, Kanpur to evaluate certain agro-techniques in hybrid pigeonpea (IPH 15-03) involving crop geometry and nutrient management (for PoPs). The yield maximization trial on hybrid pigeonpea showed that higher productivity to the tune of 17 q/ha could be realized under NEPZ condition (light and low fertile soils) at 75 x 15 cm planting geometry and higher (125%) recommended dose of NPK application (Table 5).

Table 5. Effect of agro-techniques on hybrid pigeonpea

Treatment	Yield (kg/ha)
Planting geometry	
60 x 15 cm	1402.7
75 x 15 cm	1636.9
90 x 15 cm	1416.7
LSD (p=0.05)	47.3
Fertilizer dose	
75% RDF	1418.4
100% RDF	1456.5
125% RDF	1581.3

Surface seeding of mungbean after wheat (summer crop)

A total of 34 mungbean cultivars were evaluated for germination, crop establishment, root architecture, nodulation and yield at field condition under surface seeding method of crop establishment (zero till condition) and also compared with conventional crop establishment technique (seed sown with furrow opening method in conventionally tilled field) during the summer season of the year 2021.

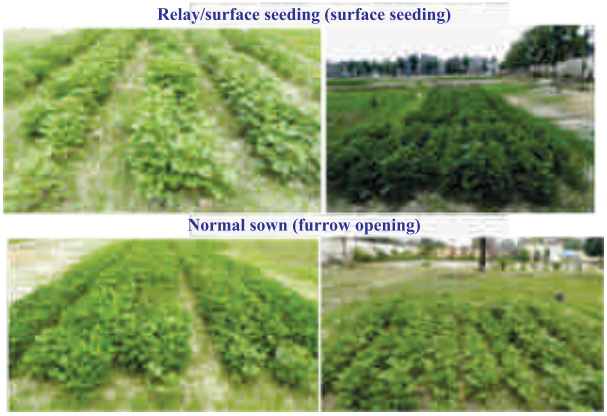


Fig. 1. Field overview of mungbean cultivars (30 nos.) established with both surface-seeding and conventional furrow opening methods.

The results of the preliminary field trial revealed that irrespective of the cultivar, there was an improved crop establishment of mungbean with surface seeding method as compared to conventional method of crop establishment. Marked variations existed in crop growth and yield attributing parameters (particularly root growth and nodulation parameters) among the mungbean cultivars.

Benefits of mungbean relay with wheat:

- Immediate sowing after wheat
- Carry over soil moisture
- Crop establish faster (germination 20 hrs, prominent plumule with leaf 54 hrs)
- Save cost of tillage and sowing
- Well fitted in mechanical harvested wheat fields

4. Nutrient management

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

A field experiment was conducted for an advanced understanding of soil P dynamics and its release kinetics form different organic sources for strategic and sustainable P management in cereal-legume cropping systems in the IGP region (Inceptisol). Treatments consisted of two cropping systems *i.e.* pearl millet-chickpea and pigeon pea-wheat each with six different P management treatments. In all crops except pearl millet, integrated nutrient management found significantly responsive in terms of yield. In pigeonpea and wheat maximum yield was observed in crop residue and phosphate solubilizing treatments *i.e.* 1582 kg/ha and 4122 kg/ha, respectively. Whereas, in case of chickpea poultry manure @ 1 t/ha showed the highest yield (1732 kg/ha) which is 13% higher than recommended fertilizer dose. Integrated treatment crop residue (50%) + PSB application increased system productivity of pigeonpea-wheat (10%) and pearl millet-chickpea (9%) over the control P treatment.

A higher leaf chlorophyll content (25%), nitrate reductase activity (21%) and plant biomass (22%) was recorded in under poultry manure amended integrated treatment over the recommended fertilizer treatment. Higher soluble P-fraction (40.3%) and labile to non-labile P fraction ratio (0.39::0.23) was observed in the residue + PSB added plot than the control in bulk soils of pigeon pea. For the chickpea crop season, a similar result was obtained.

P solubilisation study revealed that cumulative P mineralization was maximum with poultry manure at 1 t/ha by 34% over the control and pearl millet residue releases maximum P over others. Integrated treatments In case of plant growth parameters like leaf pigmentation (chlorophyll a and b), nitrate reductase, and plant height *etc.* application of organic wastes found to be better.

P-dynamics under rhizosphere of different winter weeds have been investigated with their P-uptake in different above and below ground parts. Initial results showed *M. denticulata* L. caused significantly higher soluble P content as compared to other weeds and cultivated crops like pigeonpea and wheat. Also, initial experiment of P-dynamics of two different lentil cultivar under elevated carbon-di-oxide condition have been studied.



Fig. 2. Photographs of the field experiment

Organic farming in pulses (Pearl millet-chickpea)

During 2020-21, a field experiment on pearl millet-chickpea cropping system was taken up to develop the package of practices for improved cultivation following organic cultivation. Thus, two cultivation practices were followed involving organic and inorganic/recommended practice with the main crop of pearl millet during *kharif* and two packages (normal and maximum yield research involving foliar supplement for sub factor, only during *rabi*) with chickpea were selected in order to optimize yield under the existing agro-ecosystem defined by existing soil and climatic condition. Under organic packages, nutrients were supplemented with FYM only along with need based organic plant protection measures against pests and diseases. No chemical was applied to these plots either through soil or by foliar application. In inorganic /recommended package, nutrients were applied through chemical fertilizers and crop was protected from sucking pests/pod bore through conventional inorganic plant protection chemicals.

Significantly higher yield in chickpea can be realized through organic practice only. Potential productivities in chickpea can also be achieved following foliar supply of organic forms of Zinc (Biozinc) and Phosphorus (Biophos). In a pearlmillet-chickpea system, organic practice could yield higher under BMPs (Table 6).

Table 6. Yield performance of chickpea 'IPC 2011-112' under organic vis-a-vis inorganic cultivation

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Total harvest biomass (kg/ha)	Harvest index (%)	Pods/ plant	Seeds/ pod	100-seed wt. (g)	Grain wt./ plant (g)	Grains/ plant (No.)
(A) Package of practice									
Organic	1958	1710	3668	53.3	59.5	1.58	21.8	20.3	91.1
Recommended	1499	1369	2869	52.2	37.3	1.51	19.8	14.2	55.5
CD (p=0.05)	144	103	188	NS	12.7	NS	1.08	3.29	16.3
(B) RDF *versus* MYR									
ORG RD-NPK (FYM)	1917	1686	3604	53.2	56.1	1.58	21.5	19.1	88.7
ORG RD-NPK (FYM) + Biophos & Biozinc	1999	1734	3733	53.5	62.9	1.58	22.0	21.6	93.3
INORG RD-NPK	1470	1315	2786	52.7	35.6	1.51	19.4	13.6	54.3
INORG RD-NPK + DAP-P + $ZnSO_4$-Zn	1528	1424	2952	51.8	39.0	1.51	20.1	14.8	56.8
CD (p=0.05)	178	125	223	NS	15.6	NS	1.51	4.05	19.3

Organic practice had significantly increased *Cyperus rotundus*, *Chenopodium album*, *Coronopus didymus* and *Medicago denticulata* than inorganic fertilization in chickpea. This was mostly due to external addition of FYM to the system.

Organic practice (FYM) had higher total narrow-leaved, broad-leaved and total weed density/dry weight than inorganic fertilization in chickpea. Soil chemical properties including fertility parameters (NPKS status) were superior in organic farming practices (Buffering ability of OM) over recommended practices. However, higher Zn and Fe content in seed was observed under recommended practice although net return favoured for organic practice.

Phosphorus mobilization and acquisition by winter legumes in moderately alkaline soil of IGP

In the study, four different winter legumes (chickpea, lentil, fieldpea, and lathyrus) along with a cereal crop (wheat) were grown with our without fertilizer P treatment (0, and 30 kg P/ha). The objective of the study was to evaluate the P mobilization capacity of different cool-season grain legumes in moderately alkaline tropical soil of the IGP region and their implication on crop productivity under contrasted P regimes. (Particular to tropical alkaline soils, the increased rate of soil sorption (or fixation) often largely limit the soil P bioavailability and reduce crop yields due to sub-optimal crop nutrition (P in particular)). Results revealed that fertilizer-P application had yield incremental effect on wheat, chickpea and lentil crops in tropical alkaline soil. Whereas the grain yields of fieldpea, lathyrus remained the same with or without fertilizer –P treatments. The results of rhizospheric soil P fractions revealed that among the cool-season grain legume, lathyrus had the highest P mobilization capacity followed by chickpea crop over the remaining legume crops. The highest increase in soluble-P and occluded-P, which

represents the labile to moderately labile P forms (based on crop accessibility for nutrient acquisition) was observed with lathyrus crop, therefore suggests that the crop has increased potential to mobilize P in the tropical alkaline soils. Cluster analysis graph illustrates that P pools are distinctly different from the remaining legume crops with or without fertilizer P applied soil conditions. Hence the study suggests that lathyrus and chickpea could be the potential crop having higher P mobilization capacity, and therefore these crops may be included in cropping systems to utilize the legacy fertilizer-P and increasing fertilizer P use efficiency.

Zinc accounting and enrichment in pulses through integrated crop management practices

A field trial was conducted during the *rabi* season of 2020-21 at new research campus, ICAR-IIPR, Kanpur to study the effect of different zinc (Zn) management practices on crop yield, Zn nutrition and grain Zn concentration. In addition, a separate field trial was conducted to identify potential chickpea genotype(s) having higher potential of Zn acquisition and Zn biofortified lines from a panel of 30 chickpea genotypes (core collection). Among the different zinc treatments, 11- 14% higher yield was obtained with soil application of 25 kg $ZnSO_4$ which was significantly higher over the remaining treatments. However, the foliar spray at 0.5% $ZnSO_4$ at pre-flowering stage) resulted in 12- 14% higher seed Zn concentration. Higher grain yield (2150 kg/ha) was recorded in cultivar JG 14 in comparison to IPC 11-112 (2008 kg/ha); in contrast to this, the maximum grain Zn accumulation (51.3 ppm) was found in the cultivar IPC 11-112. There exists a positive correlation between iron and Zn contents in different plant parts (leaf, stem and root). Significant genetic variability in Zn concentration was observed in the core collection of chickpea. Chickpea genotypes RSG 888, GNG 2207, IPC 10 62, Vijay, JG 24, JG 14 with high Zn concentration (45-46.5 ppm) are classified under efficient and responsive to 25 kg ZnSO4 (soil application) that could be utilized for the development of cultivars with high Zn concentration.

5. Water management

Precision irrigation scheduling in sorghum (hybrid MJ 4334) –fieldpea (IPFD 10-12) cropping system

A field experiment was carried out during 2020-21 in 'Sorghum-Fieldpea' rotation to study the effect of irrigation (sprinkler irrigation vis-à-vis normal flood irrigation at critical stages of branch and pod development) coupled with diverse tillage options (conventional- CT, reduced- RT and zero tillage- ZT) on crop performance, water use and efficiency of applied inputs. 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 field crop (Table 7). The season received only one effective rainy day with 4.1 mm rainfall. However, higher crop yield was obtained (with an average yield of 1864 kg grain yield/ha under zero tillage condition) through irrigation scheduling/ management which has a significant effect on crop productivity and its attributes.

Thus, we find ZT (on par with RT and CT) could perform better in terms of grain yield, biomass, economics despite being similar on statistical front in fieldpea IPFD 10-12. However, difference in crop responses (in terms of grain yield, biomass, pods/plant, PPD, economics including BCR) following irrigation schedules made during *rabi* 2020-21 was observed. The study also suggested that appropriate rainfall forecast and the quantum of precipitation received could change irrigation scheduling decisions (time and quantum to be applied). In addition, total seasonal evaporation during crop growth was 88.44 mm (0.84 mm/day). Since two numbers of total irrigation given with a total rainfall received of 4.1 mm /season (one effective rainfall and one rainy day), there was effect of irrigation treatments. Similarly, zero tillage had highest WUE (ZT=RT=CT) and water productivity (Crop biomass (kg)/productivity in '000 litres of water (M3)). Tillage had also influenced on WP & BCR. (ZT > RT >CT). In fieldpea, the realized yield was proportional to biomass accumulation (Table 8).

Effect of sprinkler irrigation indicated that sprinkler irrigation (average) versus rainfed cultivation (sprinkler >flood) had the following advantages; Higher productivity (1.5 q/ha), increased biomass (1.5 q/ha) along with increased pods/plant, Grain weight/plant and Differential water use over other methods. Although water use was similar, yet WUE was in order: Sprinkler > Flood >Rainfed. Similar trend with WP (kg/M3 water use) as Sprinkler=Flood (Loss is more). In addition, maximum WP (1.53) was recorded with sprinkler at both stages. Differential BCR (SPRB+P = NORB+P) and rainfed are having lowest responses. Effect of kharif sorghum due to treatments was not significant.

Table 7. Sprinkler irrigation enhanced fieldpea grain yield and its harvest attributes under Indo-Gangetic Plains

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)	Total harvest biomass (kg/ha)	100-Seed wt.(g)	Seeds /pod	Pods/ plant	Grain wt./Plant (g)	Biomass / plant (g)	Branch/ Plant (Primary)
Tillage options										
ZT	1864	1612	54.3	3476	17.9	4.59	11.3	9.12	23.9	6.59
RT	1603	1542	50.8	3144	17.6	4.84	11.2	9.60	21.5	6.45
CT	1571	1409	52.6	2980	18.0	4.62	10.6	8.95	19.7	6.04
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.41	0.39
Sprinkler Irrigation										
Ibr (SPR)	1456	1326	52.8	2782	18.2	4.60	9.55	7.81	20.1	5.43
Ipod (SPR)	1567	1451	51.8	3018	18.3	4.30	11.0	8.64	20.1	5.72
Ibr+pod (SPR)	1915	1672	54.0	3587	17.7	5.11	11.9	10.64	23.9	7.50
Ibr (NOR)	1652	1459	54.3	3111	17.5	4.74	10.6	8.86	21.8	5.73
Ipod (NOR)	1658	1395	54.6	3053	18.0	4.38	11.4	9.04	21.0	6.64
Ibr+pod(NOR)	1826	1823	50.0	3649	17.5	4.97	11.8	10.34	23.3	7.13
CD (p=0.05)	294	NS	NS	609	NS	NS	1.53	NS	2.70	1.06
Rainfed	812	1118	42.1	1930	15.8	3.47	6.4	5.72	17.0	4.21

Table 8. Effect on crop water use, WUE, WP and economics in fieldpea

Treatment	Water Use (cm)	WUE (kg/ha-cm)	WP (kg/M^3)	PPD (kg/day)	Gross return (₹/ha)	Net return (₹/ha)	BCR
Tillage							
ZT	21.48	86.62	1.62	17.7	76154	58638	3.36
RT	21.36	75.60	1.48	15.3	65657	47640	2.65
CT	22.48	69.32	1.32	15.0	64236	45719	2.48
CD (p=0.05)	-	NS	NS	NS	NS	NS	NS
Sprinkler Irrigation							
Ibr (SPR)	20.50	71.26	1.36	13.9	59584	40984	2.21
Ipod (SPR)	20.46	76.68	1.48	14.9	64135	45535	2.46
Ibr+pod(SPR)	23.49	81.78	1.53	18.2	78259	59159	3.10
Ibr (NOR)	20.52	80.55	1.52	15.7	67539	50439	2.96
Ipod (NOR)	21.13	78.75	1.45	15.8	67724	50624	2.98
Ibr+pod(NOR	24.54	74.46	1.49	17.4	74854	57254	3.25
CD (p=0.05)	-	NS	NS	2.80	11965	11965	0.68
Rainfed	15.22	53.35	1.27	7.73	33600	18500	1.23

(WUE: water use efficiency, WP: water productivity, PPD: productivity per day)

As a result of higher crop performance as evident from higher crop growth and productivity (yield and its attributes), higher NPKS content in seed and straw were recorded in *kharif* sorghum. Higher NPKS under rainfed is due to less dilution factor (Less dry wt, yield etc). However, both yield and economics are favoured in sorghum-fieldpea cropping system when fieldpea was grown with sprinkler irrigation at Br+Pod.

6. Weed management

Post-emergence herbicides in *kharif* mungbean and chickpea

Selectivity and dose/time were optimized with topramezone 20.6 ml a.i./ha at 14 DAS in chickpea and clodinafop-propargyl + Na-acifluorfen 183.5 g a.i./ha at 15 DAS in mungbean. Field experiment was conducted with clodinafop-propargyl + sodium-acifluorfen (24.5 EC: ready-mix) in mungbean (cv. Virat) with three doses (122.5, 183.5, and 245 g a.i./ha) each with four different time of application (10, 15, 20, 25 DAS), unweeded control, and weed free check for optimization of dose and time. Clodinafop-propargyl + Na-acifluorfen 183.5 g a.i./ha at 15 DAS recorded significantly higher yield (1.12 t/ha) over remaining treatments. Large plot demonstration of 750 m^2 was undertaken with yield of 1.28 t/ha. Field experiment was conducted with topramezone (33.6 SC) in chickpea (cv. 'JG 16') with three doses (20.6, 25.7, and 30.9 g a.i./ha) at four time of application (14, 21, 28, 35 DAS), unweeded control, and weed free

check for optimization of dose and time. Topramezone 20.6 ml a.i./ha at 14 DAS resulted in significantly higher chickpea yield (2.85 t/ha) than remaining treatments. It is under testing in All India Coordinated Research Project (AICRP) in chickpea since two years. Large plot demonstration of 736 m^2 was conducted with a chickpea yield of 2.11 t/ha (Control : 0.63 t/ha)

Management of purple nutsedge (*Cyperus rotundus* L.) in pulse based system

Technology to control purple nutsedge was developed employing crop rotation, stale bed techniques and herbicides. The treatment during summer comprising: (i) mungbean + halosulfuron-methyl 67.5 g a.i. ha-1at harvest; (ii) summer Sesbania (40 kg/ha) + 2,4-D 0.75 kg a.i ha; (iii) KNO3 + glyphosate 1.0 kg a.i./ha; (iv) fallow + irrigation + halosulfuron methyl 67.5 g a.i. ha; (v) sorghum during summer as fodder; (vi) ploughing during summer + irrigation + halosulfuron-methyl 67.5 g a.i. ha. The summer treatment was superimposed with two crop rotations: early pigeonpea (hybrid cv. IPH 15-03) - wheat and pearl millet-chickpea in split plot design. Summer mungbean cultivation increased *motha* (*Cyperus rotundus*) infestation in subsequent rainy season crops (pearl millet and pigeonpea). Irrigation - halosulfuron-methyl (70 WG) @ 67.5 g a.i./ha reduced motha and total weed density over summer fallow situation. It resulted in significantly higher pearlmillet (3.74 t/ha) and pigeonpea (1.41 t/ha) yields at third year of cropping cycle over summer fallow situation (Table 9).

Table 9. Grain yield (t/ha) of component crops under different weed control practices following weed control practices in summer (2020-21).

Treatment	Pearl millet	Chickpea	Early pigeonpea	Wheat
Summer mungbean + halosulfuron methyl	2.76	2.51	1.38	3.02
Sesbania + 2,4-D	3.40	2.39	1.51	5.01
KNO_3 + Glyphosate	3.38	2.06	1.12	3.65
Fallow + halosulfuron methyl	3.74	2.07	1.40	3.96
Sorghum	2.27	2.14	1.48	3.65
Plough + Irrigation + halosulfuron methyl	3.70	1.72	1.44	4.01
LSD (*P*=0.05)	0.19	0.15	0.18	0.42

7. Rainfed rice-fallows

Screening of urdbean varieties and sowing time on suitability for rice-pulse in eastern India

A field experiment was conducted to see the performance of six urdbean varieties (IPU 13-1, IPU 11-2, IPU 2-43, IPU 10-26, IPU 94-1 and Nayagarh local) at three different date of sowing (30 Nov, 10 Dec and 20 Dec) at Research Farm of ICAR-IIPR Regional Station, Khordha during rabi season of 2020-21. The study revealed that significant effect of varieties and sowing time was pertinent on yield of urdbean. Among the varieties, IPU 13-1 had significantly higher yield than other varieties tested. Similarly, date of sowing had also shown significant effect and 10 December sowing resulted in significantly higher yield compared to 30 Nov and 20 Dec. Cultivar IPU 13-1 recorded maximum grain yield at December 10 sowing date compared to others.

Screening of mungbean varieties on suitability for rice-pulse system in Eastern India

A field experiment was conducted to study the performance of six mungbean varieties (IPM 2-14, IPM 2-3, IPM 205-7, IPM 410-3, IPM 512-1 and Kamdev) at research farm of ICAR-IIPR Regional Station, Khordha during rabi season of 2020-21. Among the varieties, significantly higher grain yield was recorded with IPM 2-14 compared to IPM 205-3 and Kamdev.

Identified promising entries of chickpea under rainfed rice-fallows condition

Fifteen entries of chickpea were tested as sequential crop after harvesting of rice in rainfed condition for two years. Chickpea entries were sown under zero tillage after harvesting of rice. The highest grain yield was recorded in IPC 2011-92 (1.97-2.30 t/ha) and IPC 2014-55 (1.67-2.17 t/ha) over years. These entries had the lowest maturity duration (128-132 days) compared with other entries. Hence, these entries could be potentially utilized in rainfed rice-fallow regions.

Identified promising entries of fieldpea under rainfed rice-fallows condition

Nine entries of fieldpea were tested as sequential crop after harvesting of rice in rainfed condition for two years. The fieldpea entries included: IPFD 14-11, IPFD 16-4, IPFD 14-2, IPFD 10-13, IPFD 11-10, IPFD 12-2, IPF 12-7, IPF 12-20, and IPF 13-14. Fieldpea entries were sown in zero tillage after harvesting of rice. The grain yield of fieldpea entries varied (0.82-

1.22 t/ha) significantly among entries. Entries such as: IPFD 14-2, IPFD 10-13, IPF 13-14, and IPFD 11-10 resulted in higher grain yield (1.10-1.22 t/ha) compared to the remaining entries. Hence, IPFD 14-2, IPFD 10-13 and IPF 13-14 can be promoted under rice fallow condition for higher yield and sustainable cropping intensification.

8. Farm Mechanization

Comparative evaluation of noise levels between IIPR-mini *dal* mill and ICAR-Akola *dal* mill during operation

A comparative evaluation of noise levels at operator position (within periphery of 1 m) of IIPR mini dal mill and Akola *dal* mill was done to analyze the Permissible Exposure Limit (PEL) as per OSHA (Occupational Safety and Health Administration) and Threshold Limit Values (TLV) as per American Conference of Governmental Industrial Hygienists (ACGIH, 1994). The noise levels were measured with load and without-load conditions for both *dal* mills. The noise levels were measured at an interval of 1 min each and 20 readings were taken and mean values were reported in terms of dB(A) using a sound meter and PEL and TLV values for both *dal* mills were compared (Table 10).

Table 10. Noise Permissible Exposure Limit (PEL) as per OSHA and TLV as per ACGIH

Dal mill/ Noise level	With load dB(A)	OSHA PEL(T), h	ACGIH TLV(T), h
Akola *dal* mill	91.44	6.56	1.81
IIPR-mini *dal* mill	82.75	21.86	13.45
	Without load dB(A)	OSHA PEL(T), h	ACGIH TLV(T), h
Akola *dal* mill	89.41	8.68	2.89
IIPR-mini *dal* mill	81.84	24.81	16.62

Experimental results revealed that the load conditions noise levels were higher compared to no-load conditions for both the *dal* mills. Akola dal mill produced higher noise levels compared to IIPR mini *dal* in both the conditions. For load conditions, the Akola *dal* mill and IIPR mini *dal* mill showed noise levels of 91.44 and 82.75 dB(A) and in no-load conditions the values were 89.41 and 81.84 dB (A), respectively. As per OSHA, permissible exposure limit varied from 6.56 to 8.68 h and 21.86 to 24.81 h for Akola *dal* mill and IIPR mini *dal* mill in loaded and without- loaded conditions, respectively. Whereas, TLV as per ACGIH varied from 1.81- 2.89 h and 13.45-16.62 h for Akola dal mill and IIPR mini dal mill in loaded and no- load conditions, respectively. This study showed that IIPR mini *dal* mill performed better compared to Akola *dal* mill and have lower noise levels and can comfortably run for 8-h a day.

9. Post-harvest management of pulses and value addition

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

Performance evaluation of emery grits of different sizes for milling of different pulses in lab scale grain testing mill, indicated that emery grits of 24, 16, 20, 20, 30 and 30 mesh sizes are suitable for deshuksing of pigeonpea, chickpea, lentil, mungbean, urdbean and fieldpea crops, respectively. Accordingly, it was conceived to develop combination rollers for IIPR Mini *Dal* Mill. Three set of combination rollers, *viz*., i) Roller-I 24:30 mesh; ii) Roller-II 18:24:30; Roller-III 14:16:20:24:30, got fabricated and evaluated in experimental dal mill. Three grit combination roller gave the highest pitting of 44.4%, whereas two grit combination roller gave the pitting of 41.7% pitting in the first pass. For chickpea and fieldpea, use of vertical rubber-steel disk chakki is recommended for the Mill. After first pass, pitted grains were treated by smearing with oil @ 0.7%, followed by sun drying for 2-3 days. To evaluate the rollers, II pass was also done by emery rollers, though for IIPR Mini dal Mill, second pass is recommended for rubber-steel disk chakki. Maximum dal recovery of 69.8, 72.6, 75.5 and 70.4% were obtained for three grit combination roller for pigeonpea, mungbean, lentil and urdbean, respectively. For water soaking pretreatment, 71.2% *dal* was recovered for pigeonpea. Based on the performance, three grit combination emery roller (18:24:30) has been adopted in the new model. Cyclone separator has been fixed at the center to collect milling by-product of both, *chakki* and roller gets collected through it, which intern reduces the dust pollution generated in the emery roller unit. These two modifications have been made in the improve model of IIPR Mini *dal* Mill (Fig. 3).



Fig. 3. Improved IIPR Mini *Dal* Mill

Evaluation of existing pre-milling treatments and development of improved pre-milling treatments for ease of pulse milling

Pulses are mostly consumed after dehusking and splitting. Seed coat is tightly attached with the cotyledons due to presence of gummy substances. Premilling treatments are given to loosen the attachment of seed coat over cotyledons for ease of deshusking and splitting during milling of pulses. Traditionally water soaking and oil smearing are commonly adopted premilling treatments adopted at cottage and commercial scale pulse milling, respectively. Both these treatments are weather dependent process as they require prolong sun drying of 3-4 days. Weather independent thermal treatment has also been developed by CFTRI, Mysuru, but due high initial and operational costs, it is not widely adopted. The project envisages evaluating existing domestic and commercial pre-milling treatments and developing novel methods to loosen the seed coat. For pigeonpea, milling was performed for untreated, water and oil treated grains. First pass was made through emery roller for pitting of grain before the treatments. After treatment second pass was made through emery roller to simulate commercial dal milling and rubber-steel disk vertical dal chakki, as per recommendation of using IIPR Mini *Dal* Mill. Second pass with emery roller though give better dehusking due to abrasive surface, but leads to higher powdering loss from the cotyledons. Higher overall *dal* recovery was obtained with second pass in rubber-steel disk *chakki* in all the treatments.

For chickpea milling, 2, 3 and 4 hours water soaking of whole grains followed by sun drying till 10-12% moisture content were tried as premilling treatments, before dehusking and splitting in rubber-steel disk *chakki*. Maximum *dal* recovery of 81.24% was obtained with 4 hours of soaking treatment. In IIPR Mini *Dal* Mill, for easy to mill kind of pulses, use of rubber-steel disk *chakki* is recommended. Highest dal recovery of 75.90% was obtained with 4 hours of water soaked and dried chickpea, when milled in emery roller. *Dal* chakki yields higher overall *dal* recovery with 12-20% *dal* with husk in all the treatments.

For urdbean, highest dal recovery of 79.21% was obtained with water soaking as pretreatment and milling in emery roller. Splits of urdbean and mungbean (dal with husk) were prepared in rubber-steel disk *chakki* without any pretreatment. It resulted into 87.09 and 91.75% *dal* recovery, respectively. In case of fieldpea, 93.79% dehusked *dal* was recovered in single pass through rubber-steel disk chakki without any treatment.

Processing of pulse seeds and development of methods for their long term storage

Pulses are protein rich crops which attracts insects from the field itself. These insects are carried to the storage godowns after harvest. Multiplication of insects, mainly bruchids in case of pulses, takes place whenever the environmental conditions become favourable for insect growth, *i.e.*, high temperature and humidity. Storage of pulses in gunny bags have always been a challenge, specially, in most prevalent gunny bag storage method. In case of seeds, maintaining viability is another important issue. The present study was undertaken to evaluate behaviour of pulse seeds stored in different storage structures and packaging materials. During the year 2021, studies were conducted with lentil grain. Grains were stored in PP Woven (PPW), LDPE, HDPE and Laminated Plastic bags. Storage in jute bags and metal bins were taken as control. Change in moisture content, bulk density and infestation levels were monitored for a period of six months. Least change in moisture content (9.9 - 10.3%) was observed in case of laminated plastic bag and the highest variation (9.9 - 13.2%) was observed in *jute* bags. The change in moisture content is shown in table 11.

Table 11. Changes in lentil grains moistuce under different pleage methods

Storage duration	Jute bag	PPW	Metal bin	LDPE	HDPE	Laminated
Zero day	9.9	9.9	9.9	9.9	9.9	9.9
60 days	11.2	10.7	10.5	10.3	10.2	10.1
120 days	12.2	12.1	10.6	10.4	10.3	10.2
180 days	13.2	12.6	10.7	10.6	10.4	10.3

EXTERNALLY FUNDED PROJECTS

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

Pulses are mostly consumed after dehusking and splitting in form of *dal*. In commercial mills, the milling operation is performed in abrasive emery roller mills in multiple passes, which cause scouring losses to the cotyledons. In the project efforts were made to utilize protein, fibre and antioxidant rich pulse milling byproduct for edible purposes. Whole grains were cleaned, graded and washed prior to pitting in emery roller of IIPR Mini *Dal* Mill. In order to simulate commercial milling, second pass has also been made through emery roller after water soaking

and sun drying as premilling treatment for higher degree of dehusking. For the mill second pass is recommended with rubber-steel disk *chakki*. The milling byproduct obtained was separated with the help of electro-magnetic sieve shaker to separate different fractions based on particle size. Each of these fractions was analyzed for bio-chemical parameters, *viz*., total protein, phenol and antioxidant contents. Byproduct obtained from milling of pulses can directly be used after converting it into fine powder using hammer mill. The powder of milling byproducts was mixed with whole wheat flour and other ingredients for the manufacturing of biscuits. The powder component separated from the byproduct can be used for making various traditional and commercial value added products. The products developed were within acceptable limits in organoleptic studies.

Pulses are mostly consumed after dehusking and splitting, in form of *dal*. With milling of 75% of pulses produced, pulse milling is the 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 fibre, 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/100 g) and antioxidant activities (59.68 m mole TE/100 g). Similar studies are being conducted for other pulses. Edible bakery products (biscuits) have been prepared using pigeonpea and lentil milling by-products. Various products, *viz*., biscuits, pizza base, cakes, buns, muffins, *idali, halwa, dal*, soup, instant *dal*/soup powder, noodles, fortified *atta, dal* analogue etc. were developed using whole and powder component of the pulse milling byproduct (Fig. 4).



Fig. 4 : Editde products frame milling by products

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

Pulses production was near stagnant for about three decades and demand was always more than the supply, forcing import of pulses to match domestic demands. During the year 2017, unprecedented rise in pulse prices was observed. With intervention of improved varieties and policy supports, like, enhanced MSP, assured procurement, maintenance of buffer stock etc., the country has witnessed all time high pulses production around 23-25 million tonnes in recent years. 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 centre 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 for lentil.

The study comprised of three components: i) Survey of pulse storage go-downs and collection of samples, ii) Storage of whole lentil in *jute* bag and iii) Storage of lentil *dal* at different moisture content (10,

12 and 14%) in LDPE bags of different thickness (25, 50 and 75 microns).

In the first study, pulse storage go-downs of NAFED located at Atarra, Banda, Supa, Mahoba, Naugong, Chhatarpur; Chhatarpur, BadaMalehra, Chhatarpur; Banda, Sagar, GanjBasuda, Vidisha; Donga Mandi, Tikamgarh; Badroaghat, Tikamgarh; and Niwari were covered. Four visits were made to the locations and representative samples for pulses stored at the locations, namely, chickpea, lentil and urdbean were collected. The samples were analyzed for grain qualitative parameters and milling outturn recoveries at ICAR-IIPR, Kanpur. It was observed that the at all the locations grains were within the permissible limits of FCI pulse procurement norms. Milling outturn ranged between 78.60 - 93.80, 73.40 - 79.20 and 89.80 - 91.60% for urdbean, chickpea and lentil, respectively.

ICAR-IIPR, Kanpur, being Cooperating Centre was identified to conduct lab scale storage studies for whole lentils in gunny bags to simulate go-down conditions. Lentil grains procured from local market were stored in gunny bags for a period of 12 months. Samples were drawn on monthly basis and analyzed for qualitative parameters and milling outturn. Insect activity was observed in the month of July, 2020 and the bags were fumigated with aluminum phosphide and covered with plastic sheet for seven days. Total milling outturn for lentil ranged between 84.20 and 90.57%, indicating with proper management loss due to insect infestation can be avoided. Grade-I milling recovery increased from 67.80 to 77.76% with the length of storage duration.

Storage of lentil *dal* was also conducted at ICAR-IIPR, Kanpur, lentil *dal* was prepared and stored in LDPE bags of 25, 50 and 75 micron thickness at 10, 12 and 14% moisture contents and the *dal* was stored for 12 months. The lentil grains were milled in using abrasive emery roller to prepare lentil dal. Moisture differentials were created either by oven drying (for 10% moisture) or by moisture addition and equilibration (for 12 & 14% moisture) before filling into LDPE bags of different thicknesses. Samples from each bag were drawn on monthly basis and analyzed for change in moisture content, bulk density, 100 grain weight, percentage oviposition, percentage grain damage, infestation level, weight loss, percentage damage, protein content, water absorption and solid dispersion *etc*. Fungal activity was observed in lentil *dal* stored at 14% moisture content in 25 and 50 micron LDPE bags. *Dal* can safely be stored at 10-2% moisture without any treatment in LDPE bags.

Crop Protection

Plant Pathology

1. Pigeonpea

Host Plant resistance against wilt

A total 1416 pigeonpea lines were screened in the wilt sick field at IIPR Research Farm during *Kharif* 2021-22 for identification of new sources of resistance against *Fusarium udum* (Race-2) reiststant. Pigeonpea variety, Bahar was used as susceptible check.

Out of 127 advance breeding materials, some lines (IPA 20-1, IPA 20-4, IPA 20-5, IPA 20-6, IPA 20-7, IPA 20-8, IPA 20-9. IPA 20-10, IPA 20-11, IPA, 20-12, IPA 20-13, IPA 20-14, IPA 20-14, IPA 20-15, IPA 20-16, IPA 20-17, IPA 20-18, IPA 20-19, IPA 20-20, IPA 20-26, IPA 20-27, IPA 20-30, IPA 20-31, IPA 20-32, IPA 20-33, IPA 20-34, IPA 20-38, 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 resistant entries against *Fusarium* wilt.

Out of 30 IIPR promising pigeonpea lines, *viz.*, DPPA 85- 3, DPPA 85-5, DPPA 85-7, DPPA 85-8, DPPA 85-11, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16 and IPA-38, IPA 16F, and IPA 15F showed resistant reaction against *Fusarium* wilt.

Host plant resistance against *Phytophthora* stem blight

A total of 313 early and medium duration pigeonpea lines were evaluated on against *Phytophthora* stem blight (PSB) during *Kharif* 2021-22. UPAS 120 and ICP 7119 were sown as check after every two rows of test entry. Based on the mean disease incidence of three replications, 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, IPH18-01, IPH 18-09, IPAE 15-05, IPAB-2019-1-6, IPAB 10-67, IPAC-2 and IPA 16E-7) were identified resistant.

2. Chickpea

Host plant resistance against wilt

A total of 1181 chickpea lines were screened in the wilt sick plot at Main Farm, IIPR during *Rabi,* 2020-21 for identification of new resistance source against early and late wilt of *Fusarium oxysporum f. sp. ciceris* (Race-2). WR-315 genotype was used as resistant check, JG-62 for early wilting and C-104 for late wilting were taken as susceptible check.

Out of 227 NBPGR accessions, 16 entries were found resistant having wilt % score below 10 for *Fusarium* wilt namely, ICIC 244398, IC 269360, EC 267160, IC 331552, IC 372345, IC 395468, IC 486882, IC 512099, IC 116301, IC 116406, IC 116298, IC 244324, IC 242424, IC 275448, IC 327654 and IC 468839.

Out of 168 a Advance Breeding lines, 21 lines namely, IPC 2020-124, IPC 2020-146, IPC 2020-12, IPC 2020-47, IPC 2020-147, IPC 2020-148, IPC 2020-153, IPC 2020-167, IPC 2020-59, IPC 2020-61, IPC 2020-70, IPC 2020-181, IPC 2020-58, IPC 2020-115, IPC 2020-123, IPC 2020-134, IPC 2020-135, IPC 2020-155, Black Seeded, P 13073, IPC 97-29, were found resistant. Similarly out of 272 AICRP entries, 27 entries were found resistant against *Fusarium* wilt.

Host plant resistance against Ascochyta blight

Among 75 chickpea genotypes screened against *Ascochyta* blight, only IPCK 2013-209 (4), showed moderately resistant reaction both under field/hot spot condition at PAU, Ludhiana and green house condition at ICAR-IIPR, Kanpur.

Host plant resistance against BGM

Among 75 chickpea genotypes screened against BGM disease, only two entries *viz.* IPC-15-273 (3) and IPC-2013-248 (3) were found resistant and IPC-2015-15 (4) showed moderately resistant reaction under field condition (GBPUA&T, Pantnagar).

Screening for chickpea rust resistance

Out of a total 272 chickpea genotypes screened against rust disease, only eight chickpea lines *viz.*, P15108, P15115, P15119, P15182, P15235, 15270, 15356 and P15252 observed low severity of rust disesae. The per cent disease severity of rust ranged between 51.1 to 100 per cent. None of the entries were resistant to rust disease

3. Lentil

Host Plant Resistance against wilt

One hundred ninety five genotypes of lentil were screened against wilt in a wilt sick plot using infector row technique.Lentil genotype, L9-12 used as susceptible check, was sown after every five rows of test genotypes. Lentil genotype IG 54 showed

resistance (wilting <10%) against wilt in the third year of testing also.

Thirty three genotypes *viz*., IPL 203, IC 560150, ILL 6002, Pant L 05, WBL 77, IPLS 09-17, IPLS 09-36, IPL 534, IPL 406, IPL 321, EC 208362, IPL-M-08, IPL 161502, IG 26, IPL 131225, IG 4013, IG 70191, IPL 11702, IPL 161421, IG 4221, Pant L 4, L 4717, IG 712128, IPL 406, IG 3802, IPL 315, IPL 161426, IG 114, VL 126, IPL 171410, IPL 225, IPL 8639, IG 4686 were recorded as moderately resistance (wilt incidence 10.1-30%).

Out of 188 pre breeding lines screened against wilt, one line (IPL 406 x IG 136667-1) showed highly resistant reaction against wilt. Forty others genotypes showed wilt incidence between 15.78 – 30% and were therefore categorized as moderately resistant.

Out of 24 wild accessions, 11 (IG 146777, ILWL 20, ILWL 168, ILWL 93, ILWL36, ILWL 149, ILWL 420, IG 136651, ILWL 432, ILWL 73, ILWL 92**)** showed resistant reaction, whereas 5 genotypes (ILWL 180, ILWL 174, ILWL 375, ILWL 398, 6, ILWL 63) showed moderately resistant reaction.



Fig. 1. A view of lentil wilt sick plot

4. Screening of urdbean genotypes against YMD

During last six years, >200 genotypes/ advanced breeding lines of urdbean were screened under field conditions using infector row technique (Figure 2) against yellow mosaic disease caused by *Mungbean Yellow Mosaic India Virus* (MYMIV). The identity of the causal virus was confirmed as MYMIV by PCR assays in the symptomatic leaves of urdbean genotypes. Among the genotypes grown consecutively for six years in *kharif* season, 43 showed resistant reaction (1-2 scale) against YMD and eight of them (IPU 10-1, IPU 96-6, IPU 99-220, IPU 13-7, NP 21, PDU-3, IPU 13-3, PLU 99-10 and IPU 12-4) consistently showed resistant reaction (disease rating scale 1) with no visible symptoms on leaves indicating that these genotypes have stable resistance for MYMIV. Rest of the genotypes showed moderately resistant or susceptible or highly susceptible reactions.

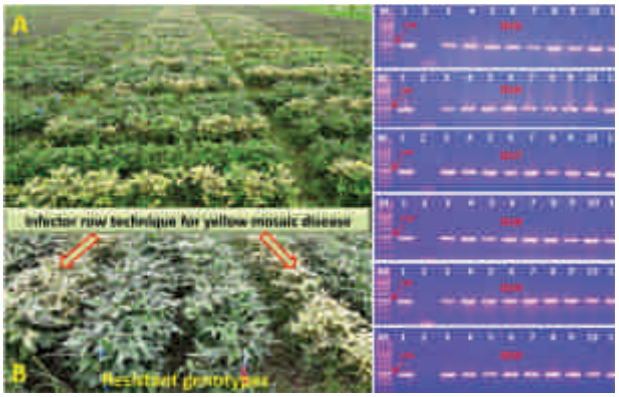


Fig. 2. Field view of the screening using infector row technique. Gel photographs showing presence of bands (~1kb) amplified from 10 randomly selected infected samples (lane 3-12).

5. Management of major soil borne diseases of chickpea through bio and chemo priming

The bioagents *Trichoderma asperellum* and *T. afroharzianum* proved effective in inhibiting chickpea pathogens such as FOC (86.39%) and *Rb* (81.70%) *in vitro*. The maximum germination percentage of 98.33%, 98.33%, and 95% were observed in *T. asperellum, T. afroharzianum* and *T. harzianum* treated seeds of chickpea (JG 62), respectively. The vigor index was highest (3584.25) in 12 hours soaked seeds with *T. asperellum* followed by *T. afroharzianum* (3417.08). The least mortality (40%) was observed in both *T. asperellum* and *T. afroharzianum* treated seeds at 12 hours of soaking. In seed germination, vigour index and mortality test, *T. asperellum* and *T. afroharzianum* gave better performance against *Fusarium* wilt of chickpea.

Among the different fungicides evaluated under *in vitro*, only two fungicides *viz*., thiophanate methyl (Topsin M) and carbendazim (bavistin) proved significantly effective at all the concentrations in inhibiting the FOC and Rb and this will be used for chemo priming study

The defense inducers such as salicylic acid (SA), adipic acid (AA) at 500 ppm concentration and potasium dichromate (PD) at 500 and 100 ppm concentration showed 100 per cent inhibition of *Ascochyta rabiei* under *in vitro* conditions using food poisoning method.

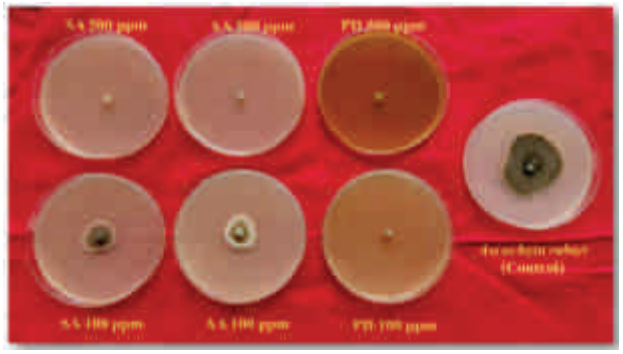


Fig. 3. SA: Salicylic acid, AA: Adipic acid, PD: Potassium dichromate ($K_2Cr_2O_7$)

Seed treatment with salicylic acid, adipic acid and potasium dichromate at higher concentration showed negative effect on seed germination with respect to delay in germination, blackening of seeds, reduced length of radicle and plumule.

6. Evaluation of fungicides against rust disease of chickpea

The efficacy of new chemical fungicides was evaluated against chickpea rust at Regional centre for off season nursery, Dharwad. The rust severity was significantly less in difenoconazole 25 EC 0.1% (17.8%) followed by azoxystrobin 20% +difenconazole 12.5% w/v 0.1% (24.1%), tebuconozole+ trifloxystrobin 0.1% (24.4%) and fluopyram 17.6%+tebuconazole 17.6% w/v 0.1% (31.1%). The maximum yield was recorded in azoxysrtobin 20% +difenconazole 12.5% w/v 0.1% sprayed plots (1419 kg) followed by difenoconazole 25 EC 0.1% (1331 kg) and tebuconazole+ trifloxystrobin 0.1% (1310 kg). Highest benefit-cost ratio was recorded in azoxystrobin 20%+difenoconazole 12.5% w/v 0.1% (1.78) sprayed plots followed by difenoconazole 25 EC 0.1% (1.69) and tebuconazole+trifloxystrobin 0.1% (1.59).

7. Secondary metabolite profiling of indigenous *Trichoderma asperellum* (IIPRTh-31) strain and their biocontrol potential against *Fusarium udum* causing wilt of pigeonpea

Co-cultivation increases the production of new secondary metabolites through the activation of signaling molecules. It also leads to the synthesis of enzymes to increase the metabolite production. It was found during the study that the phytopathogenic action and plant growth promotion potential of SHEP-6 and IIPRTh-31 increased under co-cultivation conditions.

The optimal TY medium was used for SHEP-6 and IIPRTh-31 cultivation was used and differential expression of secondary metabolites was analyzed and efficacy of the developed bio-consortia was tested for its plant growth promotion and biocontrol activity.

Fifty eight metabolites in the Dalhan bio-consortia were obtained, which was higher than the axenic culture of IIPRTh-31 (49 Metabolites) and SHEP-6 (41 Metabolites). In bio-consortia methyl cyclohexane, 6-nonylene alcohol, N-methyl pyrollidine, dermadin, ketotriol, koningin-A, and 3-(propenone)-4-(hexa- 2'-4'-dineyl)-2-(5H)-furanone were found which attributed in the antifungal activity. 2H-Pyran-3-ol, which acts as plant growth regulator and is helpful in mycotoxin detoxification was also detected in the *Dalhan* bio-consortia.

Seeds treated with the axenic and co-culture of *T. asperellum* (IIPRTh-31) and *B. subtilis* (SHEP-6) were essentially higher than control. The positive impact of seed treatment was also documented for seedling length, wet weight, dry weight and vigor index. The current research trend toward the development of biopesticides and biofertilizer focused toward the formulation of microbial consortia by mixing two separately grown microbial cultures.

Two different plant growth promoting and biological control agents were synergistically co-cultivated and optimized using the economic medium to reduce the production cost of two beneficial microbes at same time. Despite the different nature of two agriculturally important microbes, the co-cultivation of *B. subtilis* and *T. asperellum*, stimulated different signaling pathways and enhanced the production of antagonistic and mycoparasitism related enzymes, secondary metabolites, and plant growth promoting compounds.

8. Biocontrol Potential of Salt-Tolerant *Trichoderma* Isolates for the Management of pigeonpea wilt under Saline Environment

Out of 56 *Trichoderma* isolates studied, only one *Trichoderma* isolate IIPRTh-3 was able to grow at 11% of salt concentration, and showed maximum inhibition of mycelium growth. Under green house conditions pigeonpea plants obtained from bioprimed seeds of IIPRTh-3 showed better results in both germination and seedling in comparison to the control in saline soil. As compared to control, treated seeds showed higher levels of Photosynthetic pigments (Chlorophyll), Phenol and superoxide dismutase. This isolate also reduced the incidence of wilt in treated plants. This isolate was found more efficient in increasing salt stress tolerance in

pigeonpea and reducing the wilt disease.

9. Monitoring of viruses causing YMD in pulse crops

Total 55 leaf samples of 6 crops-mungbean, urdbean, cowpea, rajmash, pigeonpea and lentil and 9 weed plant species showing symptoms of viral etiology were collected to detect the viruses known to cause yellow mosaic (MYMIV, MYMV, HgYMV and DoYMV) in pulse crops. PCR results indicated that most of the crops were found to be infected with MYMIV, however, few cowpea samples showed the mixed infection of MYMIV, DoYMV and MYMV. Weed hosts such as *Pyrilenthus urinaria*, *Amaranthus californicus*, Alligator weed and Shaggy shoulder weed were found to harbour the MYMIV. YMD susceptible mungbean (DGGV-2) and Urdbean (MDU-1) were grown during summer and *kharif* to monitor the seasonal variation in the disease development. Development of YMD on both mungbean and urdbean grown in summer was relatively slow and less in comparison to *kharif*. The incidence and severity of YMD was comparatively more in urdbean than mungbean.

10. Diagnostic of seed borne viruses

For the development of diagnostics of five targeted seed born viruses (AMV, PSbMV, CMV, BCMV and BYMV), a total of 10 pairs of primers were designed using the sequences available at NCBI. Symptomatic leaf samples of pea suspected to be infected with PSbMV were processed. RT-PCR detection protocol to detect PSbMV was standardized. RT-PCR tests were successful as indicated by the presence of amplicons of the expected size in symptomatic plant samples and no amplicon in healthy samples. RT-PCR products from all the five samples (Fig. 3) with apical rosetting analysed by electrophoresis in 1% agarose gel revealed presence of band of expected size (~800bp). The amplicons were cloned and sequenced. Sequence analysis showed 99.49-88.5% nt similarity with PSbMV isolates.

Entomology

1. The pest diversity in long duration pigeonpea

The pest diversity of pigeonpea included 22 insect pests belonging to five orders *viz*., *Hemiptera, Lepidoptera, Coleoptera, Thysanoptera* and *Diptera* of the class *Insecta*. The pests belonged to nine families of hemiptera, six families of lepidoptera, five from coleopteran families and one each family from thysanoptera and diptera.



Fig. 4. Symptoms of viral etiology on fieldpea plants (A-E) suspected to be infected with PSbMV. Gel of RT-PCR products of the primers PSbMV-F/PSbMV-R; M=1kb DNA Ladder, Lane 1=healthy leaves of field pea, Lane 2-6=Samples showing mosaic and rosette,, amplified the expected size of cDNA fragment.

The leaf webber [*Grapholita critica* (Meyr.); Lepidoptera: Tortricidae] incidence was noticed from vegetative to pod maturity stage in both *Bahar* and IPA-203 pigeonpea. The incidence ranged from 0.31 to 1.54 webs per plant in *Bahar* and 0.12 to 3.00 webs per plant in IPA-203 with peak incidence during 46 and 48 MSW, respectively.

The activity of pod borer moths (*H. armigera*) was noticed from 43 to 16 MSW. The trap catches ranged from 0.50 to 80 moths per traps in IPA-203 and 0.50 to 78 moths per trap in *Bahar* with peak activity during 14 and 16 MSW, respectively.

The pod damage due to pod borer (*H. armigera*) ranged from 2 to 14 % in IPA- 203 and 4 to 16 % in *Bahar*. Pod fly caused 6 to 32% damage in IPA- 203 and 34 to 60 % in *Bahar*.

2. Population trend of *H. armigera* (Hubner) and *Spodoptera litura* (Fabricius) during the year 2021

A major peak with a maximum number of 179 moths of *H. armigera* was trapped in the 13 SMW whereas a small peak with only 18 moths was recorded in the 46 SMW. A maximum of 101 moths of *S. litura* was observed trapped in the 36 SMW (Fig. 5).

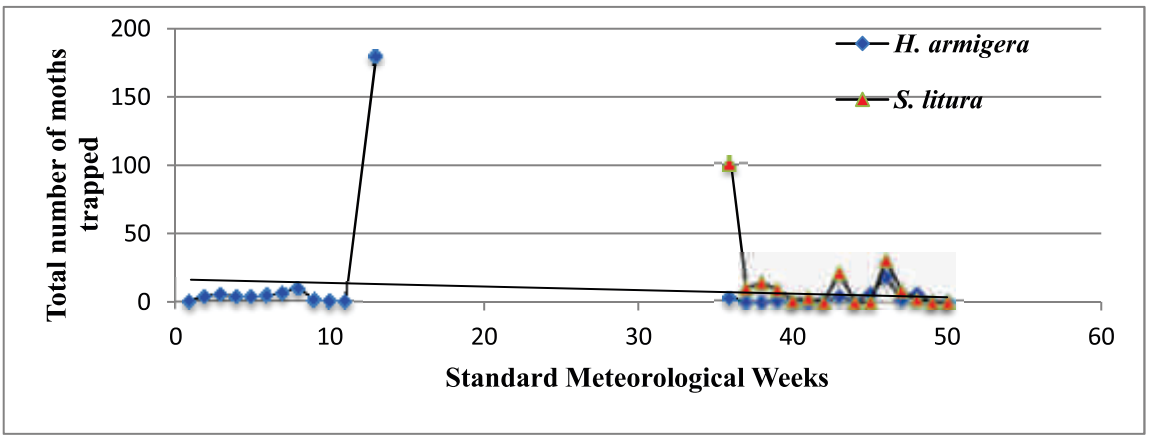


Fig. 5. Number of moths of H. armigera and S. litura trapped during the year 2021

3. Population trend of Whitefly, *Bemisia tabaci* (Gennadius) in greengram and blackgram during 2021

The population trend of whitefly, *B. tabaci* in the year 2021 was similar to the previous year 2020 in a way the major peak was observed in summer season against kharif. The maximum number of adult whiteflies was recorded in the 23, 24, 25 and 26 Standard Meteorological Weeks (SMW) *i.e.* 120, 70, 140 and 145 in greengram while in blackgram it was recorded as 141, 243, 270 and 282, respectively. The blackgram crop ecosystem recorded higher number of whiteflies as compared to greengram (Fig. 6).

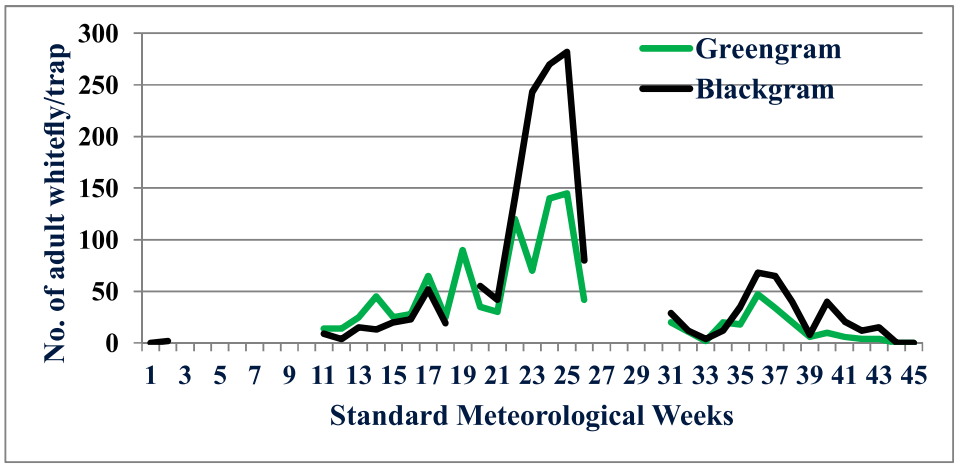


Fig. 6. Number of adult whitefly per yellow sticky trap in greengram and blackgram crop ecosystem during the year 2021

4. Evaluation of different sowing time of summer greengram with respect to incidence of major sucking insect pests

A field experiment was conducted to see the effect of sowing time with respect to incidence of major sucking insect pests *viz.*, whitefly, aphids, thrips and pod sucking bugs. Sowing of mungbean variety IPM 205-7 (Virat) was done on three different dates *i.e.* 5th April (early), 15th April (mid) and 25th April (late). It was observed that, at vegetative stage (30 DAS), infestation of whitefly, *Bemisia tabaci* (Gennadius) was significantly higher in mid and late sown crops, each with 5.14 adult whiteflies per plant, as compared to the early sown crop (1.31 adult whiteflies per plant) (Fig 6-a). At flowering stage (42 DAS); infestation was significantly higher in mid-April sown crop (6.42 adult whiteflies per plant) as compared to early (3.6 adult whiteflies per plant) and late sown (1.91 adult whiteflies per plant) crops. Aphid (*Aphis craccivora* Koch.) was observed significantly higher both at vegetative (10.85 infested plants per 30 sq-meters) and flowering stages (8.71 infested plants per 30 sq-meters) of the early sown crop as compared to mid and late sown crops (Fig 6-b). Aphid infestation was negligible at flowering stage of mid sown crop and at both vegetative and flowering stages of the late sown crops. Thrips population was observed

significantly low (2.02 thrips per flower) in early sown crops as compared to mid (10.71 thrips per flower) and late sown (10.5 thrips per flower) crops which were found at par with each other (Fig 6-c). Incidence of *Bagrada hilaris* (Burmeister) was noticed throughout the crop period with similar population (4.92, 3.14, and 3.64 bugs per meter row length) in early, mid and late sown crops, respectively (Fig 6-d).

5. Development of liquid bioformulation of indigenous *Bacillus thuringiensis* strains for enhancing its shelf life and field-efficacy

The spore crystal mixture of 2 *Bt* strains (F8.IIPR and Ak2.IIPR) were extracted and stored for liquid bioformulation development. Among the 7 different vegetable oil deployed, Olive oil and mustard oil had the highest absorption for UV A & B [Fig 7A]; While castor oil exhibited highest absorption only for UV-A followed by sesame oil and rice bran oil. Four invert emulsions *viz*., IE9, IE11, IE13 & IE14 were found to be >70% stability for a period of > 60 days [Fig 7B]. The preliminary field test of IE9 against *H. armigera* in chickpea (*cv* Shubra) revealed lowest larva per plant (0.00 & 2.00) from emamectin benzoate followed by IE9 (2.33 & 2.67) and Indoxacarb (3.33 & 0.67). Untreated control recorded highest larva per plant in both sprays (15 & 10) at 7 days after spraying during 1st spray and 2nd spray. Similarly, the lowest per cent pod damage (3.2% per plant) than untreated control (21.79% per plant) [Fig 7C]. The average yield was the highest for emamectin benzoate (2.4kg/30m^2) which was statistically superior than Bt IE9 (1.70 kg/30m^2) and indoxacarb (1.64 kg/30m^2). The lowest yield was recorded from untreated control (1.02 kg/30m^2) [Table 1 & Fig 7D].

Table 1: Efficacy of indigenous *Bt* formulation (IE9) in comparison with other insecticides

Treatment	% Pod damage/plant	Yield (kg/30m^2)
Indoxacarb14.5 sc@1ml/l	8.45 (15.86^b)	1.64 (1.46^b)
Bt (IE9)	3.20 (10.11^b)	1.70 (1.48^b)
EB @ 11g ai/ha	5.10 (13.02^b)	2.40 (1.70^a)
control	21.79 (27.21^a)	1.02 (1.23^c)

* Values within parenthesis are arcsine transformed

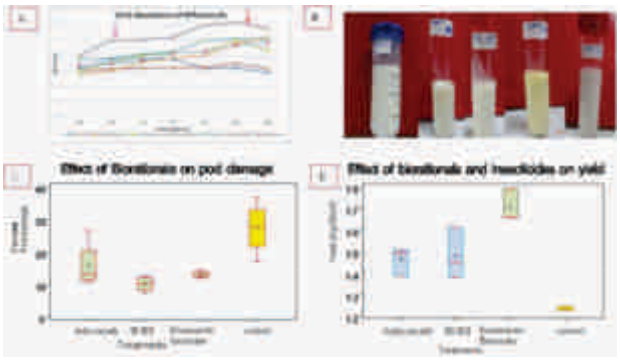


Fig. 7. Stability and efficacy of indigenous *Bt* based invert emulsion against chickpea pod borer

6. Screening of pigeonpea derivatives of *Cajanus scarabaeoides* for identifying its tolerance against pod borer

Under No choice assay condition

The field screening of 42 pigeonpea genotypes against natural infestation of pod borer (*Helicoverpa armigera* Hubner) and pod fly (*Melanagromyza obtusa* Malloch) revealed that pest susceptibility percentage varied from -236.51 (WDN2 136-4-2) to 54.91 (IPAWD28-1); while the check Asha, Maruti, PKV tara and ICPL87 had scored 0.11, -8.11, -488.50 and -5.66. The pest susceptibility rating (PSR) revealed that 3 genotypes (WDBCE4-4-5, WD12-2-1 and UPAS120) has scored PSR 5; Similarly, 5 genotypes (WDBCE5-3-1, WDBCE6-3-4-3, WDBCE6-3-4-6, WDBCE6-3-4-7 and IPAWD14-2) had scored 4 while 1 genotype (IPAWD 28-1) had scored PSR 3. All the 9 genotypes had recorded <10% seed damage and subsequently grouped as least susceptible category based on PSR resistant. The same genotypes were subjected to no choice assay against 7 days old *H. armigera* by deploying detached pods under lab condition which also revealed that WDBCE6-3-4-7 as the most tolerant genotype based on per cent decrease in pod consumption (95.17 g) followed by WDBCE 6-6-2-2 (94.76 g) and WDBCE 5-6-5-1 (87.57 g).

7. Field-carry-over infestation of *Callosobruchus maculatus* F. and its impact on stored pigeonpea

Investigations to identify the bruchid field infestation window and the impact of field-carry-over infestation on stored pigeonpea was carried out during *kharif* 2020-21 as per the systematic methodology (Revanasidda *et al.*, 2020). The bruchid infestation (*Callosobruchus maculatus* L.) commenced from 8th WAFI and the pod damage was recorded from 10th WAFI. Infestation parameters found incremental towards crop maturity. The infestation

(%), damage (%), and adult bruchid density (mean±SE) per plant ranged between 0.86–7.26, 0.32–4.37, and 1.1±0.06–6.3±0.49, respectively. Although bruchids preferred completely developed green pods over matured dry pods, the correlation studies demonstrated a significant positive correlation (at P=0.01) with dry pod density than green pods. The pods harvested from the plants which were caged between 2–6th WAFI recorded nil infestation, whereas, the pods from the plants caged after 6th WAFI recorded higher infestation parameters at one MAS. Besides, the grains which were harvested from the plants caged between 2–6th WAFI remained undamaged during storage, whereas, the grains harvested from the plants caged after 6th WAFI recorded significant grain damage with increase in storage duration due to the continuous perpetuation of infestation and damage reaching to > 90 per cent within six months of storage.

8. Post-harvest management of secondary bruchid infestation at storage level

Among the three disinfestation treatments (Sun drying, fumigation with AlPH3 and Gamma Irradiation) and five packaging materials (Gunny, Polypropylene (PP), PP Wooven, LDPE and HDPE bags) evaluated, the pre-storage disinfestation treatments with fumigation with AlPH3 56 % w/w @ 3 tablets (9 gram) per tonne of grains and Gamma (Cobalt 60) irradiation @ 0.2 kGy were effective in complete eradication of bruchid infestation.

Within packaging materials, HDPE bags were the most effective in prevention of further perpetuation of bruchid infestation and damage during storage followed by PP>LDPE>PPW, whereas, gunny bags found ineffective in preventing further perpetuation of bruchid infestation and damage during storage. Hence, the combination of AlPH3 fumigation or Irradiation with HDPE is most effective in both eradication of initial bruchid infestation and their perpetuation during storage.

9. Characterization of bruchid diversity infesting mungbean and cowpea

The bruchid infested grain samples of cowpea and mungbean were collected from all the ten selected locations. The observations on infestation parameters on grain samples from 10 locations indicated that the percent infestation and damage by bruchids ranged between 6.37–54.91 and 0.6–47.25, respectively. The egg density per grain and adult density per 100 gram grains ranged between 0.11–1.56 and 14–531, respectively.

There were seven species of bruchids collected from infested samples and were identified as *Callosobruchus chinensis* L., *Callosobruchus analis* F., *Callosobruchus maculatus* F. and *Callosobruchus theobromae* (L.). The species identified needs to be further confirmed through molecular characterization and the pure cultures of identified species are being maintained at laboratory for phosphine bioassay studies.

10. Variability for phosphine susceptibility in bruchids

The location-specific bruchid populations were subjected to phosphine bioassay to ascertain their susceptibility to the fumigant AlPH3 following FAO method. The bioassay studies to estimate LC50 values indicated that the doses required to achieve 50 per cent mortality was ranged between 0.09 to 0.032 mg L for the adults collected from different locations.

Nematology

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

Kharif Pulses (Pigeonpea, Mungbean and Urdbean)

Five pigeonpea lines, 12 mungbean and 17 urdbean lines were evaluated for their resistance against root-knot nematode, *Meloidogyne javanica*. In *pigeonpea*, out of 5 lines, 2 lines Pusa 992and TDRG -59 were highly resistant, two lines IPAE 15-06 and Pusa 2018-4 were resistant and one line KA 17-2 was moderately resistant. In mungbean, out of 12 lines one line KM 2241 was resistant and 4 lines namely Pusa BM 5, IPM 312-394-1, IPM 02-3 and MH 2-15 were moderately resistant. In urdbean, out of 17 lines 4 lines namely OBG 41, PU 1541, TPU 4 and TU 94-2 were moderately resistant to *Meloidogyne javanica*.

Rabi pulses (Chickpea, lentil and fieldpea)

Fifteen wild accessions of chickpea, 36 lentil and 30 fieldpea lines were evaluated against root knot nematode, *Meloidogyne javanica*. Out of 15 wild chickpea accessions, 1 accession ICWL 81 was moderately resistant and remaining all accessions were susceptible. All 36 lines of lentil were susceptible. Out of 30 fieldpea lines, 3 lines *viz*., HFP 9907-B, IPFD 19-1 and HFP 1574 were moderately resistant and remaining all lines were susceptible.

2. Screening for resistance against Pigeonpea cyst nematode, *Heterodera cajani*

Pigeonpea

Forty six lines which showed highly resistant and resistant reaction previous year and five other lines of pigeonpea were evaluated against *Heterodera cajani* in 3x2 feet cemented pots filled with nematode infested soil at a level of 5-8 cysts/100 cc soil. Four lines namely, WD 2019-45-2, WDBCE 4-5-3-9, WDBCE 9-4-3-1and WD 2019-35 were observed highly resistant. three lines namely, WD 2019-40-1, WD 2019-40-2 and WD 2019-45-1 were resistant, 10 lines were moderately resistant and remaining lines were either susceptible or highly susceptible to *H. cajani*.

Urdbean

Seventeen lines of urdbean were evaluated against *H. cajani*. six lines namely, BDU 12, IPU 2-43, OBG 41, Pant U 31, PU 1617, SKNU 1716 were observed as moderately resistant. Rest all lines were either susceptible or highly susceptible to *H. cajani*.

Mungbean

Out of 12 lines screened against pigeonpea cyst nematode, *Heterodera cajani*, 7 lines were highly resistant, 3 resistant and 2 moderately resistant. This confirmed mungbean as poor host of *Heterodera cajani*.

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

The trial was repeated 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, and Neemcake @ 1000 kg/ha, nematicide carbofuran 3G @ 1.5 kg a.i./ha and control were taken. Four replications were taken for each set of covering under polyethylene and uncovered. The plot size was taken 2x2.5 m. The mustard varieties were grown on equivalent area of plot size for about one and half months prior to incorporation of treatments.. The plants were cut, chopped and mixed with the soil followed by light watering on November 18, 2020. Alternate replication were kept covered with polyethylene and uncovered. Ten days after covering, the covers were removed and soil samples were collected to record the juvenile population. Same day sowing of chickpea variety ICC 2005-62 was done. Three months after sowing plant height, branches and pod numbers were recorded.



Fig. 8. Lay out of the experiment

The reduction in juvenile population in all treatments over control was significant after 10 days of treatments. The covering of plots after treatment gave more control than without cover. Maximum reduction (77.2%) under covering with polyethylene sheets was recorded in Karan Tara.

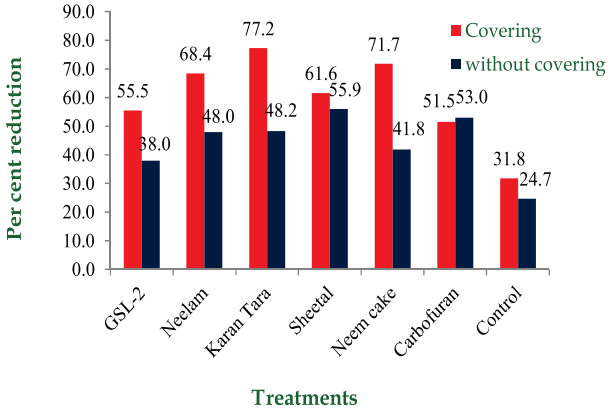


Fig. 9. Per cent reduction of root knot nematode juvenile population over initial population in soil after 10 days of treatment and covering

The plant height was more in bio-fumigated plots along with neem cake and nematicide compared to control. The plant height was more in treatments covered with polyethylene sheet after treatment except in treatments Karan Tara and Sheetal where there was no effect.

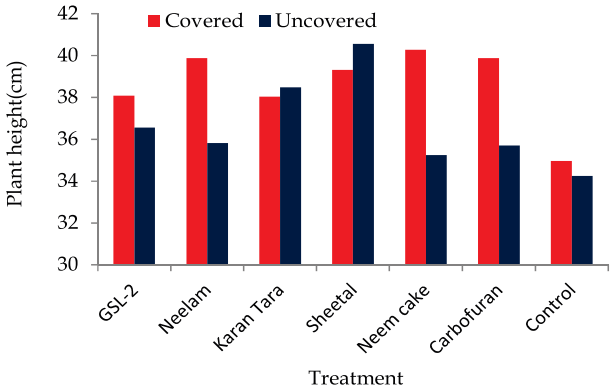


Fig. 10. Treatment effects on the plant height after three months of sowing

4. Compatibility between Nematode Biocontrol Agents and *Rhizobium*

In order to find out the ability for co-culturing of nematicidal potential strain of Actinobacteria (IIPR:KR01:03 *Streptomyces ginkgonis* (accession no: MN966860) with already identified potential strains viz., *Purpureocillium lilacinum* (IIPR-*Pl*-11), *Trichoderma harzianum* (IIPR-*Th*-64), *T. asperellum* (IIPR-*Ta*-31), *Bacillus cereus* (IIPR-*Bc*-14) and *Pseudomonas fluorescence* (IIPR-*Pf*-4), we carried out Dual Plate Assay. The results showed that all the strains are mutually inclusive and compatible. We also carried out dual plate assay to test whether all identified strains are having any adverse influence on *Rhizobium* from three crops *viz.*, chickpea, field pea and lentil or not? The results indicated that the strains do not have any antagonism towards *Rhizobium* and they are mutually inclusive (Table-2).

Table 2: Compatibility test of potential strains with *Rhizobium*

	P. lilacinum (IIPR-*Pl*-11)	*T. harzianum* (IIPR-*Th*-64),	*T. asperellum* (IIPR-*Ta*-31),	*B. cereus* (IIPR-*Bc*-14)	*P. fluorescence* (IIPR-*Pf*-4).	*Streptomyces ginkgonis*
Streptomyces ginkgonis	+	+	+	+	+	NA
Chickpea Rhizobium	+	+	+	+	+	+
Fieldpea Rhizobium	+	+	+	+	+	+
Lentil Rhizobium	+	+	+	+	+	+

5. Molecular Characterization of *M. incognita*

The genomic DNA from adult female of *M. incognita* was extracted through Worm Lysis Buffer (WLB) method described by Li et al.,1988 with slight modification. The ITS1-5.8S-ITS2 region was amplified with ITS primers and the purified PCR products were sequenced. The species of all the sequences was identified as *M. incognita*. The sequences were aligned through CLUSTAL W, trimmed, submitted and received accession numbers from NCBI. The well characterized strains of *M. incognita* will be used for various nematological research.

Organism	Strain	Sequence	Accession
Meloidogyne incognita	IIPR-Mi-1	ITS1-5.8 S-ITS2	MZ960901
Meloidogyne incognita	IIPR-Mi-2	ITS1-5.8 S-ITS2	MZ960902
Meloidogyne incognita	IIPR-Mi-3	ITS1-5.8 S-ITS2	MZ960903
Meloidogyne incognita	IIPR-Mi-4	ITS1-5.8 S-ITS2	MZ960904
Meloidogyne incognita	IIPR-Mi-5	ITS1-5.8 S-ITS2	MZ960905
Meloidogyne incognita	IIPR-Mi-6	ITS1-5.8 S-ITS2	MZ960906

Externally funded Projects

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

The incidence of wilt disease commenced during 48th MSW (Meteorological Standard Week) *i.e.*, November, and incidence peaked in 10th MSW *i.e.* March. During all the years of observation, the disease initiated at flowering stages of crop in the last week of October and gradually increased with scarcity of moisture in the soil. The mean wilt incidence ranged from 0-25.5 per cent during all years of observations. The maximum wilt incidence (25.5percent) was recorded during 2016-17 of experiment in most of the chickpea and pigeonpea growing areas of the country. Occurrence of pod borer started during first Meteorological Standard Week (MSW) in the month of January and the highest larval population was recorded in March first week i.e., 9th MSW. The maximum pod borer incidences (1.40 larval/plant) were observed during the year of 2015-16 in most of the chickpea and pigeonpea growing areas of the country.

The weather parameters *viz.*, maximum and minimum temperatures (Tmax, Tmin), relative humidity (RH) and rainfall had variable association

with wilt and pod borer incidence. Though none of the weather parameters significantly correlated with wilt incidence (Fig. 16).The incidence of diseases was positively correlated with Tmax (r=0.35), Tmin (r=0.39) and rainfall (r=0.43); and negatively with RH (-0.32). Pod borer was positively correlated with Tmax (r=0.33), Tmin (r=0.37) and rainfall (r=0.41) and negatively correlated with relative humidity (-0.26).

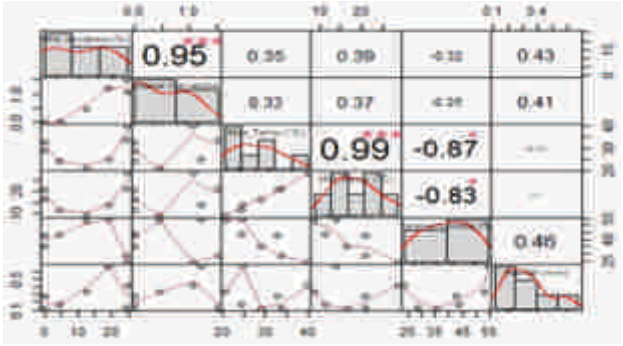


Fig. 11. The correlation matrix of incidence of wilt and pod borer; and weather parameters

The relationship between weather parameters and wilt and pod borer is depicted in fig. 14. Among the various weather parameters, the coefficient of determination was the highest (R^2=0.18) when independent variable was rainfall.

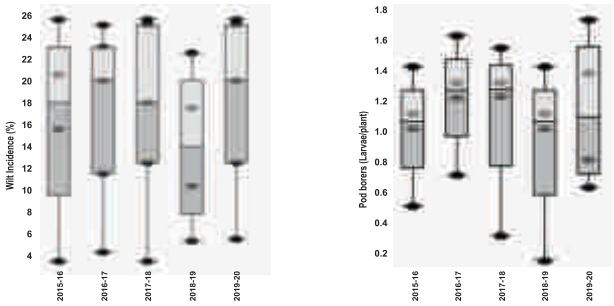


Fig. 12. Boxplot of wilt and pod borer incidence from 2015-16 to 2019-20. The line in the box indicated median value. The box boundaries are upper and lower quartiles whiskers represented minimum and maximum values.

Project : DBT network project: Genetic enhancement of minor pulses

A total of 182 samples of mungbean, urdbean, cowpea, horsegram and mothbean collected from different parts of the country were processed for the characterization of YMD causing viruses (MYMIV, MYMV and HgYMV) and to understand the diversity. PCR detection using specific primers indicated the mixed infection of three (MYMIV, MYMV and HgYMV) viruses in 5.88% samples, two viruses in 26.47% samples and 55.88% samples showed the infection of single virus. A total of 127 full lengths DNA-A and/or DNA-B molecules of YMD causing viruses were obtained to understand the genetic diversity and submitted at NCBI database. Analysis of sequences further confimed the association of three virus species *viz.*, *Mungbean yellow mosaic India virus* (MYMIV), *Mungbean yellow mosaic virus* (MYMV) and *Horsegram yellow mosaic virus* (HgYMV). The nucleotide diversity in DNA-A of the respective species remained within the species threshold level that is = or > 91%. However, MYMIV had more diversity (1-9%) in DNA-A followed by 1-8% in HgYMV and 1-4% in MYMV. Nulecotide sequence diversity in DNA-B molecules of all the three viruses is relatively low- 2-7% in comparision of DNA-A molecules.

A detailed analysis of genetic diversity of YMD causing viruses involved in mothbean revealed the presence of multiple DNA-A and DNA-B molecules of MYMIV, MYMVand HgYMV. The seven DNA components from moth bean sample (Mo1) obtained consisted of three DNA-A (MYMIV, MYMV and HgYMV) and four DNA-B having the sequence similarity with the respective virus species. One additional DNA-B molecules present in Mo1 sample was confirmed to be the cognate of MYMIV based on common region sequence identity. This indicated that MYMIV shared its cognate sequences with two DNA-B molecules. Recombination analysis of DNA-A and DNA-B of the three viruses (MYMIV, MYMV and HgYMV) indicated exchange of genetic materials amongst themselves. Segment DNA-A of HgYMV-Mo2 isolate had DNA-A of HgYMV-Mo1 as one of the major parents and DNA-A of MYMV-Mo1 and MYMV-Mo2 as minor parents. DNA-A of MYMV-Mo1 and Mo2 had HgYMV-Mo1 as one of their major parents. Similarly, DNA-B of HgYMV-Mo1 and HgYMV-Mo2 had MYMV-Mo1-B1 as one of the major parents and ToLCGV as minor parent. Recombination studies indicated that the presence of mixed infection of begomoviruses in a host plant provides opportunities for the exchange of DNA between the species which may lead to the development of new strain/virus species.

Improved screening method for identification of resistance to bruchids in pulses

The methodology challenged the genotypes to intense oviposition by the bruchids in both the tests and incubate infested seeds for F_1 adult emergence after providing sufficient time for insect development under controlled conditions (Fig. 13). The genotypes exhibiting resistant reactions in the free-choice test were further validated by challenging them to bruchid infestation in a single chamber. In no-choice test, the genotypes were challenged in individual plastic vials. The infestation parameters were recorded and the seed parameters

were correlated to the bruchid preference for different germplasm. Modifications in square shaped free-choice chamber used for free-choice (Fig. 14), exposing seeds to intense oviposition for 3–7 days, and F_1 emergence/seed damage count on daily basis from the first day of emergence till 20th-day post-emergence were the key modifications adopted in the methodology. Using this methodology, 104 mungbean, 50 urdbean and 25 cowpea germplasm were screened against three bruchid species. This methodology may serve as an essential tool to identify potential resistance sources in legume crops against bruchids and can provide a way to further elucidate the physical, biochemical, and molecular basis of resistance.

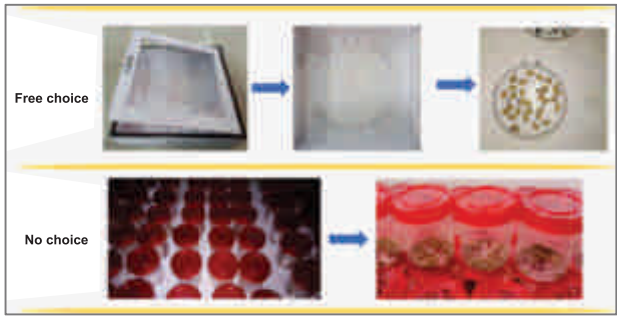


Fig. 13. 'Free choice' and 'No choice' tests for screening of pulses germplasm.



Fig. 14. Olfactory chambers to conduct 'free choice' screening test for pulses germplasm.

Identification of multiple bruchid species resistance in *Vigna* accessions

A set of 42 accessions from 13 *Vigna* species endemic to India were screened for resistance against three bruchid species (*Callosobruchus chinensis* L., *C. maculatus* F. and *C. analis* L.) in storage Entomology Laboratory, Division of Crop Protection, ICAR-Indian Institute of Pulses Research (IIPR), Kanpur, India during 2019-2021. Among the 42 accessions, four accessions of *V. umbellata* (IC251439, IC251442, PRR 2007-2 and C251440) and two accessions of *V. vexillata* (IC248326 and IC248343) were found resistant against *C. chinensis* and *C. maculatus* in FC and NC test. However, the accessions of *V. khandalensis* (Kumur local) and *V. mungo* var. *mungo* (IC251397, IC251390, IC251385 & IC251387) were found to be resistant only against *C. chinensis* under FC and NC tests. Few accessions belonging to *V. trinervia* (JAP 10-51), *V. trinervia* var. *bournei* (IC247407), *V. pilosa* (IC210575, IC210580 and IC210576) and *V. dalzelliana* (IC203864) recorded a variable bruchid damage score (5–7) and SI values (0.02–0.07) and were found moderately resistant/susceptible against *C. chinensis* and *C. maculatus* , whereas, the same lines were consistently reported to be moderately susceptible to *C. analis*. The resistant lines need to be further subjected to biochemical analysis to identify the specific seed biochemical components offering resistance to bruchid damage in these *Vigna* species. This is one of the pioneer reports on identifying the multiple bruchid species resistance in different cultivated and wild endemic *Vigna* species. The identified accessions could be deployed in the breeding programmes across different *Vigna* species to develop varieties with resistance to bruchid infestation. These identified accessions are already approved by GIC of the Institute and soon they will be registered as unique accessions at NBPGR, New Delhi.

Project : Bio-prospecting plant essential oils for insecticidal properties against pulse beetle infesting stored legumes

Bioactivity of plant volatile oil extracts to bruchid species

The plant essential / volatile oil extracts (EOs) from 15 plant species exhibited contact toxicity to pulse beetle, *Callosobruchus analis* (F.). The *Pogostemon patchouli* EO showed higher contact toxicity (0.040 µl/cm^2) to 0-3 days old adults of *C. analis*. Test EOs from 12 plant species exhibited repellent action on adults of *C. analis*. Repellency ranged from 25 (*Mentha piperata*) to 99 % (*Cymbopogon martini*) against 1-3 d old beetles of *C. analis*. Of which 7 EOs categorized as *Class*-V repellents, 3 EOs belonged to *Class*-IV, one each was *Class*-III and *Class*-II repellent on the basis of McDonald (1970) Repellency Class. The EOs of 14 plant species showed fumigant toxicity to 1-3 day's old adult beetles and LC_{50} values were ranged from 21.72 to 573.57 µl/L. The *Cuminum cyminum* (21.72 µl/L) showed highest fumigant toxicity to adult beetles. The EOs from six plant species demonstrated potential ovicidal action in fumigation assay and completely inhibited (0 % egg hatching) the hatching in five days old eggs of *C. analis* at lethal concentrations (Fig- 15). The EOs from four plant species (*Cymbopogon martini, C. winterianus, Tagetes minuta* and *Acorus calamus*) demonstrated > 75 % oviposition deterrency to *C.*

analis female beetles and over 80 % inhibition to F1 progeny emergence.

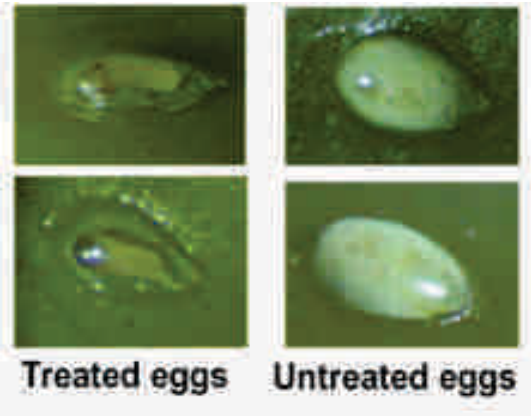


Fig. 15. The bruchid eggs at 7 days post-exposure to volatile oil extracts

Project : Management of wilt disease in pulse crops using bio-formulation.

Field evaluation of a talc based formulation of *Trichoderma*:

Two trials, each in Hamirpur and Banda district, were conducted on the efficacy of Dalhanderma against lentil wilt in farmers field using lentil variety IPL 321. Bioformulation was applied as seed treatment. In Hamirpur the trials were carried out in village Kusmura whereas in Banda the trials were carried out at village Khurhand. Results indicated that the bioformulation Dalhanderma reduced wilt incidence by 21-32% in Hamirpur and 18-21% in Banda district. Grain yield was also recorded and the results indicated an increase in yield by 19-27% (Table 3,4; Figure 16).

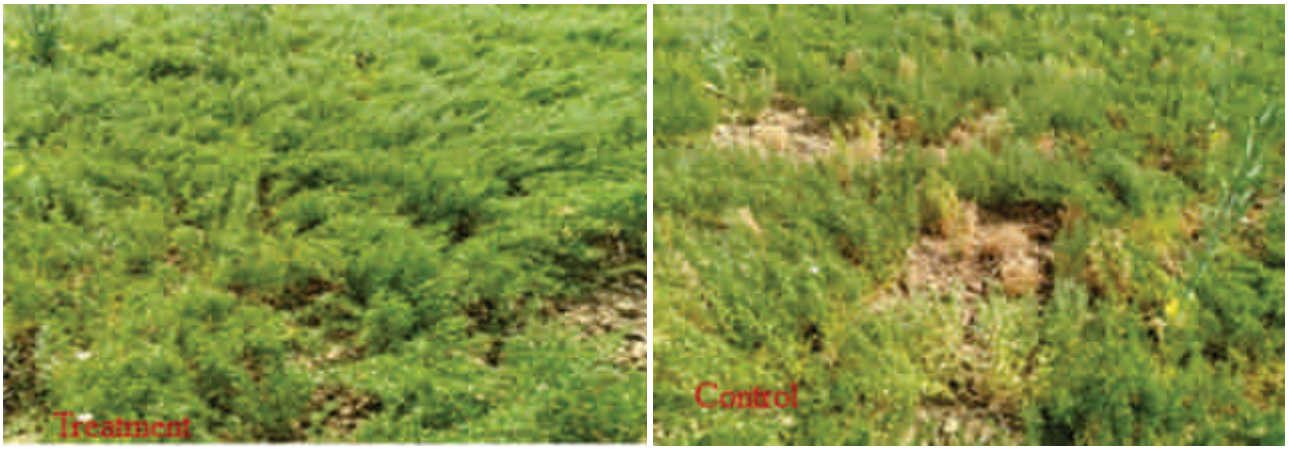


Fig. 16. A view of lentil crop at farmers field at Hamirpur, *Trichoderma* treated (left) and untreated (control) (right)

Table 3. Reduction in lentil wilt and increase in yield by seed treatment with *Dalhanderma* at Kusmura village, Hamirpur district.

Hamirpur	wilt incidence %		% reduction over check	Yield q/ha		% increase over check
	Treated	Check		Treated	Check	
Trial 1	15.3	22.5	32.00	11.2	9.4	19.14
Trial 2	18.06	22.8	20.78	10.8	8.8	22.72

Table 4. Reduction in lentil wilt and increase in yield by seed treatment with Dalhanderma at Khurhand village, Banda district.

Banda	wilt incidence %		% reduction over check	Yield q/ha		% increase over check
	Treated	Check		Treated	Check	
Trial 1	19.28	24.95	20.94	10.80	8.5	27.05
Trial 2	18.64	22.61	17.55	9.20	7.7	19.48

Basic Science

Programme 1 : Physio-biochemical interventions for improving climate resilience and nutrition enriched pulses.

Project: Identification and physiological characterisation of high-temperature and drought tolerant genotypes of lentil (*Lens culinaris* Medik.) for improving productivity and resilience

Screening for heat tolerance in lentil

A field experiment was conducted during *Rabi* season 2020-21 involving 52 genotypes of lentil for the third consecutive year for screening to heat tolerance. Sowing of the crop was done under timely (normal) and late sown (one month) conditions on ridge beds in 2 replications following the standard package of practices so that crop may be exposed to normal as well as higher temperature (>30^{0}C) at flowering. Morphological, physiological and biochemical observations apart from yield and yield attributes were recorded for screening of genotypes. Crop vigour was recorded at periodical intervals (15 days) using green seeker hand held crop sensor (Green Seeker portable NDVI). Nitrogen balance index (NBI), chlorophyll index, flavonoids and anthocyanin was 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 recorded 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 was also recorded at higher temperature (>30^{0}C). It was observed that higher crop vigour, Photosynthesis rate, MSI, pollen viability, pod formation in terminal branches, pod development and grain filling rate are the most important parameters which was severely affected when temperature increased beyond 30^{0}C. Perusal of all the data recorded from each of the genotypes from normal and late sown crop revealed that genotypes IG 3522, IG 4112, IG 2959, IG 2960 and IG 2507, respectively performed better and showed relatively higher tolerance towards heat stress.

Screening for drought tolerance in lentil

An experiment was conducted under rainout shelter during *Rabi*- season 2020-21 with 45 genotypes of lentil in 2 replications at NRC for screening to drought tolerance. Soil samples were collected from 0-15 cm and 15-30 cm depth for monitoring of soil moisture at periodical intervals. Morphological, physiological and biochemical observations apart from yield and yield attributes were recorded for screening of genotypes. Crop vigour was recorded at periodical intervals using green seeker hand held crop sensor (Green Seeker portable NDVI). Nitrogen balance index (NBI), chlorophyll index, flavonoids and anthocyanin was measured using chlorophyll SPAD meter. MSI and leaf Relative Water Content (%) was also measured from all the genotypes. It was observed that the genotypes having higher crop vigor, MSI, NBI and Chlorophyll index could produce higher dry biomass and grain yield under rainout shelter. Genotypes such as IG 3522, IG2959, IG 2960, IG 2580, IG 2507 and IG 2754, respectively showed higher tolerance to drought.

A mapping population of 200 lines of lentil including parents *i.e.* 98/193 (P1), EC 208362 (P2) was initially screened for drought stress tolerance under dugout micro plot. It was observed that one entry (200 No. 98/193 X EC 208362) has high initial crop vigor in terms of plant height as well as biomass and matured at least 8-10 days early compared to other entries including parents. Physiological and biochemical observations such as periodical NDVI, Chlorophyll Index, NBI, Flavonoids, MSI, yield and yield attributes have been recorded. Another 160 pre-breeding lines of lentil were also screened for drought stress tolerance under dugout micro plot.

Project : Physiological Characterization of Pigeonpea Genotypes for Waterlogging Tolerance

Experiment was conducted to assess the water logging tolerance in pigeonpea including genotypes ICP-5028, ICPL-20241, ICP-149, MA-3, ICPL-2376, ICPL-87091, ICPL-87051, IPAC-79 (check for tolerance) and ICPL-7035 (Check for susceptibility). Water logging stress was imposed for 24h-48h-72h, having minimum depth of water 12 inches at 30 DAS with 03 replications. A set of all genotypes were sown under normal condition as control. Meteorological

data during water logging stress showed 6.7 mm rainfall, 26.15^{0}C (Min. temp.), 33.50^{0}C (Max. Temp.) and 75.55% (R.H). Morphological Scoring (0-3) at the end of water logging stress showed highest score (0) in genotype IPAC 79 (Check for Tolerant) followed by ICPL 87091, ICP 5028 and ICPL 20241 with 01 score. Pigeonpea genotypes namely ICP 149, MA 3 and ICPL 2376 showed moderate score (02). The lowest score (03) was recorded in ICPL 87051 which was at par with ICPL 7035 (Check for susceptibility). On the basis of morphological scoring, survival per cent and recovery, pigeonpea genotypes namely ICPL 87091, ICP 5028 and ICPL 20241 seems to be water logging tolerant. Genotypes like ICP 149, MA 3 and ICPL 2376 showed moderate reaction. Development of adventitious roots was observed under water logged condition only and it was recorded highest in IPAC 79 (Check for Tolerant) followed by ICP 5028, ICPL 2376, ICPL 20241 and MA 3 genotypes. Physio-biochemical parameters including NBI, Chlorophyll, NDVI and photosynthetic efficiency were markedly reduced under water logging conditions over control. The Flavonols, anthocyanin's, anti-oxidant enzymes SOD, peroxidase and soluble sugars in leaves were increased under water logging stress. Yield attributes and seed coat colour showed no definite trend and correlation with tolerance/ susceptibility of pigeon pea genotypes against water logging stress.



Fig. 1. Morphological performance of pigeonpea genotypes



Fig. 2. Development of adventitious roots in pigeonpea genotypes

The experiment was repeated in second year (2021-22) with a total of 21 genotypes/ varieties including checks *viz.*, these are IPAC-79, ICPL-7035, ICPL-20241, ICPL-87051, ICPL-87091, ICP-2376, ICP-5028, ICPL-149, MA-3, MA-6, NDA-1, IPA-15F, Bahar, IPA-203, IPAC-211, IPAC-202, RCM/DD-17, WB-2019/25, WB-2019/26, WB-2019/27 and IPAC-212. Water logging stress was imposed for 24 h-48h-72h, having minimum depth of water 12 inches at 30 DAS with 03 replications. A set of all genotypes were sown under normal condition as control. Meteorological data during water logging stress including rainfall, maximum and minimum temperature and relative humidity were recorded. Morphological Scoring (0-3) at the end of water logging stress was done. Root anatomical studies are in progress. Observations on photosynthetic efficiency, biochemical parameters including anti-oxidant enzymes activities have also been recorded. The experiment is in progress and observations on yield attributes are yet to be recorded at crop maturity.

Project : Identification and physiological characterization of urdbean genotypes for heat tolerance

Fifty six urdbean genotypes were sown in augmented design in field under irrigated condition to find out the heat tolerant genotypes. These genotypes were selected on the basis of their performance from a large number of genotypes and their phenology like 1st flowering, 50% flowering, 1st podding, 50% podding was observed. IPU 99-31, IC 21001 and IPU 13-1 were the smallest genotypes whereas; LBG 17 was the tallest among all the genotypes. Early flowering was observed from 34-36 days in IPU 99-200. Genotype LBG 787 takes maximum days to first flower. Genotype UH 85-15 takes minimum days for pod initiation whereas; LBG 787 takes maximum time for pod initiation. Urdbean genotype PGRU 95014, UH 85-15 takes minimum days to flower and LBG 787 takes maximum days to 50% flowering. Minimum number of pods was recorded in HPU 120 and maximum in genotype IPU11-02. Out of 56 urdbean genotypes, potentially high yielding genotypes UH 32-3, PLU 294, LBG 787, BG 367, IPU 2-43, BGP 247, IPU 94-1 were selected for further studies.

Evaluation of the pollen quality of urdbean genotypes under field condition

Heat stress causes serious challenges especially during reproductive stage causing significant yield loss. During screening of urdbean germplasm, we identified PGRU 95014, PGRU 95016 as heat tolerant varieties based on high number of pod setting/ primary branch under *kharif* sown condition and maintaining higher number of filled pods /plant. Two sensitive varieties namely LBG 20, IPU 99-123 were selected. Tolerant genotypes

showed high pollen viability at 36^{0}C temperature as shown in (Fig. 3) under field condition. Whereas, sensitive genotypes show less pollen viability. Thus, these lines could be potentially used as donor parent for transferring heat tolerant traits to superior high yielding heat sensitive urdbean varieties.

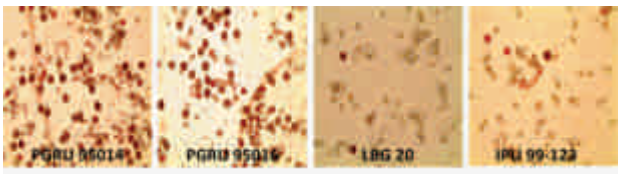


Fig. 3: Effect of heat stress on pollen viability

Project : Exploring common bean (*Phaseolus vulgaris*) genotypes for bioactive components associated with health promoting properties and flatulence

The galacto-oligosaccharides (raffinose, stachyose and verbascose) and other sugar (glucose, sucrose and maltose) content of thirty common bean genotypes (7 varieties, 3 indigenous germplasm and 20 exotic germplasm) were estimated using high performance liquid chromatography. The raffinose family oligosaccharides (RFOs) and sugars were extracted with 50% ethanol-water mixture. HPLC grade water was used as mobile phase and detection was done using refractive index detector. Hi-plex Ca column was used for the separation. The column temperature, flow rate, injection volume and total run time were 85C, 0.6 ml/minute, 10 µl and 25 minutes respectively. Retention time of verbascose, stachyose, raffinose, sucrose + maltose and glucose were 8.163, 8.416, 8.911, 9.679 and 11.362 minutes, respectively (Fig. 4).

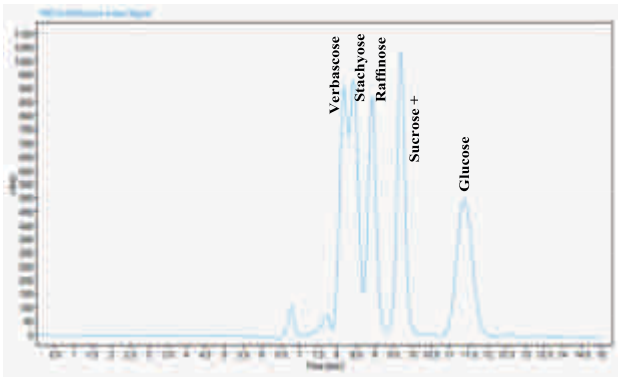


Fig. 4: Chromatogram depicting the retention time of different oligosaccharides and monosaccharides

It was observed that in common bean, stachyose and raffinose were the major alpha galactosides whereas verbascose was not detected in any of the analyzed genotypes. Sucrose and maltose were detected in all genotypes whereas glucose was detected in only some of the genotypes.

Stachyose content

Stachyose content ranged from 28.38 to 47.73 mg/g seed dry weight in seeds of common bean. Among the analyzed genotypes, the highest stachyose content was found in EC 14920 (47.73 mg/g of dry weight) and the lowest was found in Uday (28.38 mg/g of dry weight). The genotypes were categorized in to three groups based on their stachyose content *viz*., high (>40.00 mg/g of dry weight), medium (24.00 to 40.00 mg/g of dry weight), and low (<30.00 mg/g of dry weight) stachyose content. Most of the genotypes had medium stachyose content. Stachyose content was maximum in the indigenous germplasm.

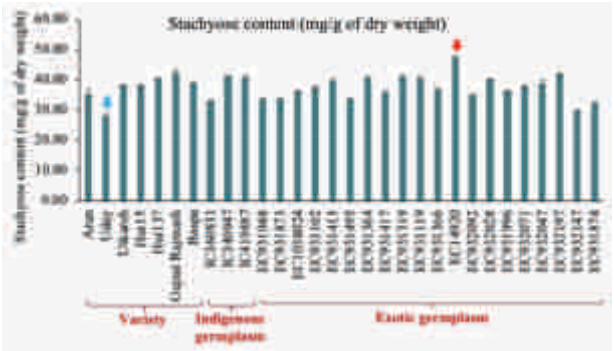


Fig. 5. Stachyose content of common bean genotypes

Raffinose content

Raffinose content of common bean genotypes ranged from 4.89 to 18.87 mg/g seed dry weight. Among the analyzed genotypes, the highest raffinose content was found in EC 931366 (18.87 mg/g of dry weight) and the lowest was found in EC 932197 (4.89 mg/g of dry weight). The genotypes were categorized in to three groups based on their raffinose content *viz*. high (>15.00 mg/g of dry weight), medium (between 5.00 to 15.00 mg/g of dry weight), and low (<5.00 mg/g of dry weight) raffinose content. Most of the genotypes analyzed had medium raffinose content. Raffinose content was found to be maximum in the exotic germplasm.

Sucrose + Maltose content

Sucrose and maltose are disaccharides; therefore, they could not be separated using Hi plex Ca column. The sucrose + maltose content of common bean ranged from 15.34 to 39.78 mg/g seed dry weight. Among the analyzed genotypes, the highest sucrose + maltose content was observed in EC 931366 (39.78 mg/g of dry weight) and the lowest was found in EC 931413 (15.34 mg/g of dry weight). The genotypes were categorized in to three groups based on their sucrose + maltose content *viz*. high

(>35.00 mg/g of dry weight), medium (between 20.00 to 35.00 mg/g of dry weight), and low (<20.00 mg/g of dry weight) sucrose + maltose content. Most of the genotypes had medium sucrose + maltose content. Maximum sucrose + maltose content was observed in the exotic germplasm.

Glucose content

Glucose was detected in seven genotypes out of 30 analyzed genotypes of common bean. Among the analyzed genotypes, the highest glucose content was found in EC 932071 (1.34 mg/g of dry weight) and the lowest was found in EC 932028 (0.07 mg/g of dry weight) (Fig. 6).

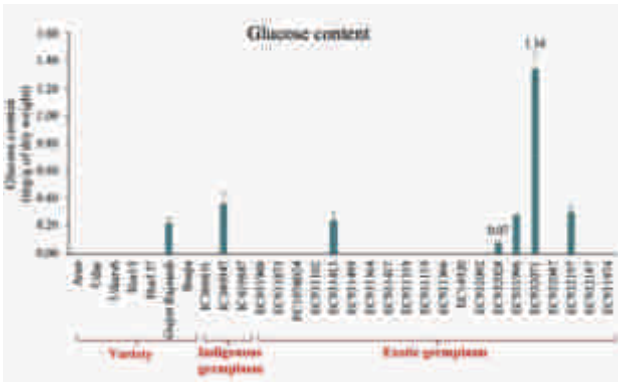


Fig. 6. Glucose content of common bean genotypes

Project : Biochemical responses of chickpea to heat stress and identifying key factors limiting its productivity

Under this project, estimation of protein, enzymes involved in protein synthesis {glutamine synthetase (GS) and glutamate synthase (GOGAT)}, starch, total soluble sugar and key enzyme of the starch biosynthesis pathway (Sucrose synthase) were carried out in developing seeds of heat tolerant (ICCV 922944, ICC 1205, Annigeri) as well as heat susceptible (ICC10685, Pant G 114, GNG 1958) genotypes of chickpea at three developmental stages [Small seeds (S), Medium seeds (M), Large seeds (L)] grown under normal as well as high temperature condition.

Protein content

Protein content at different stages of developing seeds of genotypes taken for this study were measured using Lowry's method (Lowry *et al.*, 1951). It was found to increase with the progression of the developmental stages and decreased under high temperature in the heat tolerant as well as heat susceptible genotypes (Fig. 7a). Percentage decrease in protein content due to high temperature was relatively higher in the heat susceptible genotypes compared to the tolerant genotypes.

Glutamine synthetase (GS) activity

Glutamine synthetase (GS, EC 6.3.1.2) is the key enzyme for ammonia assimilation in the plants, catalyzes the transfer of ammonia ion to the □d-carboxyl group of glutamate. Its activity was estimated using the method discussed by Cheng-gang *et al.*, (2011). Its activity was found to initially increase and then decrease with the progression of the developmental stages of seed. High temperature reduced its activity in the heat susceptible as well as heat tolerant genotypes of chickpea (Fig. 7b). Percentage decrease in GS activity due to high temperature were relatively higher in the heat susceptible genotypes compared to the heat tolerant genotypes except Pant G114.

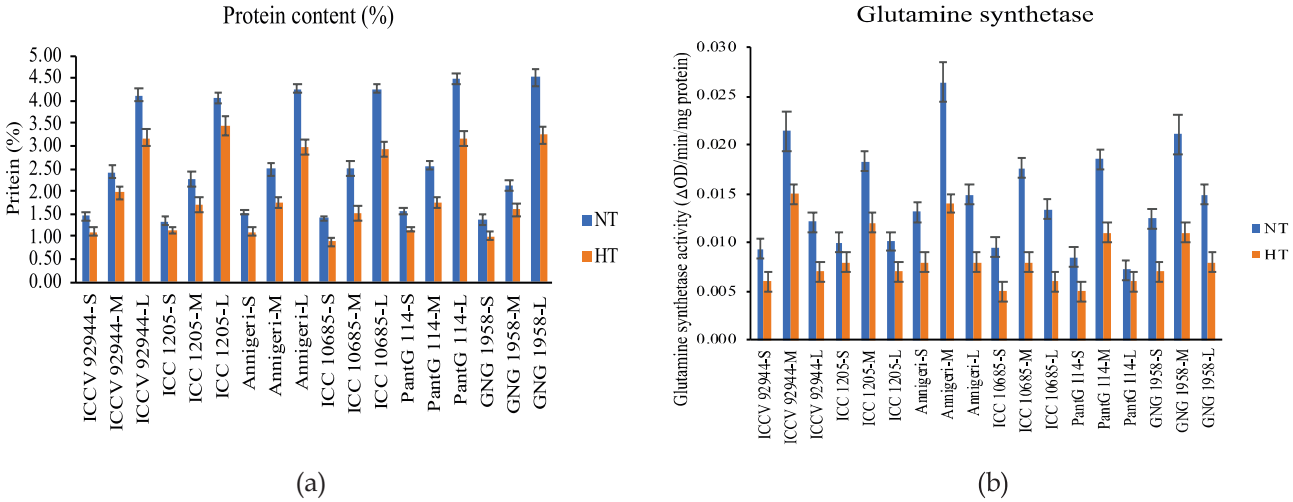


Fig. 7. Protein content (a), and Glutamine synthetase activity (b) of developing seeds of chickpea at different developmental stages grown under normal as well as high temperature condition

Glutamate synthase (GOGAT) activity

Glutamate synthase (GOGAT, EC 1.4.7.1) catalyzes the transfer of fixed nitrogen as amide in glutamine to α-ketoglutarate by reductive amination. Its activity was found to decrease with the progression of the developmental stages of seed. Further, under high temperature its activity was found to be enhanced in the studied genotypes (Fig. 8a). Percentage increase in GOGAT activity due to high temperature was relatively higher in the heat susceptible genotypes compared to the tolerant genotypes.

Starch content

Starch content at different stages of developing seeds were analyzed using anthrone method (Sadashivam and Manickam, 1991). Its content was found to increase with the progression of the developmental stages. Starch content decreased under high temperature as compared to the normal temperature at all the stages of heat susceptible as well as tolerant genotypes (Fig. 8b). Percentage increase in starch content due to high temperature was higher in the heat susceptible genotype (ICC 10685).

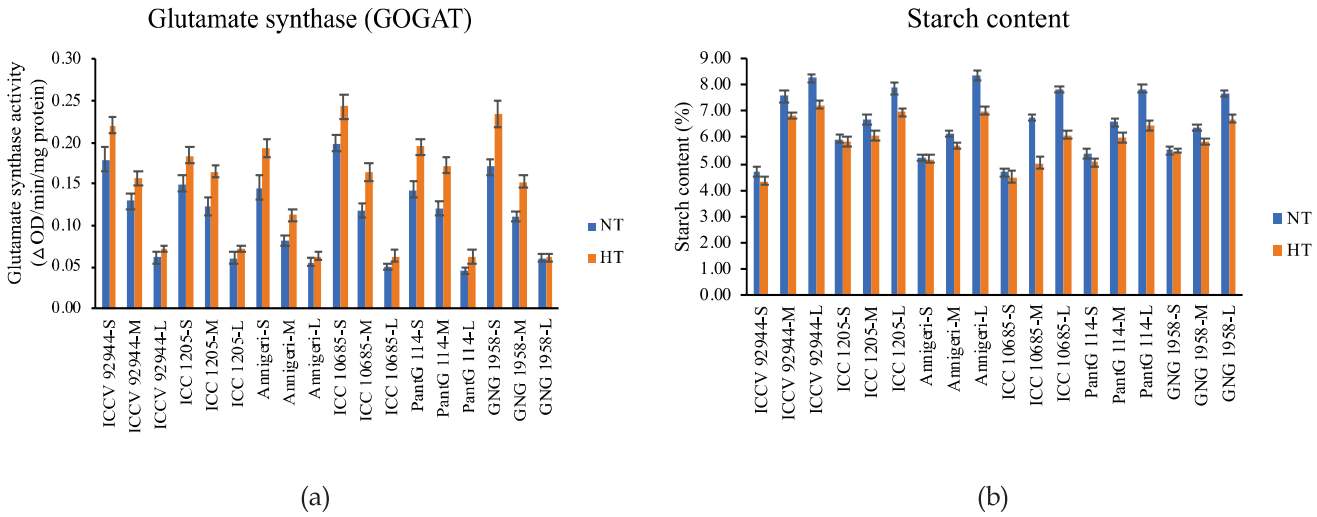


Fig. 8. Glutamate synthase activity (a), and Starch content (b) of developing seeds of chickpea at different developmental stages grown under normal as well as high temperature condition

Total soluble sugar content

Total soluble sugar content at different stages of developing seeds were analyzed using Phenol sulphuric acid method (Sadashivam and Manickam, 1991). Total soluble sugar content decreased with the progression of the developmental stages. Further, total soluble sugar was found to increase under high temperature compared to the normal temperature in all the studied genotypes (Fig. 9a). Percentage increase in total soluble sugar content due to high temperature was maximum in the heat susceptible genotype ICC 10685.

Sucrose Synthase activity

Sucrose synthase is the most important enzyme for the grain filling in the developing seeds. Its activity was measured using the method given by Wang *et al.*, 1993. Sucrose synthase activity was found to increase with the progression of the developmental stages. High temperature reduced its activity compared to the normal temperature in heat susceptible as well as tolerant genotypes (Fig. 9b). Further, percentage decrease in sucrose synthase activity due to high temperature was higher in the heat susceptible genotypes than heat tolerant genotypes.

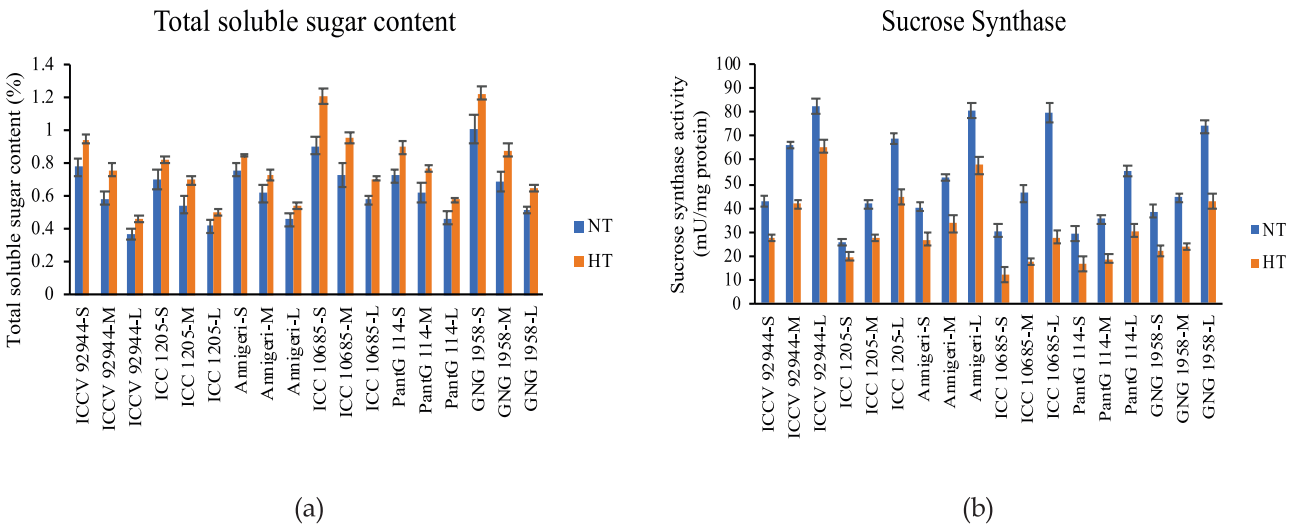


Fig. 9. Total soluble sugar content (a), and Sucrose synthase activity (b) of developing seeds of chickpea at different developmental stages grown under normal as well as high temperature condition

Project : Dynamics of imazethapyr and glyphosate residues in soil-plant system

Sowing of urdbean was done in pots, followed by application of imazethapyr at the rate of 100 g a.i./ha and 150 g a.i./ha as pre and post emergence application. To study dynamics of residual glyphosate in soil-plant system of urdbean crop, glyphosate was applied at the rate of 1.5 kg/ha and 2.25 kg a.i/ha on unsown pots, which was followed by sowing of urdbean after 10, 15 and 20 days of waiting time. Soil samples were collected from all the treatment pots and analyzed for residues of imazethapyr and glyphosate by High performance liquid chromatography (HPLC).

Programme 2: Establishment of effective symbiotic nitrogen fixation in pulses

Project : Unraveling the molecular basis for variations in nodulation and symbiotic efficiency of chickpea

Twenty six nodulation specific genes were identified following homology based search (blastp) using CDC frontier genomic information as a subject and *Medicago* and soybean nodulation genes information as query. Genes responsible for nodule initiation and development were localized in all 8 chromosomes of chickpea. Maximum number of BNF related genes were present on chromosome 2 (Ca2) of chickpea. Identification of SNPs and InDels in these genes using whole genome re-sequencing data is being carried out.

Project : Deciphering the root signals for effective nodulation of *Rajmash*

A total of 8 selected *rajmash* genotypes along with 3 varieties were revaluated for confirmation of their nodulation potential under field condition. All the genotypes except 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 2-8/plant. Nodule specific weight varied from 2-12 mg/nodule. Rajmash genotype IC 417352, IC 338795, IC 356018, EC 150250 and IC 356072 were found to be good nodulators.

Selected *Rajmash* genotypes were grown at different pH levels (ph 5.5, 6.0, 6.5, 7.0) under both sand and hydroponics system to optimize the best pH for plant growth. All the genotypes could tolerate

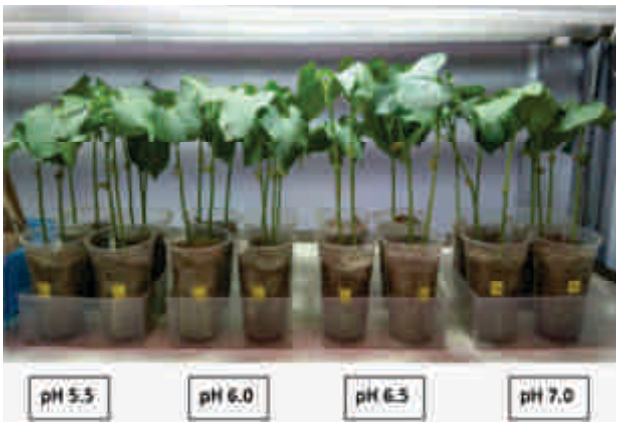


Fig. 10. Growth of rajmash genotypes under different pH range

pH level up to 5.5 (Fig. 10). But better plant growth was observed under pH range 6.0 to 6.5. All four rhizobial isolates also could tolerate low pH up to 5.5 on YEMA medium.

Four selected *Rajmash* genotype-Rhizobium combinations (*Rajmash* genotype IC 417352, EC 150250, IC 356018, IC 356072 and Rhizobial isolate IIPR-RR11, IIPR-RR14, IIPR-RR17, IIPR-RR40) were evaluated for their nodulation potential under three different growth medium (sterilized soil + Sand (1:2), sand and hydroponics system).

Variation in growth response was recorded. The best nodulation was observed in soil mix medium followed by sand. All the combinations were found positive for nodulation with genotype IC 356018 being highest nodulator. At earlier stage, no nodulation was observed in hydroponics. Good root proliferation with proper nodulation was observed in soil and sand medium whereas lesser root growth and slender type of rooting was observed in hydroponics system (Fig. 11). As presence of humus in soil organic matter may interfere with extraction of root exudates, the hydroponics system was further optimized for nodule induction.



Fig. 11. Optimization of growth medium for nodule induction (a: Soil + Sand; b: Sand; c: Hydroponics)

Revalidation of selected fieldpea genotypes for their nodulation and BNF

Ten selected fieldpea genotypes were reevaluated for their nodulation and nitrogen fixation potential. Fieldpea genotypes ET 45186, EC 324131, EC 324228, 7128, PM 9 were found to be high nodulators (Table 1). Nodule no. varied from 10-38/plant. Nodule specific weight varied from 11-40 mg/nodule. Genotype ET 45186 recorded the highest nitrogen fixation (18.59 nmole C_2H_4/g dry wt. of nodule/h) among all the genotypes.

Table 1: Screening of fieldpea genotypes for higher nodulation and BNF

Genotype	Nodule number	Nodule weight (g)	Nodule specific wt. (g)	ARA Activity (nmole C_2H_4/g dry wt. of nodule/h)
ET 45186	19.00	0.471	0.025	18.59
T-10	14.33	0.453	0.032	6.26
Azad P1	12.33	0.233	0.019	2.02
EC 324131	37.67	1.348	0.036	16.09
EC 324228	21.33	0.849	0.040	17.62
FP 331	13.67	0.331	0.024	10.08
R 41	17.67	0.344	0.019	11.56
EC 322745	13.33	0.147	0.011	3.75
7128	31.67	0.533	0.017	11.99
PM 9	26.67	0.753	0.028	10.57
CD value	3.98	0.204		

EXTERNALLY FUNDED PROJECT

Project : Identification and characterization of Nodule-specific Cysteine Rich (NCR) peptides in chickpea (DBT funded Project 2019-2021)

Transcriptome sequence analysis of small nodule, large nodule and root samples of *Cicer arietinum* cv RSG 888, *Cicer reticulatum* cv ILWC116 and *Cicer echinospermum* – ILWC-246 was carried out to identify the tissue specific expression pattern NCR peptide coding genes. The raw read data of each samples varied from 5.9-9.1 Gb with an avg of 7.01 Gb

data. The processed data of each samples varied form 5.1-8.1 Gb of data with an average of 6.35 Gb data. 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 and down and up regulation range was observed to be -7.53 to 10.38 fold.

The size of the transcriptome assembly size *Cicer echinospermum cv* ILWC 246 is 300.47 Mb and consists of 214879 genes and 334197 transcripts including isoforms. The contig N50 is 1755 bases and the average contig size is ~900 bases long. Differential gene expression analysis following RSEM is underway. Transcriptome analysis of *Cicer reticulatum* cv is being carried out with 9 samples each 3 replicates from small and large nodule and root samples following reference genome CDC Frontier based differential gene expression analysis. The overall mapping rate of the paired reads was stood at ~82% and all the samples were considered for further analysis.



Fig. 12: DEG analysis of root and nodules of *Cicer reticulatum*

Social Science

Programme 1 : Innovative extension approaches for livelihood and nutritional security through Pulse Production Technology in India

Project : Development and Evaluation of e Learning Platform for Pulse Production Technologies (eLeaP-Pulse)

e-learning platform of pulse production technologies is being created for sharing of identified pulse production technologies with the pulse growers and extension personnel of India. For this platform, video modules on pulse production technologies are being prepared. Content development, script writing, shooting and editing of 50 videos on *Kharif* and *Rabi* pulse, production technologies for the e learning portal (in *Hindi*) and Shooting for videos carried out in different crop stages.

Project : Digitalization of Quality Seed Production and Germplasm Database under Mega Project: Seed Technological Studies in Pulses

Contents on detail of seed hub centres, seed target, seed production, seed lifting, expenditure incurred, seed balance *etc.* have been collected, analysed and stored in digital format. A user-friendly interface has been designed for data entry and updation. Different links have been customized for development of digital platform. A prototype software has been developed for retrieval of seed hub information using WAMP (Windows, Apache, Mysql and PHP) technology. System architecture contains three-tier architecture *viz.*, client-side interface layer, server-side application layer and database layer. System has three basic functional modules *viz.*, Database Design Module, Data Management Module and Report Generation Module. Total seven database tables (*viz.*, User Master Table, Crop Master Table, Centre Master Table, Seed Category Table, Seed Target Table, Seed Production Table and Seed Distribution Table) have been designed under Database Design Module (*Fig.* 1). Database Management Module is used for data entry, updation, submission and analysis (*Fig.* 2). Total 4 reports (*viz.*, Crop-wise target/production report, Variety-wise target/production report, Year-wise target/production report and Target/Production pictorial report) were also generated in Report Generation Module (*Fig.* 3). System provides the information needs of farmers, researchers, exporters and policy makers and also serve as an information highway for sharing seed information through digital platform.

Project : Development of a procedure for promotion of AICRP crop performance trials IT enabled data management in pulses for policy support system

Analysis of genotypes by environmental data is often limited to evaluation based on genotype main effect (G), while GEIs are disorder factors. A large value of GEI usually has a negative effect on the yield estimate precision and indicates a decreased genotype effect on the value of the phenotypic trait. Because of the GEI, it is important to select stable genotypes that interact less with the varying environments in which they are to be grown. Several multivariate procedures proposed to explore GEI include principal component analysis (PCA), additive main effects and multiplicative interactions (AMMI) and genotype plus GEI biplot (GGE) analysis. The statistical analyses used to obtain data are multivariate analysis using AMMI model for the analysis of variance (ANOVA) based on a linear model with additive main effects and interactions. The AMMI model has been recommended for statistical analysis of yield trials, and it was preferred over any other statistical analyses because it captures a large portion of the GEI sum of squares. Based on the AMMI model, an stability index is proposed to rank the genotypes. Taking consideration of different weight of stability as 10% , 20% , 30% and 40% and weight of yield 90%, 80%, 70% and 60%, ranking of genotypes has been done for IVT trials of *desi* chickpea in AICRP chickpea of year 2020.

Project : Validation and implementation of online data submission and report generation system for AICRP

To make the process of data collection and compilation in smoothly and easier way, an attempt has been initiated to refine the online information retrieval system of AICRP. The system have three components *viz.* administrator end, user end and database development. We shall look details at user end for user-friendly operation. The various pages at the administrator end have been developed using ASP.NET with C#/ as the front end coding and for database development, SQL server are used.

EXTERNALLY FUNDED PROJECTS :

Project : Value chain analysis of Pulse crops in Bundelkhand region of Uttar Pradesh I C S S R supported project (Duration: 2019-21)

The data collection schedule was prepared for data collection from farmers, aggregators, wholesalers and input dealers. A total of 840 farmers from all 7 districts, 14 blocks and 28 villages were interviewed. In addition value chain actors like input dealers (12), aggregators (28), wholesalers (28), processors (12) and retailers (12) were also interviewed for the study. Value chains of all the major pulses (chickpea, pigeonpea, mungbean, urdbean, field pea and lentil) were mapped and their performance was recorded. Data related to agri-logistics, economics of production of pulse crops like cost of cultivation; marketing channels, market margins, marketing cost, price spread, and producers' share in consumers' price were recorded. Further, marketing efficiency of the documented marketing channel of different pulses was calculated. Constraints perceived by different actors of value chains of pulses were documented.

Table 1: Prevalent marketing channels of pulses identified from Bundelkhand region of U.P.

Sr. No.	Districts	Prevalent marketing channels of pulses
1	Jalaun	Channel : i) Farmer, Aggregator , Trader, Processor, Wholesaler, Retailers, Consumers, ii) Channel 2:Farmer, Aggregator/Trader, Processor, Wholesaler, Retailer, Consumer; iii) Farmer, Aggregators, Trader/Processor, Wholesaler, Retailer, Consumer;
2	Lalitpur	Channel : i) Farmer, Trader, Processor, Wholesaler, Retailer; ii) Farmer, Aggregator, Trader, Processor, Wholesaler, Retailer
3	Hamirpur	Channel : i) Farmer, Aggregator, Trader , Processor, Wholesaler, Retailer; ii) Farmer, Trader, Processor, Wholesaler, Retailer
4	Chitrakoot	Channel : i) Farmer, Trader, Processor, Wholesaler, Retailers; ii) Farmer, Aggregator, Trader, Processor, Wholesaler, Retailer; iii) Farmer, Village Aggregators, Trader, Processor, Wholesaler, Retailer
5	Mahoba	Channel : i) Farmer, Aggregator , Trader, Processor, Wholesaler, Retailers; ii) Farmer, Village Trader, Aggregator, Trader, Processor, Wholesaler, Retailer; iii) Farmer, Aggregators, Trader/Processor, Wholesaler, Retailer
6	Banda	Channel : i) Farmer, Aggregator , Trader, Processor, Wholesaler, Retailers, Consumers; ii) Farmer, Aggregator/Trader, Processor, Wholesaler, Retailer, Consumer; iii) Farmer, Aggregators, Trader/Processor, Wholesaler, Retailer, Consumer
7	Jhansi	Channel : i) Farmer, Aggregator , Trader, Processor, Wholesaler, Retailers, Consumers; ii) Farmer, Aggregator/Trader, Processor, Wholesaler, Retailer, Consumer; iii) Farmer, Aggregators, Trader/Processor, Wholesaler, Retailer, Consumer

Farmers, Aggregators, Traders, Processors, Wholesalers, Retailers and consumers were identified as the major actors in value chains of pulses in Bundelkhand region of U.P. Aggregator & Trader as well as Trader and Processor were observed to be a single entity in larger markets in the region. Wherein smaller markets, additional actors like village trader was additional actors besides the aforesaid actors. It could be observed from the Table 1 that shorter market channels were more efficient across all the crops in all the districts. In channel where aggregators & trader were a single value chain actor, the marketing efficiency was observed to be higher as compared to channel where Trader & Processor were a single value chain actors. The reason for this could be the fact that though the two functions were performed by single actor, processing units were usually located away from market yards that incurred additional cost in transportation of produce.

Table 2: Performance of marketing channels of Pulses

Jalaun	Chickpea		Field pea		Pigeon pea		Urdbean		Mungbean		Lentil	
	MEI	PSCR	MEI	PSCR	MEI	PSCR	MEI	PSCR	MEI	PSCR	MEI	PSCR
Channel 1	1.55	62.10	1.78	65.39	1.37	58.88	1.46	60.49	1.67	63.67	1.36	58.84
Channel 2	1.59	62.71	1.83	66.07	1.40	59.44	1.50	61.09	1.72	64.34	1.39	59.39
Channel 3	1.49	61.21	1.70	64.32	1.35	58.52	1.39	59.20	1.59	62.50	1.23	56.39
Lalitpur												
Channel 1	1.76	65.11	2.03	69.12	1.53	62.27	1.79	65.93	1.82	66.32	1.53	62.28
Channel 2	1.65	63.35	1.98	67.52	1.50	60.89	1.74	64.44	1.77	64.85	1.51	61.12
Hamirpur												
Channel 1	1.53	61.63	1.91	66.78	1.33	58.14	1.57	62.17	1.65	63.26	1.46	60.55
Channel 2	1.59	62.57	1.98	67.61	1.39	59.19	1.60	62.60	1.67	63.63	1.47	60.64
Chitrakoot												
Channel 1	1.65	64.25	2.07	69.49	1.44	60.79	1.69	64.79	1.73	65.26	1.52	62.22
Channel 1	1.62	64.18	2.06	69.45	1.39	59.84	1.68	63.92	1.71	64.99	1.48	61.85
Channel 3	1.59	62.76	1.94	67.41	1.34	58.57	1.56	62.20	1.62	63.14	1.42	60.01
Mahoba												
Channel 1	1.73	64.1	2.24	69.8	1.34	57.9	1.84	65.2	1.88	65.8	1.57	61.7
Channel 1	1.62	62.3	2.07	68	1.28	56.6	1.72	63.6	1.76	64.2	1.47	59.9
Channel 3	1.85	65.7	2.44	71.6	1.45	59.7	1.95	66.7	1.96	67.3	1.66	63.1
Banda												
Channel 1	2.63	63.16	3.05	68.40	2.41	59.50	2.71	64.23	2.73	64.42	2.50	61.12
Channel 1	2.68	63.97	3.11	69.09	2.46	60.34	2.74	64.61	2.76	64.84	2.54	61.79
Channel 3	2.62	63.07	3.02	68.06	2.41	59.49	2.65	63.37	2.62	62.87	2.48	60.80
Jhansi												
Channel 1	2.66	63.63	2.86	66.35	2.47	60.49	2.75	64.66	2.75	64.75	2.53	61.64
Channel 1	2.69	64.03	2.92	66.88	2.50	61.00	2.76	64.81	2.80	65.35	2.53	61.60
Channel 3	2.63	63.50	2.88	66.79	2.40	59.72	2.73	64.72	2.74	64.88	2.50	61.34

Marketing Efficiency Index (MEI); Producer Share of Consumer's Rupee (PSCR)

Marketing efficiency of fieldpea and mung bean was found higher among all the pulse crops. Similarly the producer's shares in consumer rupee are recorded to be the highest in case of these two crops.

Project : Establishment of Agri-business Incubation centre at ICAR –IIPR, Kanpur NAIF scheme, ICAR, New Delhi

The screening committee of ABI unit selected one applicant for extending the incubation support by ABI unit for business development under the thrust area of pulse processing. For the purpose, two MoA, for transfer of technology on Milling of Pulses in Mini Dal Mills and for incubation support were signed with Mamta Agro-India, Kanpur. In addition for supporting the marketing of product prepared by incubatees in ABI Unit, a sale counter named "Dalhan haat" has been established in Technology Incubation & Dissemination Centre Building near the Main Gate and inaugurated by Hon. Director General, ICAR New Delhi on 05th September 2021. Further, for extending the incubation support in other thrust areas, incubation labs have been strengthened.

Project : Farmer FIRST project "Integration approaches for food, nutrition and livelihood security of rural households in Fatehpur district of Uttar Pradesh"

Technological interventions under Farmer FIRST project during 2021

A. Demonstrations on improved technologies during Rabi 2021-22

Table 3: Technological interventions under the project during *Rabi* 2021-22

Crop	Variety	No. of farmers	Area coverage (ha)
Wheat	DBW 187 (Karan Vandana)	56	20.80
	DBW 222 (Karan Narendra)	5	4.50
Lentil	IPL 220	15	5 .00
Chickpea	GNG 2207	68	12.50
Mustard	Varuna	34	10.00

Under Farmer FIRST project, biofortified varieties of wheat and lentil introduced in project villages in Devmai block of Fatehpur district. Large

scale on farm demonstrations on biofortified varieties was conducted for the purpose. This included demonstration on biofortified wheat variety DBW-187 in Delemau, Khadra, Karchalpur villages of Devmai block of Fatehpur district. A total of 56 farmers actively participated in these demonstrations covering in area of 20.80 ha. Line sowing of wheat crop was also introduced for the first time in the project villages. The partner farmers that have followed line sowing are currently convinced with crop growth and enhanced tillering. In similar lines, bio fortified lentil variety, IPL 220 was introduced in Khadra village of Fatehpur district. A total of 15 farmers actively participated in these demonstrations. In addition, DBW 222 (Karan Narendra) was also introduced in the project villages in about 4.5 ha area.

In addition, technological intervention on chickpea (Var. GNG 2207) and mustard (Varuna) were conducted during *Rabi* 2021-22 in 12.5 and 10 hectares area with participation of 68 and 34 farmers, respectively.

Demonstrations on improved technologies during *Kharif* 2021

Technological interventions in paddy

During *Kharif* 2021, as a part of technological interventions, high yielding paddy hybrid named Arize 6444 Gold was introduced first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh, under farmer FIRST project. A total 29 farmers were part of this intervention that covered about 12.04 hectares. The introduced hybrid yielded 44.26 q/ha which was almost double the productivity of popular traditional variety Sarbati (21.27 q/ha) in the area. Though the average market price of produce of Arize 6444 Gold was lesser ₹ (1350/q) than that of traditional Sarbati variety (₹ 1750 /q), the difference in the productivity led to a higher gross return to partner farmers. The popular Sarbati variety fetched a better market price owing to scent characteristic which was absent in Arize 6444 Gold. The partner farmers received an average gross return of ₹ 59,751/ha by cultivating introduced paddy hybrid which was 61% higher than the traditional variety. The introduced paddy hybrid thus led to a higher yield and economic advantage to the partner farmers of the project area.



Table 4: Technological interventions under the project during *Kharif* 2021

Crop	Variety	No. of Demonstrations	No. of farmers	Area coverage (ha)	Yield (q/ha)	Yield advantage (q/ha)	Income advantage (Rs)
Paddy	Arize 6444 Gold	**29**	**29**	**12.04**	**44.26**	**22.99**	**31036**
Okra	**Navya**	**10**	**10**	**3**	**17.35**	**16.50**	**23694**
Pearl millet	Pioneer 86M84	**8**	**8**	**3.86**	**26.14**	**2.35**	**3525**

In addition, interventions were also given in vegetables like chilli (hybrid Divya Jyoti) , bottle gourd (Hybrid Vigro GSH 2) and Pumpkin (Vishal) in 8.0, 2.5 and 2.0 hectares with participation of 30, 5 and 10 farmers, respectively.

Technological interventions in okra

Navya hybrid of okra was introduced for the first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh during *kharif* 2021 under Farmer FIRST project. A total of 10 partner farmers cultivated the introduced hybrid in almost 3 ha of the area. Partner farmers could receive an average yield of 17.35 t/ha which was higher than the average yield of other popular hybrids *i.e.* 16.50 t/ha in the region. In addition, the introduced hybrid fetched better market prices than the other popular hybrids/varieties leading to an average gross return of ₹ 2.37 lakh /ha which was about 10 % higher than the average gross return from other hybrids/ varieties.

Thus, introduced hybrid leads to a higher economic advantage to the partner farmers. Besides

yield, farmers also perceived the hybrid to be superior in terms of resistant to yellow vein mosaic virus as well as the fruits were green, shiny and slender, that fetched better market price.

Technological interventions in pearl millet

As a part of technological interventions in *kharif* 2021, a hybrid Pearl millet Pioneer 86M84 was introduced the first time in Khadra, Karchalpur and Mirai villages of Fatehpur district, Uttar Pradesh on 3.86 ha area. Total eight farmers partnered the introduction of hybrid pearl millet in the project villages under farmer FIRST project were the part of intervention. The partner farmers received higher average yield of 26.14 q/ha in their experimentation plots, than that from other popular hybrids (yields 23.79 q/ha). The average market prices of both the newly introduced and traditional hybrids were the same *i.e.* ₹ 1500/q, the difference in productivity levels lead to an economic advantage to former. The partner farmers receiving an average gross return of ₹ 39, 210/ha, that was about 10% higher than the gross return from traditional hybrids.

The introduced pearl millet hybrid was also perceived to be tolerant to lodging that contributed to higher yield. These encouraging results from above interventions have lead to enhanced demand of the technological options among farming community in the region in coming future.

Frontline demonstrations conducted

A total of 128 Frontline Demonstrations on chickpea (var. GNG 2207), lentil (var. IPL 220) and field pea (IPFD 12-2 & IPFD 10-12) were conducted in 6 districts , Kanpur Dehat, Jalaun, Hamirpur, Banda and Fatehpur of Uttar Pradesh states in different production situations. About 60 ha area was covered under these demonstrations.

Demonstrations under Schedule Tribe Component (TSP) during 2021-22

For enhancing pulse production for food, nutritional security and rural livelihoods of tribal farmers of Madhya Pradesh and Chhattisgarh state, 250 demonstrations on improved pigeonpea, urdbean and mungbean production technologies were conducted in different districts of Madhya Pradesh and Chhattisgarh during *Kharif* 2021. Similarly, 400 demonstrations on improved pulse production technologies in *Rabi* 2021-22, covering 160 hectares were conducted. In addition, interventions are being conducted for safe storage of seeds and grains of pulses in form of steel storage bins and sprayers for spray of desired plant protection chemicals.

Table 5: Details of Kharif Demonstrations 2021-22

SI. No.	Districts	Crop	No. of Demonstration
1	Balrampur & Surguja districts of Chhattisgarh and Sahdol & Annupur districts of Madhya Pradesh	Pigeon pea	100
2	Balrampur & Kanker districts of Chhattisgarh and Jhabua district of Madhya Pradesh	Black gram	100
3	Barwani and Dhar district of Madhya Pradesh	Green gram	50
		Total	**250**

Table 6: Details of *Rabi* Demonstrations 2021-22

Sr. No.	Districts	Area (ha)	No. of Demonstration
1	Dindori, Dhar, Mandla & Annuppur districts of Madhya Pradesh	80	200
2	Jashpur, Kanker, Balrampur & Koriya districts of Chhattisgarh	80	200
		160	**400**

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

Interventions in Maraunda Suchit village, Unnao district

1. Improved chickpea and lentil production technologies were demonstrated in about 14 ha area. Partner farmers registered a yield enhancement of 1.29 and 0.45 q/ha, in lentil and chickpea, respectively.
2. Two farmer-scientist interaction meetings on improved pulse production technologies were conducted in project villages wherein about 110 farmers interacted.

Interventions in Badrasar village of Bikaner district

1. Demonstrations of improved high yielding cultivars of cluster bean (RGC-1033) and moth bean (RMO-2251) with full package of practices were conducted to provide for higher production with active participation of 40 farmers.
2. The interventions on cluster bean and moth bean were conducted in 10 and 20 ha area, respectively. Farmers were also trained with full package of practices of cluster bean and moth bean cultivation.

Interventions in Nagasar village of Bikaner district

1. Demonstration on improved high yielding cultivars of chickpea with full package of practices and training was provided under upland, loamy sand soils, partially irrigated situation in partnership with 50 farmers covering 7 ha area.

Interventions in Narendra village of Dharwad district

1. Demonstrations on improved variety of Chickpea (BGD 111-1), Horse gram (CRIDA 18 R-1), Cowpea (DC-15) and mungbean production technologies were conducted in Narendra village of Dharwad district. A total of 12 farmers participated in these demonstrations.
2. Partner farmers could achieve average yield with increase of 15% in chickpea, 16 % in cowpea and 20 % in horse gram as compared to farmers practice.

IIPR Regional Centre, Phanda, Bhopal

Research Achievements

Programme Accelerated genetic gain, trait discovery & PGR management

Project 1: PGR Management and utilization

(i) Sub project: Plant genetic resource management and genetic improvement of grasspea for high yield and low-ODAP content

a) A unique genotype IC 296745 is forwarded for germplasm registration for larger seed size (15-16.8 gm/100 seed wt) with gray seed coat.

b) 754 genotypes were purified and evaluated during *rabi* 2020-21 and these are subject to were ODAP estimation. Ninety exotic accessions characterized and promising genotypes will be further evaluated to identify donors.

c) Low ODAP varieties and exotic landraces have been used in crossing programme to obtain F_1 seeds and these were grown to raise F_1 progeny to obtain F_2 seeds during 2021-22. 139 mutants of grasspea were advanced to M_6 generation to select the low ODAP mutant lines. Four mutant lines viz., GML 2016-5 (0.05 %), GML 2016-6 (0.03 %), GML 2016-7 (0.05 %) and GML 2016-18 (0.05 %) of M5 were identified as low ODAP lines as compared to check variety Mahateora (0.04 %) during 2020-21. However, Gamma irradiated (BARC) grasspea mutants of M_1 generation with 5 treatments (200, 300, 400, 500 and 600 kGy) were also grown and are being characterized for germination and morphological variations during 2021-22. FLRP & International ICARDA grasspea nursery comprising of 183 entries for low ODAP, earliness and high biomass are being evaluated (*rabi* 2021-22).

(d) Maintenance of wild genera / species of pulse crops: 285 accessions

- **Chickpea:** 96 accessions of 8 annual *Cicer* species
- **Pigeonpea:** 128 accessions of 11 species belong to genera *Cajanus* and *Rhyncosia*
- **Lentil:** 39 accessions of 04 species
- **Vigna:** 18 wild accessions of 09 species
- **Grasspea:** 02 accessions of *Lathyrus cicera*
- **Horse gram**: 02 accessions *Macrotyloma africanum*

(e) Total 77 *Lathyrus sativus*, 06 *Cajanus cajan* and 01 *Pisum arvense accessions* were collected during exploration and germplasm collection in Mungeli and Kawardha districts of Chhattisgarh during Feb., 14-18, 2021. One hundred forty five germplasm of pulse crops were collected in another joint germplasm exploration and collection work was also done by NBPGR Regional Station, Akola, IIPR, Kanpur and IIPR Regional Centre, Bhopal scientists during October 8-17, 2021 in Betul and Harda district of Madhya Pradesh.

(f) Grasspea Station / global trials: ICARDA global trials (2021): **(a)** BCIP-GYIT-HB-21 (High biomass) :48 entries, (b) BCIP-GYIT-LO-21 (Low ODAP): 48 entries (c) BCIP-GYIT-E-21(Earliness) :48 entries (d) BCIP-GISPN-F7-21 (Breeding line) : 5 entries are being evaluated durin *rabi* 2021-22.



(a) Large seeded white seed coat genotype IC 296745 (b) Curling & twisting of leaves (c) flowering in M_1plant Mutant lines of grasspea var. Mahateora (M_1 generation)

Project 2: Development of biotic and abiotic stress resistant superior varieties/hybrids through conventional and modern breeding approach.

Subproject 1: Genetic enhancement of *Kabuli* chickpea for higher productivity, wider adaptability and better quality

Crosses attempted among large seeded *kabuli* varieties / lines and wilt resistant / tolerant lines to develop improved lines for wider adaptability, higher yield and improved quality. F_1 seeds obtained using exotic landraces (Gokcee, X 016TR89, Flip07-6C-S1 and Flip 09-191C) are being evaluated during *rabi* 2021-22. One fourty two breeding lines collected from ICARDA / ICRISAT / IIPR were evaluated and donors are identified for higher yield [FLIP11-94C (3767.9 kg/ha), IPCK 16-149 (3176.3 kg/ha), IPCK 15-275 (2825.4 kg/ha) and XIIth 70-S1 (2747.1 kg/ha)], for larger seed size [IPKB 2018-13 (57.6 gm) and IPCK 19-223 (46.5 gm)] and for earliness [ICCV 181302 (95 days), ICCV 181316 (97 days), ICCV 181306 (102 days) and IPCK 18-184 (102 days)]. Two genotypes identified for larger seed size [IC 297328 (52.30 gm) and IC 297328 (51.20 gm)] among 87 accessions of *kabuli* chickpea during 2020-21. Four hundred ninety eight breeding lines are being evaluated during 2021-22 for yield performance, earliness and larger seed size.

Sub Project 2 : Genetic enhancement of Pulses Crop for Different Agro-Ecological Zones

Mid-early/Medium duration pigeonpea

F_1 seeds of six crosses *viz*., 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 are grown during *kharif* 2021. Bagging of selected F_1 plants is done to obtain pure F_2 seeds. New crosses among UPAS 120 x Pusa Arhar 16, UPAS 120 x BSMR 736 and UPAS 120 x *C. Cajanifolia* is also attempted to obtain F_1 seeds.

EXTERNALLY FUNDED PROJECTS

Project : Characterization of chickpea germplasm resources to accelerate Genomics-assisted Crop Improvement

Two thousand four hundred and sixty germplasm were grown in the late sown condition under heat stress environment to identify the heat tolerant genotypes. Heat tolerant genotypes, IC 83888, IC 486922, EC 267221, IC 83777 and IC 83459 were identified on the basis of filled and unfilled pods and environmental data.

Project : CRP on Agro biodiversity in pigeonpea:

Characterization: Total 407 accessions with 4 check varieties (Pusa Arhar 16, UPAS 120, TJT 501 and Rajeshwari) were characterized for quantitative / qualitative traits (NBPGR descriptor).

Project : Enhancing breeder seed production for increasing indigenous production of pulses in India

Breeder seed of central zone/Madhya Pradesh State varieties as per given target is produced to meet the demands in seed hub programme (Table-1).

Table 1: Breeder seed production during summer, *kharif* and *rabi* 2021at IIPR, RC, Bhopal

Crop	Target (q)	Varieties	Target (q)	Seed produced	Total Prod. (q)
Mungbean (Summer 2020)	-	Virat	-	4.15	10.56
		Shikha		6.41	
Mungbean (Summer 2021)	10.00	Virat	5.00	18.00	24.00*
		Shikha	5.00	6	
Urdbean	15.00	IPU 13-1	-	0.50	23.80
		IPU 11-2	-	1.00	
		IPU 10-26	-	0.30	
		IPU 2-43	10.00	14.00	
		Uttara	5.00	8.00	
Pigeonpea	10.00	Rajeshwari	10.00	13.00	13.00
Fieldpea	55.80	IPFD 10-12	14.00	36.00	64.40
		IPFD 12-2	14.00	24.00	
		IPFD 2014-2	14.80	20.00	
		IPFD 11-5	13.00	13.00	

Crop	Target (q)	Varieties	Target (q)	Seed produced	Total Prod. (q)
Lentil	22.00	IPL 316	22.00	23.70	23.70
		IPL 534	-	0.40	
Chickpea	5.00	IPC 2006-77	5.00	5.10	10.81
		RVG 202	-	1.71	
		Kripa	-	4.00	
Total	117.80		117.80		170.27

Project : Creation of Seed hubs for increasing indigenous production of pulses in India

Quality seed is produced more than the given target in farmer's participatory mode to meet the demand of pulses seed.

Table 2: Quality seed production at Bhopal centre during 2021.

Crop	Target (q)	Varieties	Production (q) (Foundation seed)
Mungbean	75.00	Virat, Shikha (spring)	78.90
Urdbean	150.00	IPU 2-43 (*kharif*)	150.20
Pigeonpea	200.00	Rajeshwari, Rajive lochan Pusa Arhar 16	213.00
Chickpea	250.00	RVG 202, RVG 203	250.70
Lentil	150.00	IPL 316	179.35
Fieldpea	175.00	IPFD 10 12, IPFD 12 2, IPFD 11 5	203.00
Total	1000.00		1075.15

OTHER ACHIEVEMENTS

1. Development of wilt sick plots for major pulse crops:

(a) Chickpea wilt sick plot: Third year of development using JG 62.

(b) Pigeonpea wilt sick plot: Second year of development.

(c) Lentil wilt sick plot: Third year of development using L-9-12.

(d) NBRI Trials conducted: Evaluation of formulations developed by scientists of NBRI (CSIR), Lucknow under "Bio-efficacy testing of the four formulations using chickpea as a host crop" programme.

2. Technology developed:

(a) Varieties released and notified: IPU 17-1 of urdbean is released and notified for Madhya Pradesh state.

(b) AICRP trials: Entries submitted in IVT for short duration pigeonpea (02), *kabuli* chickpea (02) and for *desi* chickpea (03).

3. Lentil Station trials:

IIPR Station Trials (2020-21): Out of 13 entries evaluated, the yield performance of IPL 121802 (13.01 q/ha) was at par with the IPL 316 (13.41 q/ha).

4. Extension activities:

A. IIPR Model Pulses village programme: Village Padli is adopted to develop as a model pulses village in Sehore district. Farmers of the village are growing pulse crops in all the three seasons, *kharif*, *rabi* and *zaid*. Summer mungbean is also grown as per availability of irrigation facility. Farmer's participatory seed production and frontline demonstrations of newly released varieties of pulse crops are conducted to popularize and promote the new pulses technologies.

B. FLD's conducted at IIPR, RC, Bhopal: 70

Table 3: Front line demonstrations of new pulses technologies conducted

Crop (FLD no.)	Village	Variety	Production (q)
Chickpea (25)	Padali, Mograram, Chitawliyahema, Phandakala, Konajhir, Shikarpur, Barwai,Amlaha, Naunikhedi, Amoda	RVG 202, RVG 203	10.0- 18.0
Lentil (15)	Mahodiya, Vidisha, Nipaniyakala Padli, Naunikhedi, Amlaha, Raipur Nayakheda, Jahangirpura, Ranayal	IPL 316	6.8 - 9.5
Fieldpea (15)	Syari, Basoda, Karodakhurd, Barwai, Chatahe, Kalyakhedi, Tyonda, Basoda, Magrai, Barwai, Mudrapitambar	IPFD 12-2, IPFD 10-12	14.5-17.0
Pigeonpea (10)	Ichhawar, Padli (2), Phanda, Khadampur, Kanha saiy, Lasudiya Chhap, Kothari	Pusa Arhar 16	Crop at harvesting stage
Urdbean (05)	Phanda (2), Bijlon, Patniya, Jharkheda	IPU 2-43	Damaged due to heavy rains

C. Farmer's training: A training programme was organized on "*Rabi Dalhani Fasalo me gudvattyukt beej utpadan ki takniki*" for abot 70 farmers including seed hub and SC and model village farmers on March 16, 2021.

D. Farmers visit: One hundred and seventy five farmers visited from the Rajgarh, Ganjbasoda, Vidisha, Sagar, Bhopal, Sehore, Dhar, Shajapur and raisen districts of Madhya Pradesh under *Mukhyamantri khet* tirth yojana organised by ATMA, Agril. Department, CARD (AC & ABC scheme), Bhopal and DAESI Prog., Institute of Cooperative Management, Bhopal.

E. Seed distribution under SC sub plan: Three hundred and thirty five farmers were benefited with the seed distribution of new varieties of pulse crops programme under SC Sub Plan, DAC, Min. of Agriculture, GOI.

Development activities

(i) Main gate at Toll Plaza is constructed.

(ii) Seed drying shed is extended.

(iii) Retaining wall is constructed.

(iv) Plantations have been done for clean and green campus.

(v) Drainage channels (*kachcha*) were reformed to channelized the rain water.

(vi) Widening and extension of existing RCC approach road is under process.

(vii) Strengthening of drainage and irrigation channel is under development.

(viii) Green belt in the Surroundings of main gate at Toll plaza is developed.

IIPR-Regional Centre *cum* Off-Season Nursery, Dharwad, Karnataka

Research Achievements

Crop Improvement

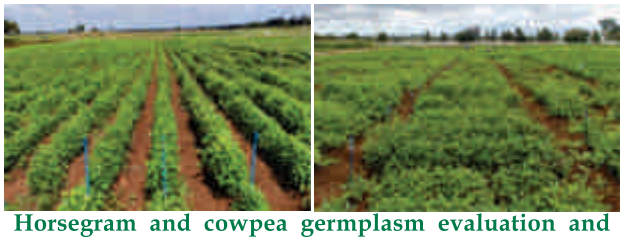
1. Plant Genetic Resources Management and its utilization through pre-breeding

Cowpea

Total 300 cowpea germplasm lines have been evaluated for yield characteristics and multiple stress resistance during *Kharif*. Wide range of variations was observed for different morphological traits. The entries such as IC 97767 and IC 724303 (75 days), EC 724284 (79 days) and EC 738194 PL-4, (80 days) were identified as early maturing genotypes of cowpea. The entries such as Goa Cowpea 3 and MP 2 (110 days) were late maturing in nature. More than 3 pods/peduncle were observed in the genotypes, RC 101, PL 4, EC 472252, GC 3. The genotypes EC 528457, GC3, EC 724751, RC 19, GC 4, IC 19786 and EC 390277 had >20 number of pods per plant. It was also characterised for nine different qualitative traits, Growth habit categorised into three type's *viz.*, climbing type (64.58%), semi erect (18.75%), erect (16.66). Leaf colour divided into two categories green (75%), dark green (25%), flower colour yellow (15%), white (5%), purple (80%), pod shape straight (73%), curved (25%), horse shaped (2%), pod attachment to peduncle Erect (29%), pendate (71%) seed shape categorised into three type's *viz.*, kidney (12%), elliptical (26%), rhomboid (62%). Four types of seed colour was observed, they were black (8%), red (15%), brown (59%), white (18%). Seed eye colour classified into three types, tan brown (63%), red (13%), black (24%), seed length (mm) segregated in three classes *viz.*, short (<5 mm), medium (5-10 mm), long (>10 mm).

Horsegram

Total 140 accessions of horsegram germplasm were maintained and characterized for different morphological traits during *Rabi*/spring season 2020-21. Significant variations were observed for different quantitative traits. The entries such as IC 71768A (85 days), IC 139556 (87 days) and IC 123021 (90 Days) were identified as early maturing genotypes of horsegram. More than 30 pods per plant were observed in the genotypes such as GPM 65, IC 19447, GPM 08 and AK 22. The entries such as GPM 28, GPM 49, CRIDA 18R and PHG 62 are showed resistance reaction to yellow vein mosaic disease and VLG 15, KBHG 01, TCR 1489, GPM 49 and PHG 62 are showed resistance reaction to powdery mildew disease under natural field conditions.



Horsegram and cowpea germplasm evaluation and generation advancement

Mungbean minicore evaluation

Total 296 accessions of mungbean received from World Vegetable Centre, Hyderabad were rejuvenated and evaluated under alpha lattice design for qualitative and quantitative traits during *Kharif*/spring-summer season. The accessions such as VI 000105 BG, VI 000537 BG, VI 001509 AG and VI 001728 AG had maximum number of pods per plant. The genotypes such as VI 001408BG, VI 001419BG, VI 001509AG and VI 002529 B-BL were found resistant to MYMV, Anthracnose, powdery mildew and *cercospora* leaf spot diseases under field conditions.



Evaluation of mungbean and urdbean germplasm

Urdbean

Total 230 accessions of urdbean were evaluated for 12 different traits in spring/summer season. The accessions such as UH 32-2, MASH 114, Mohoba local and BGP 2128 were earliest to mature (78 days), IC 47200 and IC 250245 matured in 79 days. Genotypes IPU 99-16, IPU 99-128, IPU 99-168, IPU 94-1 exhibited higher number of seeds per pod (>5) under drought. Number of pods (>20) per plant was high in genotypes IPU 99-123, PDU 103, IPU 99-3, IC 24129, IC 261179. Hundred seed weight were high (>4 gm) in genotypes SPS 34, SPS 40, PDU 3, IPU 99-147, IPU 99-211, IC 274597. Two hundred SPS with different and unique plant phenotypes has been done in 61 segregating materials of urdbean.

Pre-breeding garden

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 spring-summer season. Thirty two different wild accessions of genus *Vigna* such as *Vigna dalzelliana, Vigna glabrescence, Vigna hainiana, Vigna pilosa, Vigna stipulaceae, Vigna sublobata, Vigna sylvestries, Vigna trinervia*var. *bourbeae, Vigna vexillata* were procured from ICAR-NBPGR RS, Thrissur for evaluation and wide hybridization programme. Wild *Vigna* species such as *Vigna aconitifolia, V. vexillata*, *V. trilobata*, and *V. stipulacea*, were rejuvenated and used in crossing programme.



Pre-breeding nursery at ICAR-IIPR RS, Dharwad

Germplasm exploration and collection

Joint germplasm exploration trip was conducted by ICAR-IIPR RS, Dharwad and ICAR-NBPGR RS, Akola at Latur and Osmanabad districts of Maharashtra. A total of 89 accessions were collected from 37 collection sites (Villages) from Latur, Osmanabad and adjoining districts. Maximum accessions were collected from Latur (45) followed by Osmanbad (40), Nanded (03) and Beed (01) districts. Cowpea (4), Horse gram (2), Blackgram (9), Greengram (14), Chickpea (1), Coriander (1), *Dolichos bean* (1), Citrulus (1), Bottle Gourd (17), Bitter Gourd (3), Indian Dill (01) (*Anethumgraveolens*), Musk melon (3) *Cucumismelo*, Okra (02) (*Abelmoschusesculentus)*, Pigeonpea (3) (*Cajanus cajan),* Pumpkin (09) (*Cucurbita maxima),* Radish (01) (*Raphanus sativus*), Ridge Gourd (10) (*Luffa acutangula*), Sponge Gourd (5) (*Luffa egyptica)*, Sword Bean (2) (*Canava liagladiate*) were collected. In Germplasm exploration trip conducted by collaboration of ICAR-IIPR RS, Dharwad and ICAR-NBPGR RS, Thrissur at Wayanad district of Kerala and Nilgiris district of Tamil Nadu, total 41 crop wild species, landraces of different crop plants including pulses were collected. Among which 12 collections were multiplied and accession number (IC) was obtained number from ICAR-NBPGR, New Delhi (IC 636936, IC 636937, IC 636595, IC 636938, IC 636939, IC 636964, IC 636596, IC 636940, IC 636550, IC 636941, IC 636942, IC 636943). Different *Phaseolus* species were collected from Nilgiris district of Tamil Nadu, among which *Phaseolus vulgaris* (14), *Phaseolus lunatus* (02) and *Phaseolus coccineus* (01). *Phaseolus vulgaris* (14), collections were maintained and evaluated for different traits. Wide range of variations was observed for plant type, growth habit, days to maturity and seeds traits. Some of the extra early maturing germplasm namely LMA 20-17 (65-68 days) and LMA 20-19 (65-68 days) were identified.

2. Genetic enhancement of pulse crops for yield, stability and quality

Evaluation of advance breeding lines of pulses

Mungbean: Total 28 advance breeding lines of mungbean with 2 checks (DGGV 2 and IPM 2-14) were evaluated during summer season. The genotypes such as IPM 14-10 (1335 kg/ha), IPM 1205-2 (1430 kg/ha) and IPM 1603-7 (1160 kg/ha) were found to be promising for cultivation in southern region when compared to checks IPM 2-14 (1030 kg/ha) and DGGV 2 (884 kg/ha).

Horsegram: Advance breeding lines (08) generated from different crosses were evaluated during *Rabi* season. Two genotypes such as IPHG 2019-5 (1150 kg/ha) and IPHG 2019-4 (1090 kg/ha) were recorded higher seed yield compared to check CRIDA 18R (930 kg/ha). Two promising genotypes (IPHG 19-5 and IPHG 19-4) were evaluated in co-ordinated trial (IVT). IPHG 19-4 (820 kg/ha) was found superior to best check Bilas Kulthi 1 (802Kg/ha) in the North Zone.

Chickpea: Station trials of chickpea (Mechanical harvesting trial, rainfed trial, G x E trial and *Kabuli* trial) and special trials of chickpea were evaluated for seed yield and component traits during Rabi season.

a) **Mechanical harvesting trial:** Total 20 entries of chickpea with two checks were evaluated in RBD design during *Rabi* 2020-21. Two entries of chickpea such as IPC 18-59 (>42 cm plant height, grain yield 1897 kg/ha), IPC 18-27 (>45 cm plant height, grain yield 1800 kg/ha) were found to be suitable for mechanical harvesting compared to GBM 2 (1700 kg/ha).

b) **Rainfed trial:** Total 20 entries along with three checks were evaluated during *Rabi* 2020-21. The entries such as IPC 17-54 (2600 kg/ha) and IPC 19-139 (2550 kg/ha) were recorded higher grain yield compared to JG 11 (2400 kg/ha) and SA 1 (1830 kg/ha).

c) **Genotype x Environment trial:** Twenty entries of chickpea with three checks were evaluated during *Rabi* 2020-21. IPC 19-41 (2670 kg/ha), IPC 17-139 (2400 kg/ha) and IPC 19-152 (2364 kg/ha) produced higher grain yield compared to JG 11 (2300 kg/ha) and SA 1 (1750 kg/ha).

d) ***Kabuli* chickpea trial:** Total 17 advanced breeding lines with three checks were evaluated during *Rabi* 2020-21. The entries such as IPCK 20-190 (2130 kg/ha), IPCK 18-184 (2100 kg/ha) and IPCK 18-185 (2030 kg/ha) were found to be promising for cultivation in southern region.

e) **Special trials of chickpea**: Three special trials of chickpea such as DTIL (21), genetic gain (30) and genomic selection (480) trials were conducted during Rabi season.

f) **Entries in state MLT**: Promising entries of chickpea (IPC 20-6, IPC 17-292, IPC 19-226 and IPC 19-222) were put to state multi-location trial (MLT) to assess their suitability for cultivation in different agro-climatic zones of Karnataka.



Advanced breeding lines of chickpea

Generation of breeding material in pulses

Cowpea

Seventeen different crosses were generated in cowpea involving locally released, agronomically adopted lines as recipient parents such as DC 15, DC 47-1 and KBC 9. More than 25 trait specific donors were used as donors for improving different traits such as C 152 (erectness), GC 3 (seed size, yield), RC 19, EC 47252 (earliness determinate types), PL 1/PL2(YMV, erectness, determinate type), RC 101 (Extra early, drought tolerance), RC 101, PL 4 (>3 pods/peduncle). GC 3, EC 724751 (>20 pods/plant). Wide hybridisation using *Vigna vexillata* (Insect-pest resistance, Protein content) attempted. Some of the crosses were KBC 9 x RC 19, KBC 9 x RC 101, DC 15 x RC 101, DC 15 x PL 1, DC 15 x *Vigna vexillata,* DC 15 x RC 19, DC 47-1 x RC 19, DC 47-1 x PL 1, DC 47-1 x *Vigna vexillata,* DC 47-1 x RC 101, KBC 9 x PL 1, KBC 9 x *Vigna vexillata,* RC 19, RC 101, PL 1 and *Vigna vexillata* resulted in production of 300 F_1 seeds during *Kharif/Rabi* 2021.



Cowpea crossing block and F_1 view under rainout shelter, IIPR RS, Dharwad

Horsegram

Total seven new crosses were attempted which involves donor lines with earliness, resistance to YMV and powdery mildew diseases in horsegram (CRIDA 18R x GDH 1, PHG 02 x Bilas Kulthi, CRIDA 18R x IC 347175, KBHG 01 x IC 145297, CRHG 09 x GDH 1, CRHG 22 x IC 71754, GPM 33 x TCR 1771 and GPM 06 x Indira Kulthi). Total 29 crosses from different segregation generations (F_1-F_2/F_2-F_3/F_3-F_4/) were advanced during 2020-21. More than 100 single plant selections (SPS) were made based on their superiority for seed yield and reaction to powdery mildew disease resistance.

Urdbean

Generation advancement of urdbean material namely F_4 to F_5 (21 lines), multiparent crosses (09 lines), advancement of below mentioned crosses from F_5 to F_6, Photo-thermo insensitivity (10 lines), Heat tolerance (6 lines), Drought tolerance (15 lines) has been done. Advanced generations of urdbean have been evaluated for photo-thermo insensitivity, heat and drought tolerance, multiparent crosses were evaluated for maturity groups and for different diseases such as *Anthracnose*, *Cercospora* leaf spot and Powdry mildew, 200 SPS was selected.

Off-season generation advancement of pulses

The chickpea breeding materials for off-season generation advancement was received from various AICRP centres such as Junagadh (26), Hisar (20), PAU, Ludhiana (170), Indore (59), Bijapur (18) and IIPR, Kanpur (19) during Kharif 2021. The generation advancement was performed during *Kharif* season and advanced breeding materials were sent to the respective AICRP chickpea centers. More than 20 new crosses were generated in chickpea during the off-season.

Breeder / TL Seed production Breeder seed production of mungbean

Total 900 kg of breeder seeds of mungbean cv. IPM 2-14 and urdbean cv. IPU 2-43 were produced

during summer/Kharif. TL seed production of chickpea varieties (JG 11/SA 1) were done during Rabi and produced seed yield of about 300 kg. In horsegram variety CRIDA 18 was produced seed yield of 350 kg during *Rabi*.



Breeder seed production of mungbean

Crop Production

3. Sustaining Crop Productivity for Pulse based Cropping System through Integrated Nutrient Management in Vertisols of Peninsular India

The total rainfall received during 2021 was 1052.3 mm which was higher by around 41.5% over 35 years (1985-2020) mean rainfall of 743.7 mm. Both mungbean and maize were sown on 23rd June 2021 with an antecedent rainfall of 142.8 mm that was received from 13th-22nd June. The crop season rainfall was higher especially for mungbean (266.5 mm) and for maize, it was 406.5 mm. The higher crop season rainfall for mungbean especially in July 187.4 mm resulted in water stagnation and lower crop growth and yield in mungbean. The treatment T_8 with 100% recommended rate of fertilizer (RRF) *i.e.*, 25:50 N:P kgha recorded a significantly greater mungbean yield of 417.7 kg ha and was higher by 32% over farmers' practice (315.8 kg/ha). The higher grain yields with T_8 are attributed to higher values of yield components *i.e.* number of pods per plant, pods weight, and seed weight per plant. Even straw yield was higher by 33% (5.44 q/ha) in T_8 over farmer's practice. The higher straw yield was attributed to better plant growth with higher plant height. The higher crop season rainfall with lower evapotranspiration and lower mungbean yield during 2021-22 produce lower water use efficiency (WUE) in mungbean. The water use efficiency of 2.08 kg/ha was recorded in T_8 and it was higher than farmers' practice by 32%. The simple seed treatment of *Rhizobium* and microbial consortium with over farmer practice of fertilizer application (T_2) recorded a higher mungbean yield of 16% over control.

Even in the maize crop, grain yield and WUE increased by 21% in T_8 over the farmers' practice of maize cultivation (T_1) during *Kharif* 2021. Higher yield in maize in T_8 was attributed to better plant growth with higher values of yield components i.e. cobs weight and seed weight per plant, 100-seeds weight, and total dry matter production per plant. Even straw yield of maize also was higher by 12% (89.0 q/ha) over farmers' practice (79.8 q/ha). Higher yields in T_8 were also attributed to better root growth with greater root weight (12.00 g/plant) over farmers' practice. Higher yields of maize and mungbean in T_8 were attributed to better moisture utilization over other treatments.

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

A field experiment was conducted at IIPR RRC, Dharwad during *Kharif* season (2021) on effect of pigeonpea based intercropping systems on productivity and soil properties. Treatments composed of 3 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. Results revealed that pigeonpea+ sorghum system recorded higher system productivity of 2623.9 kg/ha. 100-100 fertlizer level recorded the highest system producitivity of 2121 kg/ha. The highest Improvement in soil properties (OC, NPKS) was recorded in pigeonpea + Mungbean system. In a pot experiment on P use efficiency in urdbean genotypes, it was observed that urdbean genotypes STY 2289, DBGV 5, SYNP 2 and DU 1 showed comparatively more PUE values when compared to other genotypes.



Pigeonpea based intercropping system

5. Effect of soil and foliar application of iron and zinc on chickpea in Vertisols

A field experiment was conducted during Rabi season to study the effect of soil and foliar application of Fe and Zn on Chickpea. There were 5 treatments

viz, 1) Control, 2) DAP, 3) DAP+ Soil application of Fe and Zn, 4) DAP + Foliar application of Fe and Zn 5) DAP + Soil and foliar application of Fe and Zn. Results revealed that highest number of root nodules (24.33), mean plant dry weight (36.6 gm) and maximum seed yield of chickpea were recorded in the treatment (T_5) of chickpea i.e. DAP + Soil and Foliar application of Fe and Zn.

Crop Protection

6. Evaluation of mungbean minicore set against yellow mosaic disease

Total 296 mungbean minicore set was evaluated against YMV disease under natural condition in summer season, in which 43 entries were identified as resistant namely, VI001548 AG, VI001557 BG, VI001562 AG, VI001692 AG, VI002012 BG, VI002173 AG, VI002176 BG, VI002487 AG, VI002529 B-BL, VI002537 AG, VI002569 BG, VI002872 BG, VI002986 AG, VI003242 AG, VI003251 A-BLM, VI003252 BG, VI003255 AG, VI003329 AG, VI003337 BG, VI003382 BG, VI003407 AG, VI003658 BG, VI003733 BG, VI003734 B-BR, VI003734 B-DG, VI003744 AG, VI003755 BG, VI003760 BG, VI003795 AG, VI003886 BY, VI003925 B-BLM, VI003942 AG, VI003958 B-BLM, VI003959 BG, VI004006 A-GM, VI004743 AG, VI004789 BG, VI004853 BG, VI004931 AG, VI004933 AG, VI004934 AG, VI004954 BG, VI004956 AG and VI004965 BG. The check entry (DGGV 2) showed 100% YMV incidence.

7. Evaluation of cowpea against powdery mildew (*Erysiphe polygoni*) and root rot disease

A total of twenty-nine entries were screened against powdery mildew resistance. Observations were recorded during flowering and podding stage of the crop in which two entries DC 15 and VCP 18-032 were resistant and KBC 9 was moderately resistant to PM. Per cent disease index ranged between 4.4 and 100%. Pant Lobia 3 and CPD 331 were resistant and VCP 18-032 and PGCP 74 were moderately resistant to root rot disease and disease incidence ranged from 7.1 to 100 per cent.



Field view of cowpea screening against PM disease

8. Evaluation of horsegram against powdery mildew (*Erysiphe polygoni*) disease

A total of nineteen entries were evaluated against powdery mildew disease. Observations were recorded during flowering and podding stage of the crop in which, none of the entries showed resistant reaction. However, VLG 15 is identified as tolerant to PM and the percent disease index was ranged between 37.8 and 100 percent.

9. Management of powdery mildew of horsegram by new class of fungicides

Efficacy of seven fungicides (Hexaconozole 5 EC, Difenconazole 25 EC, Tebuconozole 250 EC, Fluopyrum 7.6% + Tebuconozole 17.6% w/v, wettable sulphur 80WP, Azoxystrobin (20% w/v) + Difenoconazole (12.5% w/v) and Carbendazim 50 WP) was evaluated against powdery mildew disease under field conditions. Among these, two foliar sprays Azoxystrobin (20% w/v) + Difenoconazole (12.5% w/v) at 0.1% at 10 days interval reported to cause 100 reductions in disease followed by Fluopyram 17.6%+Tebuconazole 17.6% with 98 per cent reduction in disease. Hence, these two fungicides are best suited for powdery mildew disease management in horsegram.

10. Evaluation of pigeonpea genotypes against sterility mosaic disease

A total of 152 entries were evaluated against SMD disease by leaf stapling technique under field conditions. Among these, 44 entries namely, IPAE 18-04, BDN 711, ICPIL 17124, TDRG 59, TDRG 325, IPA 14-4A, IPA 15-02, -19, -21, IPA 18-08, IPA 19-29,-42, -43, -55, MAL 53, MAL 52, DA 19-1, KA 17-02, PUSA 194, BRG 4, BSMR 243, BSMR 253, MAL 13, BWR 164, BWR 24, ICPWS 1916, ICPWS 1912, ICPWS 1913, ICPWS 1918, ICPWS 1919, ICPWS 1917, ICPWS 1924, ICPWS 1906, ICPWS 1903, ICPWS 1925, ICPWS 1937, ICPWS 1938, ICPWS 1939, ICPWS 1941, ICPWS 1942, ICPWS 1947, ICPWS 1946, ICPWS 1944, ICPWS 1945 were found resistant to SMD and 9 entries (WRGE



Field view of pigeonpea screening against SMD disease

124, WRGE 128, AKTM 1637, AKTM 1644, BDN 2013-45, GJP 1915, LRG 471, DA 2020-1 and BSMR 736) were moderately resistant.

11. Estimation of yield losses due to foliar fungal diseases of Mungbean (IPM2-14)

The experiment was carried out during 2020-2021 to assess yield loss due to various diseases (*Cercospora* leaf spot (*Colletotrichum truncatum*), Antracnose (*Colletotrichum truncatum*) and powdery mildew (*Erysiphe polygoni*) diseases) of mungbean. Single, two and three foliar sprays of 0.1% Azoxystrobin (20% w/v) + Difenoconazole (12.5% w/v) at 10 days interval found to reduces yield loss up to 32.7, 35.1 and 47.1 per cent, respectively. Three times spraying decreases mungbean powdery mildew severity up to 98.4 per cent, *Cercospora* leaf spot severity up to 60.7 per cent and *Anthracnose* severity up to 39.3 per cent.

12. Ecofriendly Management of Insect Pests in *Vigna* pulses (Mungbean, Urdbean, Cowpea) and Horsegram for Southern India

Monitoring the seasonal incidence of major insect pests in *Vigna* pulses

Incidence of major insect pests in *Vigna* pulses were monitored in different seasons. In cowpea, the % pod borer damage by *Maruca vitrata* was 13.83, during summer season. During *Kharif* season, in mungbean, the pod damage by pink pod borer, *Cydia ptychora* was 50.21%, whereas in urdbean, the pod damage by pod weevil, *Apion amplum* was 33.28 and 56.66% at green pod and harvest stage, respectively.

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

A field experiment was carried out to study the effect of different planting time on incidence of major insect pests of cowpea (DC 15) during *Kharif* season 2021. Three different dates of cowpea sowing were taken at 10-15 days interval. The cowpea crop sown during second fortnight of June (25.6.2021) recorded the lowest pod damage of 17.68% as compared to the crop sown during the first and second fortnight of July by pod borer, *M. vitrata*.

Evaluation of different IPM modules in cowpea against spotted pod borer, *Maruca vitrata*

A field experiment was conducted to evaluate the different IPM modules *viz.*, Bio-intensive module, integrated module, farmers practice against spotted pod borer, *Maruca vitrata* in cowpea (var. DC-15) during *Kharif* season 2021. First spraying of insecticide was done at 50% flowering and subsequent sprays at 10 days interval. Among different modules, integrated module comprising spray of rynaxpyre @ 0.5 ml/l, followed by neem insecticide 5 ml/l and emmamectin benzoate 0.5 gm/l.) was found effective with the lowest incidence of pod damage of 12.60% and 65.25% reduction in pod damage as compared to untreated module.

Evaluation of biopesticides against pod borer, *Maruca vitrata* in cowpea

A field experiment was conducted to evaluate the different biopesticides *viz.*, microbial and botanical pesticides against spotted pod borer, *Maruca vitrata* in cowpea (var. DC 15) during *Kharif* season 2021. Among different biopesticides evaluated, the microbial biopesticide *Beauveria bassiana* @ 5 gm/L was found most effective followed by neem soap @ 10g/L and recorded 66 % reduction in pod damage as compared to untreated control.

Evaluation of advance lines of *Vigna* pulses against major insect pests

During *Kharif* season, different advance lines of mungbean, urdbean and cowpea were screened for pod borer damage. In mungbean, out of total 69 lines, the lowest pod damage of 13.06% was observed in KME 21-52. In urdbean, out of 46 lines, the lowest pod damage of 12.20% was recorded in KUE-21-21. In case of cowpea, out of 24 lines, the lowest pod damage of 14.30% was observed in CPE 3.

13. Management of major sucking insect pests in greengram and blackgram

Effect of date of different sowing on sucking insect pests in mungbean

A field experiment was conducted during summer season to evaluate the effect of different date of sowing on sucking insect pests in mungbean (var. IPM 2-14). The three different dates of cowpea sowing were taken at 10-15 days interval. The mungbean crop sown during second fortnight of April, recorded lower incidence of sucking pests *viz.*, whitefly (1.00/plant) and jassids (0.87/plant). The YMV disease in IPM 2-14 was around 0.19% as compared to susceptible check variety DGGV-2 (20.43%).

14. Development of Technologies/Varieties of pulses:

- Registration of chickpea wilt resistant genetic

stock (IPC 2007-28), IPC 2020-198, ICC 12315 and Mungbean yellow seed coat colour genetic stock (IPM 04-1-7).

- Three high yielding varieties of chickpea: IPCK 2013-163, IPC 2007-28 and IPC 2010-134.
- Involved in development of chickpea MAS product Samruddi (Improved BG 256)
- Collaborators in the development and release of high yielding variety of urdbean (DBGV 16) with UAS, Dharwad
- Identified fungicide (Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V)) for management of powdery mildew of mungbean.
- Two promising entries of mungbean (IPM 14-10) and urdbean (IPUD 2016-5) entered in state multi-location trials and were evaluated under different agro-climatic zones of Karnataka.

Extension Activities

15. Frontline demonstrations in farmers' fields and pulse model village

Total ten FLDs in chickpea and eight FLDs in cowpea and horsegram each and four FLDs in mungbean were taken up in different farmers' fields of Narendra, Rayapur, Sangreshkoppa, Harikoppa, Byahatti, Mulamuttal, Yettinagudda, Mangalgatti of Dharwad district during *Rabi* and summer seasons. Demonstrations of improved pulses varieties were also conducted in Narendra and Mulamuttal village of Dharwad under Pulse model village programme and interacted with the pulse growing farmers and advised the farmers. Scientists of the center visited pulse growing farmers' fields of Narendra, Mangalgatti, Mulamuttal, Chandanmatti, Kankura, Kavalgeri and Amargol Dharwad during *Kharif/Rabi* and interacted with the pulses growing farmers and advised the farmers regarding low cost agricultural technologies and integrated approaches for pest and disease management.

16. Implementation of SCSP Programme in Dharwad District

Scheduled Caste Sub Plan (SCSP) programme was implemented in Dharwad District in collaboration with ICAR-Krishi Vigyan Kendra, UAS Dharwad. Under this programme, total 50 beneficiary farmers from Shirur, Pudakalkatti and Hayatii villages of Dharwad Dist. were selected. Various farm and animal inputs like seeds of improved chickpea varieties, biopesticides, crop specific nutrients, sex pheromone traps, cycle weeder, sprayer, rubber mat for diary animal, seed & animal feeding turfs, small implement, tool kits and improved backyard poultry chicks were distributed to the beneficiary farmers for their livelihood improvement. One field day on Pulses at Shirur village and two animal health camps at Lokur and Shirur villages of Dharwad Dist. were conducted under the SCSP plan. The farmers field were monitored by a team of scientists constituted at RRS, Dharwad to review the progress of the crop and implementation of the SCSP programme at Dharwad.

17. Demonstation of IIPR-Mini dal mill

Demonstartion was conducted on October 18, 21 on the use and working of IIPR Mini *Dal* mill to farmers of Dharwad District. Around 50 farmers participated in the demonstration. They were appraised about the importance and use of IIPR-mini *dal* mill for becoming *Atmanirbhar* and post harvest value addition of pulses.

18. Scientist-Farmers Interface meet

Farmers-scientist interface meeting held at IIPR-RRC, Dharwad on occasion of Decennial Celebrations of ICAR-IIPR Regional Research Centre, Dharwad held on 18th October 2021. Interacted with farmers of Dhrawad region and disseminated plant protection measures and importance of IPM in pulses.

19. Major Events Organized and other Institutional activities at IIPR-RRS, Dharwad

- Organised "Decennial Celebrations of ICAR-Indian Institute of Pulses Research, Regional Research Centre, Dharwad on 18th October 2021. Dr. MB Chetti, Hon. VC, UAS Dharwad; Dr. J.H. Kulkarni, Ex. VC, UAS, Dharwad; Dr. PL Patil, Director of Research, UAS, Dharwad and Dr. N.P. Singh, Director, IIPR, Kanpur graced the ocassion. Farmers, pulse scientists from UAS Dharwad and staff of RRS, Dharwad participated in the event.
- Inauguration of IIPR-Mini Dal Mill and Foundation Stone Laying for Farm & Seed Operation Services building at IIPR-RRS Dharwad on October 18, 21.
- Organized and conducted Institute Foundation day at RRS, Dharwad on September 5, 21. Felicitated the awardee farmer from Dharwad Region on the occasion.

- Hosted Dr. P.M. Salimath, Ex. VC and Chairman, RAC, IIPR, Kanpur to conduct 27th RAC Meeting in virtual mode from RRS, Dharwad.
- Conducted World Environment Day on June 5, 21, on this occasion planted trees and plants in RRS farm.
- Organised various institutional activities and programmes like Institute foundation day, World Environment day, *Parthenium* Awareness Week, Vigilance Awareness Week, *Swachata Pakwara*, *Van Mahotasav* Programme etc., at RRS.



Decennial Celebrations of IIPR-RRS, Dharwad

Developmental works and infrastructure/ facilities created at IIPR-RRS, Dharwad

Below mentioned new infrastructure facilities were created at RRS, Dharwad:

- Fixing and commissioning of 100 KV transformer at RRS farm
- C/o and electrification to new seed storage building cum threshing floor
- Electrification & commission of new tube well for irrigation purposes
- Electrification to rainout shelters and Hitech green houses to conduct various research activities
- Electrical backup connection to National Nursery Building from DG set
- C/o Vehicle Parking Shed
- Installation of cemented pots for various research activities
- Purchase and installation of IIPR-Mini *Dal* mill



Field visit by Dr. N.P. Singh, Director, IIPR and Dr. P.M. Salimath, RAC, Chairman

- Purchase of tractor operated cultivator for use in research farm
- Purchase and fixing of permanent field name boards in different blocks of research farm
- Purchase and installation of LPG connection to crop protection laboratory

ICAR- IIPR, Regional Centre, Bikaner

Research achievements:

1. Genetic enhancement in arid pulses (mothbean and cowpea) for abiotic and biotic stresses

Mothbean: In *Kharif* 2021, 300 mothbean accessions were evaluated in augmented design under the hot and arid climate at APRC, Bikaner, Rajasthan to estimate the presence of genetic variability and to identify suitable donors. Data was recorded for different agro-morphological traits at different growth stages of the crop. High variability was observed for traits such as 50% flowering, plant height, clusters per plant, pods per plant, test weight and grain yield per plant. Accessions IC-8851, IC-370508, IC-415116, IC-415127, IC-415139 IC-415143 IC-415155, IC-415164 and IC-120963 were identified as early type, and IC-402285, IC-11352, IC-315520, IC-329051 and IC-370508 exhibited yield advantage over the check varieties (Fig. 1).

Mothbean accessions were also screened for yellow mosaic virus, leaf crinkle virus and *Cercospora* leaf spot. These diseases were detected under natural field condition and spread through a large whitefly population. The key to deal with biotic stresses is to screen germplasm for resistant genotypes that may be included in a long-term disease control strategy on a sustained basis. Among the three biotic stresses studied, *Cercospora* leaf spot had the highest disease incidence, ranging from 5-90%, followed by crinkle leaf virus (10-50%) and yellow mosaic virus (5-80%). The accessions IC-329051, IC-36623IC-415104, IC-415116, IC-415127, IC-415139, IC-415155 were highly susceptible to *Cercospora* leaf spot and one accession IC-103154 was found highly susceptible to yellow mosaic virus. Two accessions, IC-39734 and IC-39827, were identified on as highly resistance to all the three diseases.

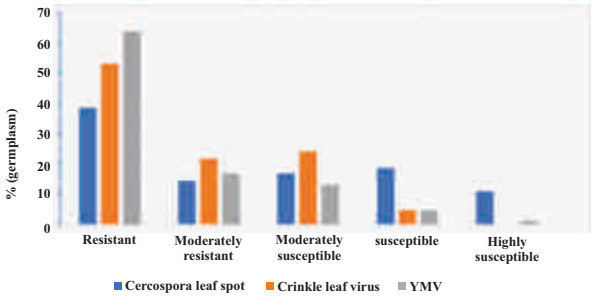


Fig. 1. Behaviour of mothbean accessions against biotic stresses

Cowpea: Total 50 accessions of cowpea were evaluated and observations were recorded for different qualitative and quantitative traits (flower colour, plant growth habit, plant twining tendency, days to 50% flowering, pod length, pods/plnat, seeds/pod, seed eye colour, seed test weight, yield/plant). Wide range of variability was observed for different morphological traits. Three accessions *viz.* EC-738156, EC-738206 and EC-738093 were identified early type (50% flowering < 45 days) and based on maximum no. of seeds/pod accession EC-723808 was identified best (> 17 seeds/pod). On the basis of pod length (>15 cm) EC-724555, EC-724859, EC-528393, IC-396744 were selected as promising genotypes (Table 1).

Table 1: Identification of trait specific promising accessions of cowpea

Character	Promising accessions
Early flowering (<45)	EC-738156, EC-738206, EC-738093
Pod length (>16 cm)	EC-724859, IC-202777, IC-396744, IC-396767, EC-528393, C-198355-2
No. of pods/plant (>20)	EC-402180, EC-458425, EC-472271, IC-209891
No of seeds/pod (>15)	EC-725017, EC-723808
Seed test weight (>15 g)	EC-724035, EC-724601, EC-738125, EC-738156, EC-738236
Grain yield (>20 g)	EC-725017, EC-738236, EC-402180, EC-458425, EC-472271, EC-528393, EC-472271

Evaluation and advancement of cowpea segregating material: The segregating material of F_3 and F_5 generations of cowpea was received from IIPR, Kanpur and evaluated under arid climatic condition at APRC, Bikaner. In F_3 generation, 190 SPP were evaluated and promising single plants were selected and in F_5 generation 200 individual lines were evaluated and harvested separately for further advancement and evaluation.



Fig. 2. Field of cowpea segregating material

2. Drought and heat tolerance in *kharif* legumes (mothbean, mungbean and pigeonpea)

Mothbean: The experiment was conducted to study the genotypic variation for drought stress in 21 mothbean genotypes (Fig. 2). The total biomass and seed yield was significantly reduced under drought conditions. Relative per cent reduction in total biomass was found higher in MB-10 and MB-7, whereas it was less in RMB-25 and RMO-2251. Seed yield also significantly reduced are drought in all the mothbean accessions. Among all the mothbean genotypes, the highest percentage reduction in number of pods/plant was observed in genotypes MB-50845, the lowest percentage reduction in number of pods/plant was recorded in MB-9 and RMB-25. Significant effect on 100-seed weight was not found in this study. Harvest index was recorded higher in RMO-257 and RMO-435.

Mungbean : Experiments were conducted to study the genotypic variation for drought stress in 20 mungbean genotypes. Out of 20 mungbean genotypes, IPM 1103-1, IPM 312-20 (Vasudha) and IPM 410-3 (Shikha) showed considerable resilience to drought and noticed less reduction in chlorophyll content, dry matter and seed yield.

3. Enhancing input use efficiency and productivity of pulses in arid ecosystem

Tillage, residue and nutrient management in different cropping system

A field experiment was conducted during *kharif* 2020 to study different cropping systems under conservation agricultural practices in arid ecosystem. The experiment was conducted under split plot design with three replications. Main plots consist of 3 tillage management practices *viz*., i) Conventinal tillage in both *kharif* and *rabi* crops (CT-CT), ii) Conventional tillage for *kharif* crops and zero tillage for rabi crops with residue retention of previous crop (CT-ZT), iii) zero tillage for both *kharif* and *rabi* crops with residue retention of previous crop (ZT-ZT), and two cropping system in sub plot *viz*. Pearl millet-chickpea and clusterbean - mustrad and two level of nutrient management in sub-sub plot *viz*. 100% recommended dose of fertilizer (RDF) for both *kharif* and *rabi* crops and 75% RDF for both *kharif* and *rabi* crops. The result revealed that grain yield was not significantly influenced under tillage management options and recorded maximum yield under CT-CT. However, the increase in grain yield was significant under cropping systems and recorded significantly higher in clusterbean- mustard system as compared to pearl millet-chickpea system. Among nutrient management options, 100% RDF recorded significantly higher yield of the component crops over 75% RDF. System productivity in terms of chickpea equivalent yield (CEY) was not significantly affected under all the tillage management options. Among cropping systems, clusterbean- mustard cropping recorded significantly higher CEY (2473 kg/ha). Further, 100% RDF gave significantly higher CEY (2240 kg/ha) over 75% RDF. Net return and benefit cost ratio was recorded significantly higher under CT-CT followed by CT-ZT and ZT-ZT, respectively. However, CT-CT and CT-ZT was statistically equivalent to each other. Among the cropping systems, clusterbean-mustard cropping system was found more remunerative in comparison to pearlmillet- chickpea. Under nutrient management options, 100% RDF significantly improved the net return and BCR over 75% RDF.

Irrigation and nitrogen management

A field experiment was carried out during *kharif* 2020 to study the effect of nitrogen and irrigation management in mothbean for enhancing nutrient and water use efficiency under arid conditions. The treatment consisted of three level of nitrogen management (15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering stage, 15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at pod development stage and 15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering and pod development stages) and three level of irrigation management (single irrigation at branching stage, two irrigation at branching + pod development stages and two irrigation at flowering + pod development stages) under factorial randomized block deign with three replications. Result revealed that 15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering and pod development stage recorded significantly higher yield of mothbean over 15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering stage and 15 kg N + 40 kg P_2O_5+ foliar spray of urea (2%) at pod development stage. Further, irrigation at two stages *viz*. vegetative/branching + pod formation stage registered significantly higher yield of mothbean followed by two irrigation at flowering stage + pod formation stage and single irrigation at vegetative/branching stage, respectively (Table 2).

Table 2: Effect of nitrogen and irrigation management on productivity of mothbean

Treatment	Yield (kg/ha)			
	Grain	Haulm	Total biomass	HI
Nitrogen management				
15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering stage	688	1929	2617	26
15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at pod development stage	710	2077	2786	26
15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering and pod development stage	863	2626	3488	25
CD (P=0.5)	80	301	374	NS
Irrigation Management				
Vegetative/branching stage	551	1561	2111	26
Vegetative/branching + pod formation stage	885	2612	3497	25
Flowering stage + pod formation stage	825	2459	3284	25
CD (P=0.5)	80	301	374	NS

Net return and benefit cost ratio (BCR) were significantly influenced by nitrogen application to mothbean. The highest net return and widest BCR of mothbean was earned with 15 kg N + 40 kg P_2O_5 along with foliar spray of 2% urea at flowering and pod formation stages over single dose foliar spray of urea at flowering and pod formation stages. Further, irrigation at two stages *viz*. vegetative/branching + pod formation stage and flowering stage + pod formation stages recorded significantly higher net return and BCR of moth bean over single irrigation at vegetative/branching stage.

Resource conservation technologies in arid ecosystem

Effect of tillage and residue on pulse inclusive cropping systems

During *Rabi* 2020-21, a field experiment was initiated at the ICAR-IIPR, APRC, Bikaner Research Farm to evaluate the performance, economics, energy efficiency and input use efficiency of four different cropping systems (Pearl millet – Mustard, Pearl millet – Chickpea, Moth bean – Mustard, Cowpea – Chickpea) under two tillage (conventional and zero tillage) and residue management (with and without residue) options in a split- split plot design. The first-year results showed that tillage, cropping system and residue management strategies had no significant effect on the yield of chickpea and mustard. While zero tillage treatment resulted in a higher net return (18.5 per cent) and B:C ratio compared to conventional tillage practices. In contrast to chickpea, mustard provides a higher net return and B:C ratio. Since this was the first crop, there was no difference in the results regarding residue management practices. Similar trends for energy use efficiency and productivity were observed under tillage, cropping system and residue management practices.

4. INM in pulse-based cropping systems

The present field experiment was carried out during 2020-21 in pearl millet – mustard, mothbean – mustard, pearl millet - chickpea, clusterbean + sesamum (6:2) - chickpea system to study the effect of nutrient management practices (100% RDF, 75% RDF + 5 t FYM, 75% RDF + 5 t FYM + biofertilizers and 50% RDF + 5 t FYM + biofertlizers + crop residue) on crop performance, economics, energetics, nutrient and input use efficiencies. The result revealed no significant difference among cropping system as this was the first crop. However, yield of both crops was significantly influenced by nutrient management practices. A higher yield of mustard (14.45 q ha) and chickpea (12.7 q ha) was observed with RDF-75%+5 t FYM+Biofertilizers followed by 100% RDF. Mustard crop gave a higher net return and B:C ratio as compared to chickpea. While in nutrient management practices, 100% RDF recorded a higher net return and B:C ratio compared to other treatments. We observed almost similar trends for energy use efficiency and energy productivity (Table 3).

Table 3: Effect of cropping systems and nutrient management on yield of chickpea and mustard

Treatment	Grain/seed yield (q/ha^{-1})	
	Chickpea	Mustard
Cropping systems		
Pearlmillet-Chickpea Peralmillet-Mustard	10.77	13.00
Clusterbean+Sesamum-Chickpea Mothbean-Mustard	11.47	14.09
CD (p=0.05)	NS	NS
Nutrient management		
100% RDF	12.3	13.96
75% RDF+5 t FYM	10.4	11.91
75% RDF+5 t FYM+ Biofertilizers	12.7	14.45
50% RDF+5 t FYM+ Biofertilizers+Crop residue	11.2	12.76
CD (p=0.05)	1.11	0.91

5. Efficacy of growth supplements on performance of cluster bean and mothbean cultivars

Exogenous application of growth supplements is known to improve plant resistance against abiotic stresses. A field experiment was conducted with 7 growth supplements i.e. thiourea (1000 ppm), K_2SO_4 (0.2%), Salicylic acid (100 ppm), Urea (2%), NPK solution (0.5%), Acetic acid (20 mM), $MgSO_4$ (0.5%), and water spray as control. For better comparison, cultivars of different nature of cluster bean (RGC-936 and RGC-1066) and mothbean (CAZRI Moth 2 and RMO-2251) were kept. Growth supplements were applied as foliar spray at vegetative and pre-flowering stage. The experiment was laid out in factorial randomized block design and replicated thrice. Application of growth supplements maintained water relations, enhanced membrane stability, content of photosynthetic pigment, activity of antioxidant enzymes and declined lipid peroxidation which reflected in higher yield in treated plots. Among growth supplements, K_2SO_4 showed its superiority in enhancing drought tolerance in both the crops which was at par with thiourea (Table 4). In cluster bean, RGC-936 and in moth bean, CAZRI Moth-2 responded better to growth supplements and reported higher yield as compared to other cultivars. Application of potassium sulphate and thiourea resulted in 8.0-10.0% higher seed yield over water spray.

Table 4: Effect of growth supplements on seed yield (kg/ha) of different cultivars of cluster bean and moth bean

Growth supplements	Cultivars			
	Cluster bean		Mothbean	
	RGC-936	RGC-1066	CAZRI Moth-2	RMO-2251
Water	1035f	1022f	702e	569e
Thiourea (1000 ppm)	1120a	1095a	756a	617a
K_2SO_4 (0.2%)	1125a	1106a	765a	626a
Salicylic acid (100 ppm)	1085bc	1076bc	741bc	608bc
Urea (2%)	1064de	1050de	728d	590d
NPK solution (0.5%)	1070cd	1055cd	733cd	593cd
Acetic acid (20 mM)	1108ab	1085ab	746b	611b
MgSO4(0.5%)	1055e	1044e	715e	582e

6. Identification of suitable intercropping system and row ratio for legume cultivation in arid region

A field experiment was conducted during *kharif* seasons of 2021 to evaluate the performance of moth bean var. RMO-2251, cluster bean var. RGC-1066, with pearlmillet (*Pennisetum glaucum*) var. MPMH 17 intercropping systems in hot arid rainfed conditions. Three intercropping combinations of pearl millet with cluster bean and mothbean (1:1, 2:1 and 3:1) along with sole crop treatment were executed in second fortnight of July with the onset of monsoon. The experiment was laid out in factorial randomized block design and replicated thrice. Results of the study revealed that sole pearl millet was found superior than other treatments. The highest pearl millet equivalent yield (PMEY), gross return, net return and B: C ratio were obtained in sole cluster bean. In the intercropping, cluster bean outperformed the mothbean, irrespective of row ratios (Fig. 3). Despite the intercrop competition,

PM+CB (1:1) recorded highest total yield having LER of 1.33 indicating intercropping advantage followed by PM+CB (2:1). In comparison to cluster bean, mothbean failed to perform as an intercrop irrespective of row ratios.

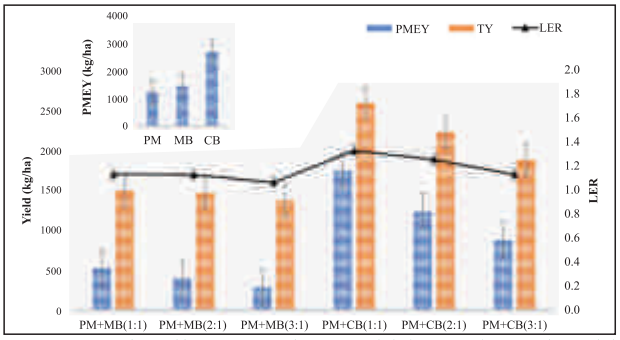


Fig. 3. Pearl millet equivalent yield (PMEY), total yield (TY) and land equivalent ratio (LER) of sole and different intercropping systems of pearlmillet (PM), cluster bean (CB) and mothbean (MB). Bars on the primary axis represent the PMEY and TY of intercropping systems, and line on secondary axis represents the LER values.

Developmental activities

Gardening and landscape development

Around 1600 plant saplings were planted along with 60 potted plants and hedging in 250 m area. Lawn grasses also planted in 3000 m^2 area.

Infrastructure developed

- Seed godown
- Farm gate (3 nos.)
- Diggi for canal water storage at Seed Production Farm (Unit 2)
- Electricity connection for Seed Production Farm (Unit 1)
- Established hybridization garden
- Farm road
- Toilet & shed for field labours
- Installed IIPR Mini Dal Mill



Hybridization garden



Grill construction



Diggi for canal water storage (20 lakh litres)

Developmental activities

Events/activities organised at APRC, Bikaner



Scientist-farmer interactions meet at farmer field in Badrasar village, Bikaner district on 9th Feb, 2021



Celebrated World Pulses Day on 10th February, 2021



Field IRC during *kharif* 2021



Seed distribution & farmer scientist seminar organised on 30th October, 2021

ICAR-IIPR Regional Station Khordha, Odisha

ICAR-IIPR-RRS, Khordha (Odisha) was established in January, 2020 to cater to the needs of research on pulses in hot and humid regions of Eastern India. The station is situated at **20°18'8" N, Long: 85.622 E & 75 MSL Altitude** in an area of 29.395 acres. The mean annual rainfall is 1449 mm with the mean daily maximum temperature being 38.5°C in April and 26.5°C in January. However, the mean daily minimum temperature is 14.7°C in January and 25.8°C in April. The major *kharif* crops of this region are paddy, mungbean, pigeon pea, cowpea, maize and small millets, etc. and mungbean, urdbean, chickpea, field pea and mustard in *rabi* season.

Thrust areas

The objectives of the centre are to cater to the needs of pulse growing farmers of eastern region of country by developing location specific technologies, large scale quality seed production, characterization/ screening and evaluation of germplasm, generation of breeding material of pulses for the eastern agroecosystem, demonstration and transfer of technologies, and coordination of pulses research through networking of testing centres across the zone, particularly in Odisha State.

Research Achievements

1. Development of climate smart agro-technologies for pulses under diversified agro-ecological Regions of India

Project: Sustainable intensification of rice-fallows with inclusion of pulses in Eastern India

- Among the urdbean varieties screened, IPU 13-1 had significantly higher seed yield over other varieties tested.
- In respect of dates of sowing, sowing done on 10 December had significantly higher yield as compared to sowing done on 30 November and 20 December and IPU 13-1 recorded maximum seed yield (1103 kg/ha).
- Among the mungbean varieties tested, significantly higher grain yield was recorded in IPM 2-14 as compared to IPM 205-7 and Kamdev.

2. Epidemiology and characterization of major and emerging pests and diseases of pulses and diagnostic of seed borne viruses

Project: Epidemiology and search for resistance against major diseases of mungbean and urdbean

Five genotypes of uradbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check mungbean (DGGV 2) & urdbean (MDU 1) were screened against YMD during kharif season & found that the YMD was observed only in susceptible check



Fig. Screening of Urdbean genotypes against YMD during kharif season

(MDU-1) with DI of 100 %, DS of 73% & rest others line are free from YMD & the susceptible check (DGGV-2) was also free from YMD.

- Ninety nine entries of uradbean were evaluated against powdery mildew during rabi season and found that none of the entries were resistant or moderately resistant.



Fig. Screening of Urdbean genotypes against powdery mildew

Intraction with farmers





Developmental activities

Infrastructure:

- Laboratory-cum-administrative building- Under construction
- Farm office & threshing floor- Under construction
- Boundary wall (650 m) constructed
- Road constructed (CC Road 420 m)
- 62 KVA DG Set (1 Nos.) installed
- Electricity connection with transformer –completed
- Main gate- Under construction

Laboratory equipment:

The following equipment's purchased for use in laboratory:

- BOD Incubator-1
- Hot Air Oven-2
- Shaker-1
- All Quartz Double Distillation Units -1
- Microprocessor Flame Photometer-1
- Electronical Weighing Scale (up to 300kg) -1
- Electronical High Precision Weighing Balance -1
- Mridhaparikshak -1
- Laminar air flow-1

Farm Implements procured:

The following equipment purchased for agricultural operations along with office vehicle:

- Office Vehicle- Bolero
- Tractor New Holland- 65 HP, & 35 HP
- Tractor Trolley
- Thresher Multipurpose
- Seed cum fertilizer drill
- Cultivator 9 Tyne
- Cultivator 13 Tyne
- Disc Harrow
- Disc Plough
- MB Plough
- Power Weeder
- Bund Maker
- Rotavator
- Power Sprayer
- Water Tanker
- Lawn Mower
- Diesel Pump Set
- Raised Bed Multicrop Planter
- Water Purification System with inbuilt Water Cooler
- Seed Bin (2)
- Spray Machine (Manual)
- Mobile Seed Processing Unit-1







ICAR-IIPR Off-Season Activity at Kullu (H.P.)

In an effort towards establishment of off-season nursery for generation advancement and development of new breeding materials, various evaluation trials were conducted at several locations in Himachal Pradesh. During 2020 and 2021, trials were undertaken at CSWRI, North Temperate Regional Station, Garsa, Distt. Kullu. During Kharif 2020 experimental materials of ricebean (74 lines) and seed multiplication plots of rajmash were sown. 49 kg genetically pure seed of 3 varieties of rajmash including 13 kg of Arun, 27 kg of Uttkarsh and 09 kg of Uday varieties was produced while 20 kg seed mixture was handed over to NTRS Garsa as per the term of MoU. During rabi 2021 seed multiplication of chickpea, lentil and fieldpea was undertaken. The crop performed well and the total produce is still to be weighed. Simultaneously, exploratory trials comprising 33 genotypes in chickpea, 29 in lentil, 09 in rajmash, 10 in fieldpea, 11 in mungbean, 5 in urdbean and 6 in fieldpea were raised at CSKHPKV, Highland Agricultural Research Station, Kukumseri, Distt. Lahaul and Spiti during rabi 2020-21. All the trials were conducted in two replications and data were recorded w.r.t. morpho-physiological traits. Superior genotypes were identified. Mungbean and urdbean materials could not adapt to the local conditions. The same materials were also raised at CSKHPKV, Sundarnagar and 5 genotypes in chickpea viz., GNG-1958, DCP 92-3, IPC 20011-112, GNG-2144 and IPC 2010-142, 6 in fieldpea viz., IPFD 14-2, IPFD 9-2, IPFD 13-2, IPFD 6-3, HFP 9426 and IPFD 12-2 and 5 in lentil (IPL315, IPL526, PPL321, IPL81 and IPL220_ were found to be superior and adapted to local conditions. Likewise, evaluation trials comprising 10 varieties of mungbean and 5 each of rajmash and urdbean were also raised at CSK Himachal Pradesh Krishi Vishvavidyalaya, Regional Station, Berthin during Kharif 2021.



Pulses evaluation trials at (A) Sundarnagar, and (B) Garsa, Distt. Kullu in Himachal Pradesh during 2020-221

All India Co-ordinated Research Projects
Chickpea

CROP IMPROVEMENT

Varieties identified for release:-

S No	Crop	Variety	Area of Adoption	Salient features
1	Chickpea	NBeG 857	South Zone: Andhra Pradesh, Telangana, Karnataka and Tamil Nadu.	• Pedigree: ICCV 12419 × JG 11. • Avg. Yield: 18-19 q/ha • Maturity: 95-100 days • 100 seed weight: 23.4 g • Resistant to *Fusarium* wilt
2	Chickpea	RG 2016-134	South Zone: Andhra Pradesh, Telangana, Karnataka and Tamil Nadu.	• Pedigree: ICCV 03112 x ICCV 10. • Avg. Yield: 16-17 q/ha. • Maturity: 110 days • 100 seed weight: 25.7 g • Moderately resistant to *Fusarium* wilt
3	Chickpea	IPCK 2013-163	North West Plain Zone (Punjab, Haryana, western Uttar Pradesh, North Rajasthan and Jammu and Kashmir)	• Pedigree: JGK-1 x Phule G 0517 • Avg. Yield: 19-20 q/ha • Maturity:147 days • 100 seed weight: 28.7 g • Resistant to *Fusarium* wilt
4	Chickpea	RKGK 13-414	West Central Zone (Southern Rajasthan, Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Gujarat and Maharashtra)	• Pedigree: BG 1044 x BG 1111 • Avg. Yield: 17-18 q/ha • Maturity: 115 days • 100 seed weight: 27.3 g • Resistant to *Fusarium* wilt
5	Chickpea	CSJK 174	South Zone: Andhra Pradesh, Telangana, Karnataka and Tamil Nadu.	• Pedigree: ICCV 2 x RSGK 6 • Avg. Yield: 14-15 q/ha • Maturity: 100-115 days • 100 seed weight: 37.8 g • Moderately resistant to *Fusarium* wilt
6	Chickpea	GJGK 1617	North West Plain Zone (Punjab, Haryana, western Uttar Pradesh, North Rajasthan and Jammu and Kashmir)	• Pedigree: ICC 14195-P3 x ICCV 92337 • Avg. Yield: 13-14 q/ha • Maturity: 143-148 days • 100 seed weight: 43.5 g • Moderately resistant to *Fusarium* wilt
7	Chickpea	GLK 17301	North West Plain Zone (Punjab, Haryana, western Uttar Pradesh, North Rajasthan and Jammu and Kashmir)	• Pedigree: ICC 19281 x JGK 1 • Avg. Yield: 13-14 q/ha • Maturity: 144 days • 100 seed weight: 42.5 g • Moderately resistant to *Fusarium* wilt

8	Chickpea	IPCMB 19-3	Central Zone (Madhya Pradesh, Maharashtra, Gujarat and Bundelkhand region of U.P.)	• Pedigree: [(Pusa 256///(Pusa 256/ Vijay]. • NIL of Pusa 256 developed through marker assisted backcross breeding. • Carries wilt QTLs for wilt resistance race 2 on LG 2, introgressed in Pusa 256 from Vijay • RPG recovery: 94% (using 51 polymorphic SSR markers) • Avg. Yield: 20-21 q/ha • Maturity: 100-110 days • 100 seed weight: 24.1 g • Resistant to *Fusarium* wilt
9	Chickpea	IPC L 4-14	North West Plain Zone (Punjab, Haryana, western Uttar Pradesh and plains of Jammu and Kashmir)	• Pedigree: [(DCP 92 -3/// (DCP 92-3/ ICC 4958]. • NIL of DCP 92 -3 developed t hrough marker assisted backcross breeding. • Carries "QTL hot spot" for drought tolerance from ICC 4958 • RPG recovery: 91% (using 45 polymorphic SSR markers) • Avg. Yield: 15-16 q/ha. • Maturity: 128-133 days • 100 seed weight: 16.6 g
10	Chickpea	BG 4005	North West Plain Zone (Punjab, Haryana, western Uttar Pradesh and plains of Jammu and Kashmir)	• Pedigree: [(Pusa 362///(Pusa 362/ ICC 4958]. • NIL of Pusa 362 developed through marker assisted backcross breeding. • Carries "QTL hot spot" for drought tolerance from ICC 4958 • RPG recovery: 95% (using 56 polymorphic SSR markers) • Avg. Yield: 16-17 q/ha. • Maturity: 131 days • 100 seed weight: 22.4 g

- On the basis of three years of multi-location evaluation, promising *desi* chickpea genotypes are NBeG 857 (2023 kg/ha), RG 2016-134 (1693 kg/ha) and DC 2017-1111 (1596 kg/ha) in SZ. Among *Kabuli* lines, IPCK 13-163 (1647 kg/ha), GLK 17301(ELSK) (1463 kg/ha) and GJGK 1617 (ELSK) (1530 kg/ha) in NWPZ; IPCK 13-163 (1372 kg/ha), RKGK 18-414 (1487 kg/ha) and RKGK 13-416 (1490 kg/ha) in WCZ; CSJK 174 (1291 kg/ha), Phule G 16318 (1252 kg/ha), NBeG 810 (ELSK) (1574 kg/ha) and GJGK 1617(ELSK) (952 kg/ha) in SZ are the high yielding genotypes. In DTIL trial, L4-14 (1664 kg/ha), BGM 10218 (1457 kg/ha) and BG 4005 (1637 kg/ha) in NWPZ and NBeG 506 (1576 kg/ha) in SZ were the high yielding genotypes. In WRIL trial, IPCMB 19-3 (2105 kg/ha) and BGM 20213 (1827 kg/ha) in CZ and SZ were the high yielding genotypes.
- Thirteen thousand and thirty (13030) accessions were maintained at 19 centres. These accessions were evaluated for morphological traits and are being maintained.
- At total 8967.66 q of breeder seed of 62 chickpea varieties was produced against DAC indent of 7100.51 q including the carryover seed of indented varieties available with seed producing centres.

Crop Production

Agronomy

- A new promising PoE herbicide (Topramezone) was effective at Ludhiana, Imphal & Raipur (20.6 g a.i./ha at 14 DAS), Shillongani & Kalaburagi (20.6 g a.i./ha at 21 DAS), and Dholi & Ranchi (25.7 g a.i./ha at 21 DAS).
- At Sriganganagar, biofortification of Zn and Fe in chickpea through agronomic intervention (*i.e.*, combined application of RDF along with Zn 0.5% + 0.5% Fe as foliar sprays at pre-flower and pod formation) was useful.
- 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 CFG 1 (with NPKSZnMo based on 100% recommendation) at Sriganganagar, Samba, Raipur, Sehore and Kalaburagi, while CFG 3 (that with 125 % recommendation) at Imphal was optimum.
- To scale up crop productivity and profitability in a tactical chickpea based intercropping (6:2) system, it revealed that linseed/chickpea + linseed at Samba; chickpea + linseed at Durgapura, Shillongani & Raipur; and chickpea + mustard at Ranchi were optimum.
- For enhancing crop and water productivity with supplementary irrigation through sprinklers in chickpea, the study showed that sprinkler irrigation at both branch and pod stage as seen at Dholi, Sehore and Kalaburagi was optimum. At Kalaburagi, zero tillage (ZT) in chickpea was better over conventional tillage (CT), while at Dholi and Sehore, crop response to CT was evident.
- 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 hydrogel was beneficial at Samba, Durgapura and Raipur only. On the use of foliar supplementation at flower initiation and pod development, it showed that NPK::19:19:19 at 0.5% at Samba, Ludhiana, Sehore and Kalaburagi, while at other locations, salicyclic acid 100 ppm (Durgapura) or urea 2% (Raipur) was useful.

Plant Physiology

- Three elite lines such as IPC (L4-25), CSJ 515 and Pusa chickpea 10216 performed well under drought situation based on NDVI, SPAD chlorophyll index and leaf water potential. The grain yield was also relatively higher in these lines under drought.
- The chickpea genotype ICCV 92944 showed the highest net photosynthetic rate at saturated irradiance level 1500 µmol photons $m^{-2}s^{-1}$ followed by ICC 4958, Pusa Green 112, K 850 and the least shown by ICC 10685 under normal as well as partly late sown rainfed condition. Transpiration rates and stomatal conductance showed similar trend. The higher photosynthesis, transpiration and stomatal conductance of these genotypes could be due to deep rooting system maintaining appropriate water content in leaf tissue for photosynthesis.
- The genotypes Pusa 212, Pusa 244, Pusa 362, PG 96006, JG 315, Pusa 240, JG 63, PBG 5, Pusa 1003, JG 16, BG 256, Vishal, BG 276, BGD 103, SAKI 9516 grown at Kalaburagi flowered at the same time irrespective of origin of these varieties at different geographical locations where they flower at different time after sowing. Therefore, flowering time of these genotypes did not interfere for assessing these genotypes under similar drought situation. These genotypes are better adapted to drought condition as their yields were also higher under drought.

Microbiology

- At Sehore center three new isolates of *Mesorhizobia i.e.* RVSGRS 141,142 and 143 were procured from Sehore, Dewas and Bhopal blocks from chickpea nodules. All isolates were tested for their growth on different NaCl and pH ranges.
- Ludhiana centre isolated 10 *Mesorhizobia* and 18 endophytic bacteria from chickpea nodule and soil samples. The bacterial isolates were subjected to various biochemical tests. Two *Mesorhizobium* isolates LCRR2 and FRW2 were found promising with the highest IAA (25.16 and 23.33 µg/ml, respectively), P-solubilization

(9.00 and 8.62 mg/100 ml respectively), siderophore production and ACC deaminase. Out of 18 endophytes, 5 bacterial isolates LCNE3, LCNE2, LCSE4, LCSN9 & LCSN3 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 RFC-117 (Kanpur) out yielded than all other strains with an increase of 18.0% in grain yield over the un-inoculated control. However, LGR 2018 (Ludhiana) enhanced yield by17.4%, followed by strain RFC-79 (Kanpur) and reference strain LGR 14-2 (Ludhiana) by 17.1% over the un-inoculated control. Four strains *viz.* RFC-117 & RFC-79 (Kanpur), LGR 2018 & LGR 14-2 (Ludhiana) were found superior to 20 kg N/ha treatment for grain yield. Nitrogen treatment improved the yield by 16.2% over control.
- On pooled mean basis across 6 locations, T3+ Microbial Consortium-II Methylotrophs (IIPR Kanpur) improved symbiotic traits and yield by 16% followed by T3+RE-9 *Pseudomonas fluorescence* (Ludhiana) by 11.2% over *Mesorhizobium* local (Check) +*Trichoderma* local. Among all the treatments, T3+*T. aspergillum* (RST512B, NBAIM) and T3+*Bacillus subtilis* (RP-24, NBAIM) showed minimum grain yield on pooled mean basis. Microbial consortia treatment recorded lower wilt incidence compared to absolute control treatment.
- On the basis of pooled data across the locations, maximum improvement in grain yield (13.4%) over control was recorded with T1+ 25 kg $ZnSO_4$ /ha (Soil application) + Zn and Fe solubilizers followed by T1+25 kg $ZnSO_4$ /ha (Soil application) (10.1%) and T1+ 0.5% $ZnSO_4$ + 0.1% $FeSO_4$ /ha (Foliar spray) + Zn and Fe solubilizers (9.7%) over control. Whereas, T1+Zn and Fe solubilizers treatment improved the yield by only 7.4% over control treatment.
- At Ludhiana, two AVT II entries *viz.* GNG 1581(ch) and BG 4011 were excellent nodulators in terms of symbiotic traits *viz.* nodule number, nodule dry weight and leghaemoglobin content of nodules with high soil dehydrogenase activity. At Sehore, AVT entries *viz.* RSG 888 and NBeG 810 were excellent nodulators and produced high soil dehydrogenase.

Crop Protection

Plant Pathology

- GNG 2462, NBeG 798, NBeG 857, GL 17020, BDNG 2017-44, PG 237, NBeG 690, BG 4011, RKG 19-1, RSGD 1071, H12-22, GL 16063, BDNG 2017-49, IPCD 2016-134, RG 2016-134, ADBG 487, GNG 2475, BRC 09-14, Phule GNG 2461, Phule G 1201-20, Phule G 1107-5 and RVSSG 83 were resistant or moderately resistant to wilt at 8 or more locations in different zones of India.
- In AVT 2 (K + ELSK), eight entries were tested against wilt, among them only two entries IPCK 13-163 and GJGK 1617 were resistant or moderately resistant to wilt at 8 or more locations. Whereas, In AVT 1 (*Kabuli*) out of seven entries, three entries *viz.* RVSSG 89, NBeG 789 and BG 4018 were resistant or moderately resistant to wilt at 8 locations.
- Another experiment constituted was Elite Plant Pathological Screening Nursery, in which fifty-three entries showing resistant/moderately resistant reaction to wilt were included for confirmation of wilt resistance. During 2020-21, sixteen entries amongst these, belonging to different groups *viz.* GJG 1809, GJG 1912, RVKGI 34401, GJG 1907, IGK 2017-106, GJG 1803, IGK 1017-102, GNG 2459, GL 17020, IG 2020-21, IG 2018-111, GJG 1815, IG 2019-118, X11th-82-IFS4, ICCV-60035- F_4-P22-BP and ICC x 060138- F_4-P64-BP again expressed resistance/tolerance to wilt confirming the previous year reaction.
- NBeG 798 and NBeG 690, Phule G 1201-20 expressed moderately resistant reaction to dry root rot at three locations out of five locations.
- Three new *Trichoderma harzianum* strains obtained from various sources and *Trichoderma* mutant from BARC were used as seed treatment and compared with chemical seed treatment for the management of wilt and dry root rot diseases of chickpea. *Trichoderma harzianum* T6 + Propineb (@ 10 g + 1.5 g/kg seed) was the most effective in minimizing

wilt/DRR incidence at six centers *viz*. Sehore, Jabalpur, Dholi, Vijyapur and Raipur.

Entomology

- The compatability of insecticides, Chlorantraniliprole 18.5% SC and Emamectin benzoate 5% SG with foliar nutrients Urea, DAP and KNO_3 @ 2 per cent alone and their combinations were significantly effective in terms of larval reduction and lower pod damage and thus higher grain yield. The combination of insecticides and foliar nutrients did not show any phytotoxic effect on the crop when they were tank mixed together.
- In evaluation of ecofriendly approaches for the management of gram pod borer, *H. armigera* the treatment Chlorantraniliprole 18.5 SC % @ 0.25 ml/litre, *Ha* NPV (2 x10^9PoBs) @ 250 LE/ha and Mahastra (DOR *Bt* 1%) @ 4.0 g/litre were statistically effective in terms of larval reduction and lower pod damage and thus higher grain yield of chickpea crop was recorded.
- In bio-intensive management of pulse bruchids in chickpea under storage conditions, Deltamethrin 2.8 EC @ 0.04 ml/kg followed by Neem oil @ 5 ml/kg and Diatomaceous earth @ 5 g/kg was found significantly superior in reducing bruchid infestation at various intervals ie; (3, 6, 9 and 12 months) with the lowest per cent infestation after 12 months of storage.

Frontline Demonstrations

- Four hundred demonstrations were conducted on package technology. On an average, 1602 kg/ha of yield was obtained through package technology against 1335 kg/ha by farmer's practice with an increase in grain yield by 20.0 per cent.
- Seventy-five demonstrations were conducted on package technology in rice fallows. The overall mean grain yield of package technology in rice fallow was 1433 kg/ha and mean yield of local practice was 1098 kg/ha. The per cent increase in grain yield was 30.5%.
- Five demonstrations were conducted on Insect Pest management technology. The overall mean grain yield through IPM was 1561 kg/ha and mean yield of local practice was 1300 kg/ha. The per cent increase in grain yield was 20.9.
- Five hundred and eighty demonstrations were conducted in tribal areas under Tribal Sub plan which gave an average yield of 1269 kg/ha which was 28.7% higher than yield obtained through traditional practices and varieties (986 kg/ha).

All India Co-ordinated Research Projects
Pigeonpea

CROP IMPROVEMENT

Varieties released for commercial cultivation

Early duration

Pusa Arhar 2018-4 and IPA 15-06: The proposal of candidate variety Pusa Arhar 2018-4 was submitted for North West Plain Zone (NWPZ) while, the variety IPA 15-06 was submitted for Central Zone (CZ) rainfed/irrigated condition. Both these varieties belong to early duration (121-150 days) and have exhibited high yield superiority over the respective best checks. Pusa Arhar 2018-4 exhibited tolerant reaction to *Phytophthora* blight, sterility mosaic disease and *Fusarium* wilt. Whereas, IPA 15-6 recorded resistant to sterility mosaic and Cercospora leaf spot diseases and moderately resistant to *Fusarium* wilt, *Phytophthora* and *Macrophomina* blight. Both the entries have shown relatively less damage due to pod fly and pod borer at field conditions. Hence the variety Pusa Arhar 2018-4 has been identified for NWPZ comprising of Punjab, Delhi, Haryana and Western U.P. under early duration and IPA 15-06 has been identified for CZ (comprising Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh and Jharkhand) under early duration.

Medium Duration

TDRG 59: The proposal of candidate varieties TDRG 59 was submitted for South Zone (SZ). It is a medium duration (170-175 days) variety and has exhibited high yield superiority over the best check. Variety TGRG 59 is moderately resistant to *Fusarium* wilt and sterility mosaic disease. It has also shown relatively less damage due to pod borer and pod fly at field conditions. Thus, the varieties TDRG 59 has been identified for South Zone comprising of Karnataka, Andhra Pradesh, Telangana, Tamil Nadu and Odisha under medium maturity group.

Table 1: Pigeonpea entries promoted to advanced trials of *Kharif* 2021

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 (Early 131-150 days)	**NWPZ**	AH 17-13	1587	10.98	86	137	8.27
		Pusa 2020-2	1552	8.53	85	137	9.46
		PA 650	1548	8.25	88	139	7.83
	CZ	IPAE 15-08	1645	10.11	104	151	9.34
		RVKT 333	1647	10.24	100	149	8.79
		IPAE 15-05	1787	19.61	103	149	8.62
	SZ	IPAE 15-08	1148	11.78	101	143	8.54
		PA 650	1132	10.22	88	127	7.86
AVT-1 (Early 131-150 days)	**CZ**	CRG 16-12	1644	10.04	94	142	9.58
AVT-2 (Early 131-150 days)	**NWPZ**	Pusa 2018-4	1726	20.70	84	142	8.82
AVT-2 (Early 131-150 days)	**CZ**	IPAE 15-06	1645	10.10	107	149	9.67
IVT (Mid-early: 151-165 days)	**CZ**	PT 2017-1	2066	10.13	109	164	10.87
		RVSA 14-2	2097	11.78	105	159	10.23
		WRGE 138	2318	23.56	110	166	10.41
		PT 2017-2	1971	5.06	107	162	10.92
		WRGE 124	1971	5.06	108	162	10.91

AVT-1 (Mid-early: 151-165 days)	**CZ**	PT 10-1-1-2	1871	10.12	115	170	9.98
		BDN 2013-2	1870	10.06	116	174	10.75
	SZ	PT 11-4-4-1	1791	10.07	111	160	11.24
IVT (Medium: 166-185 days)	**CZ**	PT 11-16	1822	5.20	110	172	10.65
		GRG 622	1822	5.20	111	175	12.06
		GJP 1915	1820	5.08	118	181	10.34
	SZ	LRG 471	2490	11.46	123	177	11.31
AVT-1 (Medium: 166-185 days)	**CZ**	AKTM 1637	1906	10.05	113	178	10.11
AVT-2 (Medium: 166-185 days)	**SZ**	TDRG 59	2459	10.07	117	171	11.55
IVT (Late:>200 days)	**NEPZ**	DA 2020-2	2203	5.10	140	239	10.12
		IPA 19-26	2204	5.15	145	245	10.16
		Pusa 197	2202	5.06	141	240	10.96
		MAL 53	2202	5.06	144	245	10.98
AVT 1 (Late:>200 days)	**NEPZ**	IPA 15-21	2392	10.02	149	247	10.52
AVT 2 (Late:>200 days)	**NEPZ**	KA 17-2	2392	10.02	146	246	10.92

Pigeonpea hybrids promoted to advanced trials of *Kharif* 2021

To develop CMS based hybrids in short and medium duration pigeonpea, research activities were carried out at twelve different locations. Based on the technical programme, three trials namely IHT + AHT 1+ AHT 2 (Early) (North Zone), IHT (Early) (South and Central Zone) and IHT (Medium) (South and Central Zone) were conducted. Since only limited entries could be promoted to AHT 1 and AHT 2 last year, IHT was merged with AHT 1 and AHT 2 in case of Early North trial. The IHT (Early, North Zone) comprised of seven hybrids (PAH 13, PAH 05, PAH 11, IPH-18-02, IPH 19-01, PHP 158 and PHP 155) while three hybrids (IPH 17-01, IPH 18-04 and PAH 10) and one hybrid PAH 05 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 Zone). In a similar manner, IHT (Early, South and Central Zone) comprised of nine hybrids (IPH 2429, IPH-18-01, SKNPH 1807, IPH-18-04, ICPH 2447, ICPH 2438, BDNPH 13-05, ICPH 4690 and ICPH-17-01). Three checks (Rajeswari, CORG 9701 and GTH 1) were used for evaluation in this trial. In IHT (Medium) (Central & South Zone), six hybrids (ICPH 4187, BDNPH 13-03, ICPH 3461, BDNPH 18-04, ICPH 3933 and BDNPH 13-01) were evaluated. A total of twelve locations were selected (Kanpur, Delhi, Ludhiana, Pantnagar, Badnapur, Patancheru, Rahuri, Sehore, SK Nagar, Navsari, Bangalore and Warangal)

Genetic resource development, evaluation and management

- During *Kharif* 2020, a total of 87 new crosses were achieved over the 97 targeted with sufficient quantity of F_1 seed under pigoenpea national crossing programme. Similarly, a total of 223 crosses were made by different centres located in different zones under their state programme and sufficient quantity of F_1 seed was harvested for generation advancement.
- The targeted traits across the zones for the national and state crossing programme were resistance to wilt, sterility mosaic disease, Phytophthora blight and tolerance to pod fly and pod borer. Along with aforementioned treats, zone specific traits were also taken into consideration for developing new crosses.
- Generation of photo-thermo insensitive extra early and early maturing breeding materials were mainly focused for all zones. The centre namely Ludhiana, Pantnagar, IIPR Kanpur, Kota, Akola, Coimbatore, Virinjipuram, Nagaland and Tripura have generated successful F_1 crosses involving early maturing parents.
- Water logging tolerant and extra large seeded donors are now available for pigeonpea breeders. Keeping this in view the dual

purpose trait (grain and vegetable type) integrated crosses were developed by IIPR, Kanpur and Nagaland centres.

- The central zone centres have developed highest (129) number of F_1 crosses involving the landmark varieties such as Asha, PKV tara, BSMR 736, BSMR 716, GT 101, GJP 1 and BDN 711 as female parents and Rajeshwari, Rajiv Lochan, IPA 203, Vipula, CG Arhar 1 & 2, PDAT-16 and BRG 5 as male parents.
- Different AICRP on pigeonpea coordinating centres have a pool of 307 fresh F_1 crosses, 351 F_2 populations and 5470 breeding lines derived from different crosses. A total of 425 fixed lines were evaluated under preliminary yield trials and/or their respective station trials by different centres.
- AICRP on Pigeonpea has a total of 7601 germplasm collections with its 24 differerent coordinating centres spreading across different zones. Of the total collections, 145 accessions are of wild type belonging to 17 different species.
- SK Nagar centre has 145 wild pigeonpea accessions belonging to 17 different species followed by Badnapur having 30 accessions belonging to nine different species.
- During crop season 2020-21, a total of 3,227 pigeonepa grmplasms were evaluated for different yield attributinhg, biotic and abiotic stress resistance/tolerance, vegetable type, maturity *etc*. traits for use in active breeding programme of the centres.
- Across the zones, an average of 22.31 per cent germplasm utilization was recorded by different pigenpea coordinating centres. The highest per cent utilization was reported by Rahuri (28.87%) followed by Virinjipuram (11.27%), Berhampur (9.66%), Warangal (9.12%) and Nagaland (8.33%)
- A total of 462 new germplasm collections were added by different AICRP on Pigeonpea centres. Badnapur centre made the highest (334) number of collections followed by Virinjipuram and Coimbaore that collected 15 numbers each.
- Five centres namely Gulbarga from South Zone, Badnapur from Central Zone, IIPR, Kanpur from North Eastern Plain Zone, Ludhiana and IARI, New Delhi from North Western Plain Zone were identified as pre-breeding hubs for pigoenpea improvement during crop season 2020-21. These centres may use different accessions of crossable wild species like *Cajanus scarabaeoides, C. serecius, C. volubilis, C. albicans, C. cajanifolius* and other species; local varieties/ landraces with unique traits; resistant donors for wilt, sterility mosaic disease and Phytophthora stem blight, tolerant donors for pod fly, pod borer, drought and heat; early/super early lines for earliness and African derivatives for yield traits in this programme.
- Presently, a total of 175 accessions belonging to 17 different species are being maintained across the pre-breeding centres. However, five species namely *C. cajanifolius, C. scarabaeoides, C. platycarpus, C. Acutifolius and C. albicans* are being used for widening the genetic base in pigoenpea

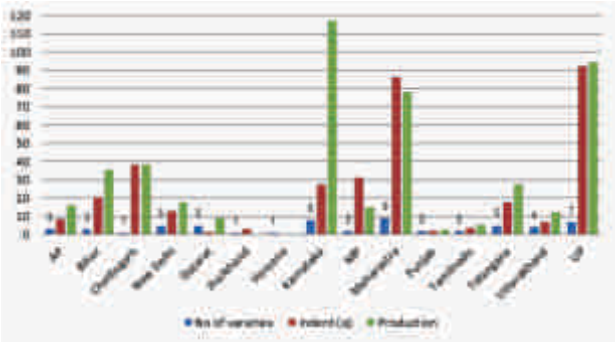
Table 2: Centre-wise information on wild pigeonpea species utilized in pigeonpea pre-breeding programme

SN	Centre name	Name of the wild species used	Targeted traits
1	Gulbarga (SZ)	*C. cajanifolius* (ICPL 15058), *C. platycarpus* (ICPL 11084), *C. acutifolius* (ICPL 15042), *C. platycarpus* (ICPL 11023)	Earliness, Broad genetic base
2	Badnapur (CZ)	*C. albicans*	SMD & Pod fly resistance
3	Ludhiana (NWPZ)	*C. scarabaeoides* (ICP 15683, ICP 15694, ICP 15724, ICP 15710)	Earliness and multiple disease resistance
4	IARI, New Delhi (NWPZ)	*C. scarabaeoides, C. platycar* pus, *C. acutifolius*	Pod borer resistance, fertility restoration, PSB
5	IIPR, Kanpur (NEPZ)	*C. scarabaeoides, C. cajanifolius*	Earliness, resistance to wilt, SMD, PSB and Nematode

Pigeonpea Breeder Seed Production (BSP)

- A total of 470.00 quintals of breeder seed was produced against the consolidated indent of 353.52 quintals for 58 varieties received from Department of Agriculture, Co-operation & Farmers' Welfare (DAC & FW), Ministry of Agriculture, Govt. of India for crop season 2020-21.

The state wise number of varieties, total BSP indent and production is detailed as given below :



Crop Production

Agronomy

Effect of Nipping and Spacing: Nipping of pigeonpea at 45 days after sowing (DAS) with the spacing of 90 cm x 30 cm or 120 cm x 30 cm recorded significantly higher pigeonpea grain yield, GMR, NMR, B:C ratio and Rain water use efficiency.

Enhancing production through foliar nutrition: This trial was allotted to ten centres coming under South and Central Zones to study the effect of different foliar nutrients on growth and productivity of pigeonpea.

South and Central Zone

- Higher seed yield (2462 kg/ha) was recorded with foliar application of Pulse magic (1%) at flowering and it was at par with 19:19:19 spray at 0.5 % concentration at flowering.
- Pooled data of three years indicated that RDF + 19:19:19 @ spray of 0.5% recorded significantly higher pigeonpea grain yield, net returns and B C ratio.
- Application of RDF+ $ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5% recorded significantly higher seed yield of pigeonpea.
- The growth and yield contributing parameters of pigeonpea were significantly higher with the RDF+ Pulse magic application @ 1%.

Use of Gibberellic acid for enhancing productivity of pigeonpea: This trial was allotted to seven centres coming under South and Central Zones to study the effect of Gibberellic acid on growth and productivity of pigeonpea.

Central and South Zone

- Application of 75 ppm gibberellic acid at flower and pod initiation stages recorded significantly higher grain yield of pigeonpea and recorded higher gross and net returns and B:C ratio.

Evaluation of post emergence herbicide in pigeonpea: This trial was allotted to eight centres coming under South and Central zones to study the effect of post emergence application of herbicides on growth and productivity of pigeonpea.

Central and South Zone

- Application of propaquizafop 2.5% + Imazethapyr 3.7% w/w @ 50 + 75 = 125 g a.i/ha at 20-25 DAS registered significantly higher pigeonpea grain yield, higher WCE and lower total weed density and weed dry weight at different growth stages when compared to rest of the weedicide treatments.

North Eastern Hilly Zone (NEHZ) and North Western Plane Zone (NWPZ)

- Effect of nipping & spacing in pigeonpea under North Eastern Hilly Zone and North Westren Plain Zone: This trial was allotted to three centers coming under North Eastern Hilly Zone (NEHZ) and North Western Plane Zone (NWPZ) :
- Nipping at 45 days after sowing resulted in significantly higher grain yield of pigeonpea. Sowing of pigeonpea crop at 75 cm x 30 cm recorded significantly higher grain yield of pigeonpea.

Response of pigeonpea to tillage and mulching under North Eastern Hilly Zone (NEHZ): This trial has been allotted to Nagaland and Tripura centres.

- The effect of various tillage treatments on the grain yield of pigeonpea was found non-significant. However, polythene mulch recorded significantly more number of branches, pods/plant and yielded significantly

higher grain yield over other mulches.

Organic nutrient management in pigeonpea: This trial has been allotted to S.K. Nagar and Junagadh of Central zone and Nagaland and Tripura of NEHZ.

Central and North Eastern Hilly Zone

- Application of RDF through chemical sources recorded significantly higher grain yield over organic nutrient management practices.

Microbiology

- Diversity of native *Rhizobium* for improving nodulation and nitrogen acting potential of pigeonpea was explored at five centres *viz.*, Akola, Kalaburagi, Kanpur, Ludhiana and Varanasi. A total of 28 rhizobial isolates were obtained and strains like GAKPR-7-20, RA-20-06, RA-20-05, IIPR-PR-367 and IIPR-PR-369 were identified as potential candidates for further study.
- Performance of five rhizobial strains *viz.*, GAKPR-16 (Akola), RA 18-06 (Varanasi), RA 18-16 (Varanasi), KRR-18-5 (Kalaburagi), and KRR-18-12 (Kalaburagi) on improving nodulation and yield of pigeonpea under different agro-ecological conditions were assessed during 2020-2021. It was observed that the native rhizobial strains *via Rhizobium* strain GAKPR-16 (21.00 nodules/plant &1812 kg grain yield/ha) at Akola, KRR-18-05 (26.23 nodules/plant & 1255 kg/ha of grain yield) at Kalaburagi, RA-18-06 at Varanasi (29.2 nodules/plant & 1330 kg yield/ha) are performing better than alien strains including national check at concerned testing centers.
- Effect of Pulse Magic Spray (PMS) on nodulation and grain yield of pigeonpea was assessed. Pulse magic was sprayed at two crop growth-stages *viz.*, 25th and 40th days after sowing with two levels *viz.*, 5.0 g and 10.0 g/litre of water individually and in combination with *Rhizobium*. Results from Kalaburagi, Ludhiana and Vamban 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 five endophytic bacterial strains *viz.*, NE 10 (Pantnagar), BHU-3 (Varanasi), BHU-4 (Varanasi), PGPR 18-05 (Kalaburagi), *and* PGPR 18-14 (Kalaburagi) along with *Rhizobium* on nodulation and yield of pigeonpea was assessed. Results from Akola and Kalaburagi indicated that PGPR-18-14 enhanced the yield of pigeonpea, while strain BHU-4 recorded the highest yield (1724 kg/ha) at Varanasi

Crop Protection

Plant Pathology

I. Host Plant resistance:

In screening trials against major diseases, total 162+30 entries were evaluated along with respective resistant and susceptible checks. Overall average per cent disease incidences cum scales were considered for evaluating pigeonpea entries against major diseases highlights of which are mentioned below :

A. Wilt:

Out of 192 screened pigeonpea entries (along with repeatedly used resistant and susceptible checks), total 27 entries were resistant, 95 were moderately resistant and 70 were susceptible against wilt disease by considering the overall average percent of wilt incidences obtained from total 12 centres. Among 27 resistant germplasm lines, few entries *viz.*, BSMR 1, ICPWS 1902, ICPWS 1904, ICPWS 1905, ICPWS 1906 and ICPWS 1919 were found promising against wilt during *Kharif* 2020.

B. Sterility mosaic:

Total 72 entries were resistant, 84 were moderately resistant and 36 were susceptible against sterility mosaic disease, out of 192 screened pigeonpea entries during *Kharif* 2020 by considering the overall average percent disease incidence obtained from nine centres. Out of those 72 resistant entries, some entries are IPAE 18-04, BDN 711, WRGE 124, DA 2020-1, IPA 14-4A, IPA 15-02, IPA 15-19, KA 18-1, MA 6, MAL 53, BDN 711, MAL 52, DA 19-1, IPA 15-21, Pusa 194, SKNPCH 1807, BSMR 1, BSMR 65, BSMR 74, BSMR 79, BSMR 243, BWR 24, ICPWS 1902, ICPWS 1904, ICPWS 1905, ICPWS 1906, ICPWS 1908, BDN 2013-45, ICPIL 17124, LRG 471, TDRG 59 and TDRG 323.

C. *Phytophthora* stem blight:

Out of 157 screened pigeonpea entries (along with repeatedly used resistant and susceptible checks *i.e.* 127+30), 19 entries were moderately resistant and 138 were susceptible against *Phytophthora* blight disease during *Kharif* 2020. Entries *viz*., MAL 52, IPA 15-06, BSMR 1 and MAL 13 were moderately resistant to *Phytophthora* blight disease.

D. *Macrophomina* stem blight:

Amongst 137 entries (111+26), 15 entries were resistant, 27 were moderately resistant and 95 were susceptible against *Macrophomina* blight during *Kharif* 2020. Entries *viz*., Pusa 2020-2 and BSMR 339 were recorded resistant reaction against *Macrophomina* blight during *Kharif* 2020.

E. *Cercospora* Leaf spot:

Eighteen entries were moderately resistant (*e.g.* MAL 52, IPA 15-21) and 40 entries were moderately susceptible against *Cercospora* leaf spot disease out of the 143 (115+28) screened pigeonpea entries against *Cercospora* Leaf spot disease. However 70 entries were susceptible and 15 entries were highly susceptible against *Cercospora* Leaf spot disease during the *Kharif* 2020

F. *Alternaria* Leaf spot:

Twenty one entries were moderately resistant (*e.g.* BRG 4 & BSMR 1) and 31 entries were moderately susceptible against *Alternaria* leaf spot disease out of 143 (115+28) screened pigeonpea entries. However, 67 entries were susceptible and 24 entries were highly susceptible against *Alternaria* Leaf spot disease during the season *Kharif* 2020.

II. Epidemiology

1. Epidemiology of *Phytophthora* stem blight:

Four centres *viz*., Ludhiana, Sehore, Nagaland and Kalaburagi reported that *Phytophthora* stem blight disease positively correlated with rainfall which is similar with previous year's conclusion. Whereas *Phytophthora* stem blight disease incidence was low at Varanasi and Tripura centres, hence their reports were not included.

2. Epidemiology of *Macrophomina* blight:

During the *Kharif* season 2020, rainfall and rainy days were more than average which resulted in retaining high moisture in soil throughout the season which resulted in complex of *Phytophthora* stem blight, wilt and dry root rot disease within field. Whereas, absence of moisture stress in soil adversely affected the epidemiological conclusions of *Macrophomina* blight disease. Hence reported data of Varanasi and Badnapur were not included.

3. Epidemiology of *Cercospora* Leaf spot:

Sehore centre concluded that minimum temperature and rainfall showed positive correlation with incidence of *Cercospora* Leaf spot disease. While maximum temperature showed negative correlation, but not significantly, whereas, correlation of rainfall was significant during the *Kharif* season 2020 and similar trend also reported by Kalaburagi.

4. Epidemiology of *Alternaria* Leaf spot:

Nagaland centre reported that relative humidity positively correlated with incidence and severity of *Alternaria* Leaf spot disease during *Kharif* season 2020.

III. Monitoring of race of *Fusarium udum*:

The reaction on pigeonpea host differentials in wilt sick plot at eleven locations during the *Kharif* season 2020 across different three zones indicated the possibility of presence of variability in *Fusarium udum* population across centres.

IV. Variability study regarding pigeonpea sterility mosaic disease:

The study indicated presence of variability in the pigeonpea sterility mosaic virus pathogen (PPSMV) at different centres *viz*., Dholi, Varanasi, Badnapur, Rahuri, Bengaluru, Coimbatore, Dharwad and Warangal. The existence of variability is on the basis of pigeonpea host differential reaction against virus at these centres. Tirupati and Vijayapura, centres have also reported data of the *Kharif* season 2020 for knowing about the strain of virus responsible for sterility mosaic disease.

V. Pigeonpea disease detection through Artificial Intelligence:

All the 24 centers have submitted photographs of major pigeonpea diseases. More than five thousand images have been collected as raw data. Step of data analysis and augmentation was carried out. Further required work is in progress and photographs of multiple diseases on single plant will be collected in the coming year by each centre to conclude it.

VI. Management of pigeonpea diseases:

Incidences of respective diseases were significantly reduced and yield of treated pigeonpea crops were significantly higher than untreated control treatment which indicated the importance of management of diseases.

VII. Survey:

On various farmers' fields or the research fields of different centres, incidences of major diseases indicated the status of the wilt, sterility mosaic, *Phytophthora* blight, *Macrophomina* blight, *Cercospora* and *Alternaria* leaf spot. Few centers have also reported incidences of collar rot and phoma blight disease.

VIII. ICAR-ICRISAT's screening trials:

Forty seven germplasm lines were screened against *Fusarium* wilt, sterility mosaic disease and 12 entries were screened against *Phytophthora* stem blight disease.

Entomology

Under preliminary screening, among 252 germplasm lines of different maturity group (10 extra early, 58 early, 12 mid early and 172 medium duration), 86 lines were promising against pod borer complex with pest resistance rating (PRR) of 3 (8 no.) and 4 (78 no.) which were considered under resistant and moderately resistant category, respectively and were promoted for further screening at their respective centres.

Under early maturity advanced varietal trial (AVT)the test entries *viz*., CRG 16-12 (AVT 1) & IPA 15-06 (AVT 2), respectively with 28.1 and 24.8% pod damage were equal in performance as that of the check, UPAS 120 (26.2%) at CZ.

Whereas, the test entry, Pusa 2018-4 (AVT 2) with 12.8% pod damage was superior to the check entry, Pusa 992 (23.0%) but equal in performance to other two checks *viz*., PA 291 and PAU 881 (14.0 and 12.0%, respectively) in NWPZ.

Under mid early duration advanced varietal trail (AVT), the test entries, *viz*., RVSA 28-1, PT-10-1-1-2, PT 11-4-4-1 and WRGE 128 respectively with 20.1, 22.0, 24.5 and 26.5% pod damage due to pod borer complex performed well over the check entry, PT 0012 (26.7%) in CZ.

Whereas in SZ, the test entries, *viz*., PT 11-4-4-1 and WRGE 128, respectively with 24.0 and 26.5% pod damage due to pod borer complex were better over the check entry, PT 0012 (29.1%). Further, the test entry, PT 11-4-4-1 has registered the highest grain yield (1383 kg/ha) over check (1187 kg/ha).

Under medium duration advanced varietal trial (AVT), the test entries, *viz*., AKTM 1644 and AKTM 1637 respectively with 26.2 and 26.5% pod damage due to pod borer complex were equal in performance to that of the check entry, ICPL 87119 (25.1%). However, AKTM 1644 has registered the highest grain yield (1037 kg/ha) over check (913 kg/ha) in CZ.

In SZ also, the test entry, TDRG 59 with 26.2% pod damage due to pod borer complex was equal in performance to that of the check, ICPL 87119 (27.6%). However, TDRG 59 has registered the highest grain yield (1576 kg/ha) over check (1307 kg/ha).

Under late maturity advanced varietal trial (AVT), at Varanasi, all the test entries (19.2 – 23.2%), except KA 18-2 (17.2%) were in equal in performance as that of checks (20.4 – 20.5%) against total grain damage by different insect pests.

Results pertaining to hybrid entries evaluation trial revealed that PAH 10 with 8.4% pod damage due to pod borer complex was better than check, PAU 881 (10.1%). Other hybrids *viz*., PAH 13, PAH 5 and PAH 11 have respectively registered 9.7, 9.8 and 12.0% pod damage.

Studies on mechanism of resistance against lepidopteron pod borers revealed those flowers, flower buds and green pods when subject to chemical analysis, the tolerant entries ICPHaRL 4985-11 and ICPHaRL 4985-10 recorded significantly the highest carbon (56.5 to 57.3%) and the lowest nitrogen percentage (1.98 to 2.12 %). Similarly, the reducing

sugars were also significantly less (22 to 23.5 mg/g). These two entries recorded more tannins and phenols as compare to check. These chemical parameters may be responsible for imparting resistance to pod borers.

Experimental results on evaluation of insecticides against pod fly revealed that flubendiamide 480 SC @ 0.2 ml/l at Raipur and Virinjipuram; Thiamethoxam 25 WP @ 50 g a.i/ha along with Jaggery (5.0 g/l) at Badnapur, Coimbatore, Rahuri and Warangal; Dinetofuron 20 SG @ 40 g a.i/ha at Bengaluru; Thiacloprid 21.7 SC @ 76 g a.i/ha at Guntur and Tripura; Diafenthiuron 50 WP @ 350 g a.i/ha at Kalaburgi were found to be effective in reducing pod fly incidence and thereby pod and grain damage with higher yield.

Experimental results on bio-efficacy of insecticides against pod boring weevil revealed that Cypermethrin 25 EC @ 50 g a.i/ha, Indoxacarb 15.8 EC @ 50 g a.i/ha and Spinosad 45 SC @ 73 g a.i/ha at Guntur and Nagaland; and Lambda cyhalothrin 5 EC @ 25 g a.i/ha at Tripura was found to be effective in reducing pod weevil incidence and there by grain damage with higher yield.

Experimental results on evaluation of bio-pesticides against pod borers in pigeonpea revealed that among bio-pesticides, *Bacillus thuringiensis var. kurstaki* 0.5 % WP serotype 3a, 3b, 3c strain DOR *Bt* 1 @ 2.5 g/l was found to be effective at all the centres. However, the chemical check, chlorantraniliprole 18.5 SC @ 30 g a.i/ha was highly effective in recording less pod damage due to pod borer complex with significantly higher grain yield at all the centers. Overall, 55.5 and 78.6% reduction of lepidopteron pod borer damage over control was obtained respectively with DOR *Bt* 1 and chlorantraniliprole.

Experimental results on monitoring of major insect pests on pigeonpea revealed that in CZ, 40 to 48, in SZ, 38-52, in NWPZ, 41-44 and in NEHZ, 41-52 standard meteorological weeks were crucial for different stages of *Helicoverpa* and *Maruca* which corresponds to active vegetative to pod development stage.

Farmer's field surveys carried out during 2020-21 revealed that in CZ, pod damage due to gram pod borer and pod fly ranged between 1.0–12.3% and 1.0 to 10.0%, respectively. In SZ, pod and seed damage due to lepidopteron pod borers, pod fly, pod bug, pod weevil and SMD incidence ranged between 1.2–35.0%, 9.8–28.2%, 12.2–29.2 and 9.4–20.4% and 4.0–45.0%, respectively. In NEHZ, *Maruca,* pod weevil and blister beetles ranged between 6.2-9.3 webs/plant, 2.8-5.2/plant and 2.8-4.4 / plant, respectively. In NWPZ, *Maruca* and pod fly were the predominant pod borers and pod bug was the major sucking pest of pigeonpea.

Frontline demonstrations

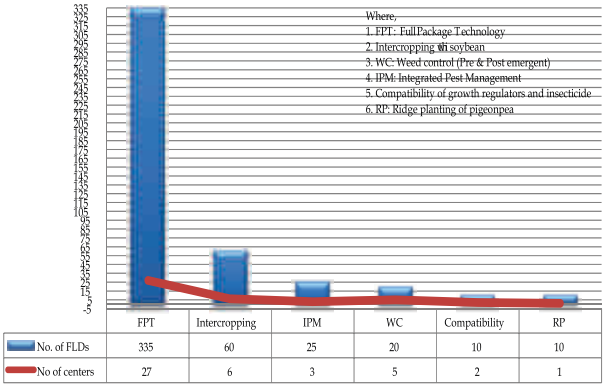
- During Kharif 2020, a total of 460 pigeonpea Frontline Demonstrations (FLDs) were targeted and all the demonstrations were executed on six different components *viz*., Full package technology (335 No.), Intercropping with soybean/other crops (60 No.), Weed control-pre and post emergence (20 No.), Integrated Pest Management (IPM) to manage pod borer complex (20 No.), Compatibility of growth promoter and insecticides (10 No.) and Ridge planting (10 No.) at 27 coordinating centres spread across the pigeonpea growing areas of the country.
- All together 445 demonstrations on six different components have reported the results from all the centres except Khargone for intercropping (10 No.) and SK Nagar (5 No.) for compatibility demonstrations.
- Full package technology increased grain yield by 33.15%, 39.34%, 24.53%, 34.94% and 25.39 % in NWPZ, NEPZ, CZ, SZ and NEHZ, respectively. Across the zone, the full package technology was 31.47% superior over the farmers' practice and 59.26% superior over the district average yield. Further, the high benefit over the cost invested in the production of pigeonpea (B:C=2.1) was recorded in full package demonstration.
- Intercropping of pigeonpea with soybean was more remunerative than growing sole crop of pigeonpea or soybean in South Zone centre at Warangal (43.21 %) than the Central Zone centres (39.00%) over the farmers practice of sole crop.
- Demonstrations on pre and post emergence weed management recorded 19.85% and 27.12% more grain yield over improper weed management in farmers practice in Central and South Zones, respectively. Further, the ratio of benefit on every rupee invested was 2.12 over farmers practice.
- Insect pest management was found more

beneficial and recorded 39.00% higher grain yield with 1.84 cost to benefit ratio in 25 demonstrations conducted at Lam, Warangal and Gulbarga centres.

- Compatibility of growth promoter and insecticide (Effect of combined application of insecticide and growth regulator on yield) by applying this 37.2% more grain yield was obtained than the local practice with 49.87% higher net return
- FLD on ridge planting of pigeonpea found superior over flat bed sowing with grain yield of 1904 kg/ha as compared to farmers practice (1509 kg/ha)

Salient Results

Total 460 demonstrations were planned to organize at 27 different AICRP centres spread across five different pigeonpea cultivation zones of the country on six different components (Fig 1).



	FPT	Intercropping	IPM	WC	Compatibility	RP
No. of FLDs	335	60	25	20	10	10
No of centers	27	6	3	5	2	1

Fig. 1: Component wise number of FLDs and total number of centers assigned to each components

Central zone was allotted the highest number (194) of FLDs across five different components namely, full package technology, Intercropping with soybean, compatibility of insecticide and growth regulators and weed management demonstrations all together it contributes 42% of the total full package technology demonstrations. Whereas, South Zone has 39 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* 2021, six new farmer varieties were 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, 15 entries in IVT early and about 128 germplasm and several breeding lines have been evaluated in Medziphema, Nagaland and Tripura centres, five acres each of FLD was also demonstration on pigoenpea production package technology in the respective centres.

ZARS, Khargone (M.P.), IGKV, Raipur (CG), BAU, Kanke, Ranchi, Jharkhand are the centres working under TSP, Pigeonpea. Accordingly 40 acres of FLD has been allocated to three centres for demonstration of pigoenpea production technology.

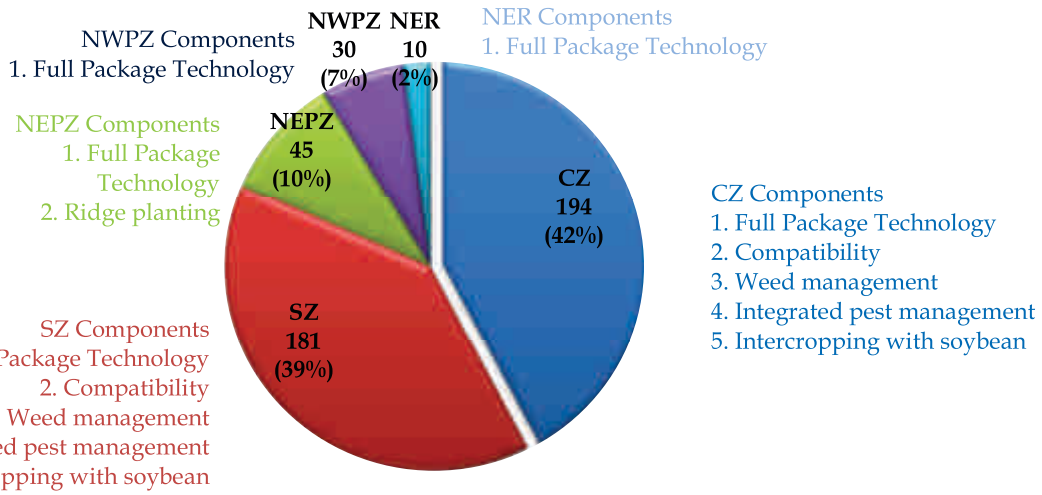


Fig. 2: FLD area allocated to different zones of pigeonpea cultivation

All India Co-ordinated Research Projects
MULLaRP

Crop Improvement

A. Crop varieties released and notified

S. No.	Crop	Variety	Area of adoption	Salient features
1.	Mungbean	Pusa 1641	National Capital Region of Delhi	Suitable for summer season, average seed yield 12-13 q/ha, maturity 62-64 days, resistant to MYMV and low incidence of major insect pests
2.	Mungbean	Phule Chetak (PM-707-5)	Maharashtra	Moderately resistant to major diseases (Powdery Mildew, Mungbean Yellow mosaic virus). Maturity duration: 70-75 days Potential yield: 10-12 q/ha.
3.	Mungbean	ML 1808	Punjab	Resistant to yellow mosaic disease Maturity : 70 – 75 days Potential Yield: 11-12 q/ha
4.	Mungbean	MGG 385 (Madhira Pesara-01)	Telangana state for *kharif*, summer, *rabi* and rice fallow cultivation	Average yield of 12-13 q/ha Maturity duration: 70-75 days Resistance to leaf crinkle, leaf curl and moderate resistance to YMV It has green, shining and attractive medium large seed (3.9 g/100 seed weight).
5.	Urdbean	Kalinga Urd 41	Odisha, Andhra Pradesh, Tamil Nadu and Karnataka	Resistance against MYMV, Leaf crinkle virus & CLS, moderately resistant to Web blight, Powdery mildew, Macrophomina blight, Anthracnose and root rot diseases.
6.	Urdbean	Kota Urd 5 (KPU 52-87)	Tamil Nadu, Andhra Pradesh, Karnataka, Telangana and Andman & Nicobar, Odisha state	Resistant to Urdbean Leaf Crinkle Virus (ULCV), Leaf Curl Virus, *Maruca virata*, pod weevil and moderately resistant to MYMV, Cercospora Leaf Spot (CLS), Web blight, Powdery mildew, Anthracnose diseases.
7.	Urdbean	Pant Urd 12 (PU 1541)	Western Uttar Pradesh, northern Rajasthan, Delhi, plains of Uttarakhand, Punjab, Haryana and part of Jammu and Kashmir	Resistant to MYMV, Leaf crinckle, Powdery Mildew, Leaf Curl Virus, Web blight, and moderately resistant to *Cercospora* Leaf Spot (CLS) & Root rot
8.	Urdbean	IPU 17-1	Madhya Pradesh	Resistant to Urdbean leaf crinkle Virus, Leaf Curl Virus, Web Blight, Bactrerial Leaf Blight, Powdery Mildew and *Cercospora* Leaf Spot Average grain yield : 10-12 q/ha Maturity : 73-74 days
9.	Urdbean	Mash 1137	Punjab during spring season	It is resistant to MYMV Yield potential:10-11 qt/ha Maturity duration: 72-77 days
10.	Urdbean	CO 7 (COBG 10-05):	Tamil Nadu state during *kharif* and *rabi* seasons	Resistant to MYMV, matures in 60-65 days and has yield potential of 10-11 q/ha.
11.	Urdbean	LBG 791	Tamil Nadu state during *kharif* and summer season	It is resistant to MYMV, leaf spot and anthracnose disease. Yield potential of this variety is 9-10 q/ha and mature in 75 -80 days. The 100 seed weight is more than 5 g.

S. No.	Crop	Variety	Area of adoption	Salient features
12.	Urdbean	Birsa Urd 2 (RUB 12-02)	Jharkhand	Resistant to MYMV *Cercospora* leaf spot, root rot and Powdery Mildew Average grain yield: 12.2 q/ha Maturity duration : 79-85 days
13.	Lentil	Pant Lentil 11 (P L 164)	Uttarakhand Plains	Resistant to rust disease and moderately resistant to pod borer. Average yield : 10-11 q/ha
14.	Lentil	Jammu Lentil 144	Jammu Province of Jammu and Kashmir.	Seeds having high protein content : 22%, Average yield 11-12 q/ha Matureity duration:122-125 days
15.	Lentil	Jammu Lentil 71	Jammu Province of Jammu and Kashmir.	Resistant to Wilt & Root Rot Protein content: 24% Average yield : 10-11 q/ha Maturity duration:140-145 days
16.	Fieldpea	Pant Pea- 347 (Pant P 347)	*Rabi* season in North West Plain Zone	Average yield: 2538 kg/ha Maturity duration:124 days It is resistant to powdery mildew & *Ascochyta* blight and moderately resistant to rust & root rot diseases.
17.	Fieldpea	Pant Pea - 195 (Pant P 195)	Uttarakhand Plains	Average yield: 1479 kg/ha, Maturity duration: 114-136 days It is resistant to powdery mildew and rust diseases.
18.	Fieldpea	IPFD 16-3	Uttar Pradesh	Resistant to powdery mildew, rust and *Ascochyta* blight disease. Maturity Duration: 115-125 days Average yield : 16-17 q/ha
19.	*Rajmash*	Badwerwah Rajmash- 104 (BR 104)	Jammu and Kashmir	Tolerant to *Anthracnose* and angular leaf spot. Average yield: 6.76 q /ha. Maturity duration:127 – 132 days
20.	*Rajmash*	Sikkim Rajmash-1 (SKR 57A)	Sikkim	Resistant to bean *Anthracnose*, Tolerant to angular leaf spot, Moderately resistant to collar rot. Average yield: 10.0-12.0 q/ha Maturity duration : 105 days

B. Breeder Seed Production

Crop	No. of Variety	Seed Indent (q)	Breeder Seed Produce (q)
Mungbean	55	627.13	742.92
Urdbean	39	657.28	608.84
Lentil	38	539.77	558.07
Fieldpea	25	777.07	576.57
Lathyrus	04	132.50	112.10

C. Plant Genetic Resources

- A total of 9,885 germplasm lines of mungbean and 3520 of urdbean were maintained at different centres.
- During Rabi 2020-21, total 10,083 accessions of lentil (3420), fieldpea (1422), lathyrus (2551) and rajmash (2690) were maintained at different centres and many of them were evaluated for different traits.

2. Crop Management

- Application of 100% recommended dose of fertilizer (18-25 N:40-50 P_2O_5: 20-25 K_2O: 20 S kg/ha) along with 5 tonne FYM/ha and seed inoculation with either *Rhizobium* or combination of *Rhizobium* + LMn 16 was found better for higher grain yield of mungbean and urdbean.
- In mungbean, foliar application of TNAU Pulse wonder @ 5 kg/ha + 0.5 % $ZnSO_4$ twice at pre

flowering and pod initiation was found effective for maximizing the grain yield (1144 kg/ha).

- Application of Fomesafen @ 220 g + Fluzifop p butyl at 220 g/ha at 20 DAS as post emergence was found effective for controlling weeds and obtained higher grain yield, net return, and maximum weed control efficiency at 30 and 45 DAS over weedy check in mungbean and urdbean.
- Application of Clodinafop propargyl 8% + Aciflourfen sodium 16.5 @ 187.5 g/ha at 15-20 DAS was found effective for controlling weeds and produced higher grain yield of summer mungbean (1478 kg/ha) as compared to weedy check.
- Mungbean seeds inoculated with LSMR 1 + RB 3 at the time of sowing along with post emergence application of Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125 g /ha at 15-20 DAS and foliar spray of 19: 19: 19 NPK at 2% at flower initiation and pod initiation was recorded maximum grain yield and economic returns.
- Application of Propaquizafop 2.50% + imazethapyr 3.75% ME @ 2.0 l/ha (commercial dose) at 15-20 DAS was found effective for controlling weeds and produced higher grain yield of summer urdbean (1095 kg/ha) as compared to weedy check.
- Urdbean seeds inoculated with *Rhizobium* + Phosphate solubilizing bacteria (PSB) at the time of sowing along with post emergence application of Propaquizafop 2.50% + imazethapyr 3.75% ME @ 125 g /ha at 15-20 DAS and foliar spray of Urea @ 2% at flower initiation and pod initiation was recorded maximum grain yield and economic returns,
- Urdbean seeds inoculated with LSMR 1 +RB 3 at the time of sowing along with post emergence application of Fomesafen @ 220 g/ha + Fluzifop-p-butyl @ 220 g/ha at 15-20 DAS and foliar spray of 19: 19: 19 NPK at 2% at flower initiation and pod initiation was recorded maximum grain yield and economic returns.
- 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, net return and B:C ratio in Lentil and field pea.
- 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, Net return and B:C ratio of lentil under relay cropping in rice.
- In fieldpea, application of 120 kg seed /ha along with either soaked seeds in water for 6 hours or seed priming with 1% KNO_3 was found effective for enhancing grain yield.
- 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 (1390 – 1480 kg/ha) of lathyrus.

3. Crop Protection

- Seed treatment with imidacloprid 5g/kg seed followed by foliar spray of Tebuconazole 50% + Trifloxystrobin 25%wg @ 0.75g/litre at appearance of disease was highly effective against foliar fungal diseases in mungbean and urdbean.
- In lentil, fungicides like propiconazole and tebuconazole were effective for lowering the disease severity of rust and increasing the yield. Whereas the fungicide amistar was highly effective against stemphylium blight
- The IPM module comprised of seed treatment, tall growing millet crop @ 2 thick row around the field as barrier crop, monitoring with yellow sticky trap @ 50 per ha, NSKE 5% spray on appearance of whitefly on sticky trap and need based application of insecticides in rotation at 10 days intervals diafenthiuron 50 WP @ 312.5 ai per ha/ acetamiprid 20 SP @ 20 g ai/ha found effective in reducing insect-pests incidence and give more yield and net return in mungbean and urdbean.
- The efficacy of novel insecticides against sucking pests was taken up in *Rabi* mungbean at Lam. The new chemicals viz spiromesifin 240%

SC @ 1.25 ml/lt, diafenthiuron 50% WP @ 1.25 g/l, flonicamid 50 WP @ 0.3 g/l and Clothianidin 50 WDG @ 0.1 g/l were found effective against thrips.

- Evaluation of some eco-friendly management practices against major insect pests of fieldpea indicated that among eco-friendly management, the seed treatment with Imidacloprid 600 FS @ 3 ml/kg of seed + *Baccillus thuringiensis* kurstaki 127 SC @ 3 ml/l found effective treatments at Mohanpur, whereas, seed treatment with Imidacloprid 600 FS @ 3 ml/kg of seed + *Beauveria bassiana* @ 5 g/ l found effective.

4. Frontline Demonstrations

- Package technology in *kharif* witnessed 25 per cent higher grain yield and 41 per cent increment in net returns over local farmers practices.
- Adopting package technology in *rabi* accomplished 30 per cent increase in grain yield along with 37 per cent monetary advantage.
- Under rice fallow situation, it was observed that there was a yield advantage to the extent of 14 per cent and in monetary terms ,the advantage was 20 per cent.
- A total of 330 frontline demonstrations were conducted with full technology packages in lentil and fieldpea which has resulted in 23% and 35% increase in yield, respectively.
- With the adoption of improved technologies, there was net monetary benefit of 23% and 33% in lentil and fieldpea cultivation, respectively.
- Demonstrations were also conducted with proven production technologies for lentil in rice-fallow cultivation which resulted in 26% increase in yield.

Arid Legumes

Crop Improvement

Variety released & notified:

Horse gram

BSP 17-3 (Sabri Kulthi): This variety is derived through selection from landrace collected from Bilaspur District. It is semi-determinate type with light brown seed coat colour. It matures in 100-103 days with average grain yield of 17-18 q/ha. It is resistant to dry root rot and has 24.4% protein content. Hence, it has been released and notified for northern part of the country.

BSP 17-1 (Alakh Kulthi): This variety emanated by selection from landrace collected from Bilaspur district. It has semi-determinate plant type with light brown seed coat colour. It matures in 105-106 days with average grain yield 16-17q/ha and 3.0 gm 100 seed weight. It is rich in protein with 26.1% protein content. It is resistant to dry root rot. Hence, it has been released and notified for cultivation in northern part of the country.

ATPHG-11 (Anantha Vulava): This variety is developed from local germplasm ATP-1 through selection. Its plants have medium sized leaves and grayish brown seed coat colour. It maturity period varied from 105-110 days with 8-10 q/ha grain yield and 2.9 g weight of 100 seeds. The seed protein content is around 24.0%. It is resistant to dry root rot and moderately resistant to YMV. Therefore, it has been released and notified for cultivation in northern part of the country.

Cowpea

Pant Lobia-7 (PGCP-24): This variety is suitable for rainfed and irrigated conditions. It matures in 70-75 days with average grain yield of 11.0-12.0 q/ha. It has 27% protein content and is resistant to YMV. Hence released and notified for northern part of the country.

Jamu Lobia Super 60: This variety has average grain yield is 12-13q /ha and maturity period ranged from 60-65 days. It has resistant to wilt and YMV. Hence, it has been released and notified for cultivation in Jammu province of Union Territory of Jammu & Kashmir.

PGCP 6: This variety is suitable for early and late *Kharif* sowing. It matures in 70-75 days with average grain yield of 9-10 q/ha. Therefore, it has been released and notified for cultivation in Karnataka states.

KBC-11: This variety is suitable for summer season. It mature in 95-100 days with and average seed yield of 11.0-12.0 q/ha. Hence, it has been released and notified for cultivation in Karnataka states.

Cluster bean:

Gujarat Guar 3: This variety matures in 98-100 days with average yield 13-14 q/ha under normal conditions. It has lesser infestation of bacterial leaf blight, white fly and leaf hopper. Gum content is 29.40%. Hence, it has been released and notified for cultivation in Gujarat.

Breeder Seed Production

In case of Guar, 229.12 q of breeder seed was produced against the DAC indent of 146.02 q of 11 varieties. In this way, 83.10 q of more breeder seed was produced against DAC indent. In case of variety RGC 1033, breeder seed of 108.06 q was produced. Fifty quintal breeder seed of variety RGC 1038 was also produced.

In case of cowpea, an indent of 15.90 q of 6 varieties was received and 23.18 q of breeder seed was produced. In case of variety Hisar cowpea 46 and RC 101, shortfall in breeder seed production was observed. Breeder seed of cowpea was surplus by 7.28 q with respect to DAC indent .

In mothbean, DAC indent of 20.70 q of two varieties was received and 41.29 q of breeder seed was produced. In moth bean, 20.59 q of more breeder seed was produced with regard to DAC indent. The highest quantity of 26.0 q of breeder seed was produced for newly released variety RMO-2251 without indent.

In case of horsegram, indent of 22.47 q of 9 varieties was received. Total 20.44 q of breeder seed was produced. The highest quantity of 6.6 q of breeder seed was produced for variety Gujarat Dantiwada Horsegram-1.

Agronomy

Experiments conducted: 6

In the experiment "Effect of crop establishment

method and weed control practices in clusterbean", the seed yield (1673 kg/ha), net return (₹ 52,149 /ha) and B:C ratio (3.67) were obtained with broad bed sowing method. Whereas weed control practices, the higher clusterbean seed yield (1704 kg/ha), net return (₹ 54,290 /ha) and B:C ratio (3.90) were recorded with the application of Pendimethalin 30% + imazethapyr 2% @ 1000 g/ha as PE, followed by Imazethapyr @ 40 g a.i/ha as PoE.

In Integrated nutrient management in clusterbean, 100% RDF + seed treatment with *Rhizobium* + PSB + 1% 19:19:19 spray gave the highest seed yield of 1523 kg/ha across the locations.

In the trial "Effect of foliar application of nutrients to enhance productivity through combating the dry spell effect in clusterbean", foliar spray of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stage was the best. This treatment gave an average yield of 1291 kg/ha followed by treatment (T4) of foliar spray of soluble NPK (19:19:19) @ 1% at pod formation stage (1191 kg/ha).

In the experiment "Effect of different spacing and fertility levels in cowpea, the highest mean seed yield of cowpea (1543 kg/ha) was obtained with a spacing 45 x 10 cm, whereas for fertility levels, higher cowpea seed yield (1596 kg/ha) was recorded with the application of 100% RDF.

Plant Pathology

Experiment conducted: 7

For managing Alternaria blight of clusterbean, 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 (11.13 and 13.92%). Maximum seed yield and straw yield (2613 and 4321 kg/ha, respectively) was also recorded in this treatment.

In the trial "Evaluation of seed dressing fungicides against charcoal rot of cowpea", minimum charcoal rot incidence (3.33%) was recorded in treatment T5 i.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. Maximum grain yield (680.40 kg/ha) was also recorded in treatment T5.

Entomology

Experiment Conducted: 5

Two sprays of NSKE 5% @ 50 g/lit or Beauveria bassiana 1.15 WP 4g/lit or Azadirachtin 1500 ppm @ 4 gm/l first at ETL (30-40 days after sowing) and second at 15 days after first spray was found effective and economical for the management of sucking pests in cluster bean.

In evaluation of bio-pesticides against major insect pests of cowpea trial among the treatments Azadirachtin 1500 ppm @ 4 ml/lit had minimum population of whitefly (1.21 and 1.98/leaf) and jassid (1.98 and 2.32/leaf) also gave maximum grain yield of cowpea (560 kg/ha) followed by *Beauveria bassiana* @ 5 g/lit (552 kg/ha).

Frontline Demonstrations

In cowpea, total 70 frontline demonstrations were allotted to 7 centres and all were organized by these centres. Overall mean yield of high yielding varieties with improved technology was 1164 kg/ha and yield of local practices was 922 kg/ha. 26.26 percent increase in yield was recorded in demonstrations.

In horsegram, 66 frontline Demonstrations were allotted to 6 centres. All centres implemented the programme and organized 66 FLD's. The average yield of demonstrations with improved practices was 710 kg/ha which was 30.27% higher than the yield of farmers practices (545 kg/ha).

In mothbean, in Gujarat state, SDAU, S.K. Nagar organized 5 demonstrations with improved variety GMO-2 and recommended package of practices. The average yield of demonstrations plot with high yielding variety was 522 kg/ha, which was 14.1% higher than the yield of farmer's practice (446 kg/ha).

In Rajasthan, SKRAU, Bikaner conducted 25 frontline demonstrations with newly released variety RMO 2251. The average yield of improved management practices was 382 kg/ha and average yield of 330 kg/ha was obtained by applying farmer's practices. In this way with improved practices, 15.76% higher yield was obtained.

Transfer of Technology

For effective dissemination of new pulse production technologies among farmers and other stakeholders, following trainings, interactions and other extension activities were organized during the year 2021:

A. Training Programmes

Sl. No.	Activity	Duration	No. of participants	Participants
For Farmers				
1.	Training on Seed Production Technologies of *Kharif* Pulses	16/07/2021	16	Farmers of Kanpur dehat and Hamirpur, UP
2.	Training on Improved Pulse Production Technologies	16/10/2021	100	Farmers of Fatehpur, UP
3.	An online training on Pulses for Human Nutrition and Health	26/08/2021	40	Farmers of Uttar Pradesh
4.	Training on Improved Production Technology of *Rabi* Pulses	03/12/2021	46	Farmers of Kanpur Dehat, UP.
5.	Training on Crops Protection Technologies of *Rabi* Pulse Crops	16/12/2021	50	Farmers of Fatehpur, UP
6.	Training on Protection Technology of *Rabi* Pulses	19/12/2021 to 20/12/2021	50	Farmers of Jalun, UP
For Extension Officials				
7.	Online collaborative training programme organized with MANAGE Hyderabad on "Improved Pulse Production Technology for Sustainable Agriculture & Nutritional Security"	06/09/2021 to 09/0902021	44	Extension personnel from different parts of the country

B. Interaction with Stakeholders

Sl. No.	Activity	Duration	No. of participants	Participants
1.	Farmer-Scientist Interaction on Climate Resilient Technologies For *Rabi* Pulses	28/09/2021	50	Farmers of Fatehpur, UP
2.	Farmer-Scientist Interaction on Waste To Wealth	12/10/2021	242	Farmers of Fatehpur, UP
3.	Student-Scientist Interaction on Agriculture and Environment: The Citizen Face	26/11/2021	26	Student of 4 Schools of Kanpur
4.	Farmer-Scientist Interaction on World Soil Day celebration	05/12/2021	156	Farmers of Fatehpur, UP
5.	Farmer-Scientist Interaction on Pulse Production technology	23/12/2021	53	Farmers of Fatehpur, UP

C. Exposure Visit at ICAR-IIPR Kanpur

Sl. No.	Date/ Duration	No. of participants	Details of Participants
1.	25/09/2021	50	Farmers of Chitrakoot, UP
2.	26/09/2021	50	Farmers of Banda, UP
3.	26/09/2021	55	Farmers of Barabanki, UP
4.	23/10/2021	77	Farmers of Jhnasi, UP
5.	10/11/2021	15	Farmers of Bhind, MP
6.	23/11/2021	40	Input dealers of Lakhimpur Kheri, UP
7.	09/12/2021	09	Farmers of Umaria, MP
8.	09/12/2021	20	Farmers of Bundelkhand, UP
9.	14/12/2021	43	Farmers of Sikar, Rajasthan
10.	15/12/2021	32	Farmers of Gorakhpur, UP
11.	17/12/2021	56	Farmers of Hathras, UP

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Research Papers

Akram M, Kamaal N, Pratap A, Muin A, Ahmad A, Agnihotri AK, Shinde P, Sabaale PR and Singh NP (2021). Molecular characterization of Begomoviruses causing yellow mosaic disease in *Vigna stipulacea* and evidence of recombination. Journal of Food Legumes. 33: 232-244.

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Training and Capacity Building

Seminars/Symposiums/Conferences/ Workshops/Meeting

Aditya Pratap attended pre-RMP programme on 'Management development programme on leadership development, organized by ICAR-NAARM, Hyderabad as December 13-24, 2021.

Aditya Pratap attended National Workshop on 'Bridging Yield Gaps to Enhance Foodgrain Production: A Way Forward', organized by TAAS on Aug. 26, 2021.

Aditya Pratap attended Final Review Meeting, ACIAR International Mungbean Improvement Network on Nov. 29-30 and Dec. 01, 2021.

Aditya Pratap participated in Virtual Workshop and Annual Review Meeting of ABIs/ ZTMCs/ ITMUs under ICAR Institutes of Crop Science Division on October 09-10, 2021.

Aditya Pratap participated in review and Sensitization Workshop of ZTMUs/ITMUs/ PMEs under NAIF Scheme, Review of Crop Institutes on 11th October, 2021.

Aditya Pratap attended Annual Online Review Meeting of CRP on Molecular Breeding on Dec. 8, 2021.

Aditya Pratap attended Brainstorming Meeting on "Intensification and Sustenance of Pulses in North Hill Zone of India" organized on 24th September 2021 at CSK Himachal Pradesh Krishi Vishvavidyalaya (CSKHPKV), Palampur.

Aditya Pratap, Organized 'Brainstorming Meeting on Intensification and Sustenance of Pulses in NHZ was organized on 24.09.2021 at CSKHPKV, Palampur.

Ashok Parihar attended Annual Group Meet on *Kharif* Pulses during May 27-28, 2021

Asik Dutta attended XV Agricultural Science Congress & ASC Expo' and National Academy of Agricultural Sciences and Banaras Hindu University at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during November 13-16, 2021.

Bandi, SM. Participated Sixth National Conference on "Biological Control: Innovative Approaches for Green India" NCBC-2021. Organized by SBA, Bengaluru. ICAR – NBAIR, Bengaluru. 3-5th March, 2021.

Bandi, SM. Participated National Web Conference on 'Sustaining Pulse Production for Self Sufficiency & Nutritional Security' February 09-11, 2021. Organized by ISPRD and ICAR-IIPR Kanpur.

Bansa Singh attended National Web Conference on 'Sustaining Pulse Production for Self Sufficiency & Nutritional Security' February 09-11, 2021 organized by ISPRD and ICAR-IIPR, Kanpur.

Banwari Lal attended 5th International Agronomy Congress on "Agri innovations to combat food and nutrition challenges" organized by the Indian Society of Agronomy at PJTSAU, Hyderabad (India) on November 23-27, 2021.

Basavraj T participated in Annual Group Meet on MULLaRP on *Kharif* Pulses Crops organised by IIPR, Kanpur through virtual mode/Zoom Meeting on May 27-28, 2021.

Basavraj T Served in publication committee member in National WebCon on Sustaining Pulse Production for Self sufficiency and Nutritional Security Feb. 9-11, 2021.

Basavraj T Served in Poster Session Committee in National WebCon on Sustaining Pulse Production for Self sufficiency and Nutritional Security Feb. 9-11, 2021.

C.S. Praharaj, Narendra Kumar, Prasoon Verma, KK Hazra, CP Nath, Asik Dutta, Mrunalini K. and Man Mohan Deo attended National Web Conference on Sustaining Pulse Production for Self-sufficiency and Nutritional Security, held on Feb. 9-11, 2021, organized by ISPRD and ICAR-Indian Institute of Pulses Research, Kanpur.

C.S. Praharaj attended NAAS Regional Chapter-Barapani, Meghalaya, International Union of Organic Agriculture, Shillong and CoA, CAU, Kyrdemkulai, Meghalaya and presented a lead paper.

C.S. Praharaj presented a paper in 5th International Agronomy Congress (IAC) 2021 on "Agri-

Innovations to Combat Food and Nutritional Challenges" held at PJTSAU, Hyderabad, Telengana, India during November 23-27, 2021 and presented a paper and received IAS GOLD MEDAL 2018.

Devraj, attended online Hindi Workshop on "Statistical Modeling and Forecasting in Agriculture" organized by ICAR-IASR, New Delhi during June 24-26, 2021.

Devraj, attended "Nutricereal Mega Conclave" organized by ICAR-IIMR, Hyderabad through virtual mode during Sept. 17-18, 2021.

Devraj, attended Webinar on "Implementation and Use of Agricultural Research Management System (ARMS)" organized by ICAR-IASRI, New Delhi on Oct. 20, 2021.

DP Patel attended a Virtual Round table on "Life-Lifestyle for Environment" organized by International Life Sciences Institute India (ILSI) on November 24, 2021.

DP Patel attended an Interactive Panel Discussion on "Nutrition and Health for All" organized by International Life Sciences Institute, India (ILSI) on December 21, 2021.

Hemant Kumar, attended National WebCon on "Sustaining Pulse Production for Self-Sufficiency and Nutritional Security" (Pulse Webcon2021) organized by Indian Society of Pulses Research and Development on February 9-11, 2021.

Hemant Kumar, attended International Conference (virtual mode) on Emerging Trends in Statistics and Data Science" organized by Indian Society for Probability and Statistics (ISPS), during September 7-10, 2021.

Jagadeeswaran participated (virtually) the International Conference on Advances in Nematology 2021, organized Association of Applied Biologist, London on 14.12.2021.

Jitendra Kumar attended Webinar on Biofortification organized by ASSOCHAM INDIA on Oct 1, 2021.

Jitendra Kumar attended Webinar on Translating Genomics for Next Generation Crop Improvement. Tata Institute for Genetics and Society & Biotech Consortium India Ltd. Held on June 10, 2021.

Jitendra Kumar attended Germplasm Diversity Day on Feb 20, 2021 at ICAR-NBPGR, New Delhi.

Jitendra Kumar attended National Web Conference on 'Sustaining Pulse Production for Self Sufficiency and Nutritional Security held on Feb 09-11, 2021 at ICAR-IIPR, Kanpur.

Krishnashis Das attended National Webinar on "Microbial Biopesticides: Next Generation Preparedness" organized by Department of Plant Pathology, Assam Agricultural university, Jorhat, Assam on July 2, 2021.

Krishnashis Das participated in International Webinar on 'Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone' Organized by SKRAU, Bikaner, India on July 17, 2021.

L K Rolaniya attended International Webinar on Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone held at SKRAU, Bikaner on July 17, 2021.

Man Mohan Deo attended Magnitude of Tractor-trailer System Vibration under Different Operating Conditions (HWWE228979). 18th International Conference on Humanizing Work and Work Environment (HWWE-2020) organized by Theem college of Engineering, Boisar, India during December 10-12, 2020.

Manjunatha, L. Participated National Web Conference on 'Sustaining Pulse Production for Self Sufficiency & Nutritional Security' February 09-11, 2021. Organized by ISPRD and ICAR-IIPR Kanpur.

Mrs. Monika Punia attended International Webinar on Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone at SKRAU, Bikaner on July 17, 2021.

Narendra Kumar attended Webinar on 'Weeds of National Importance' organized by ICAR-DWR, Jabalpur on Feb. 25, 2021.

Narendra Kumar attended XXVI- Meeting of ICAR Regional Committee-VI coordinated by ICAR-CSWRI, Avikanagar on March 13, 2021.

Narendra Kumar attended Webinar on 'Parthenium weed Problem and its Management at Global Level' organized by ISWS, Jabalpur on August 16, 2021.

Narendra Kumar attended National Webinar on '*Krishi Me Nanotechnology Ka Upyog: Nano-fertilizer*' organized by ICAR-RCER, Patna & IFFCO on September 13, 2021.

Narendra Kumar attended Webinar on 'Diversifying

Indian Agriculture & Food System: New Opportunities for Farmers' organized by ICAR-IISWC, Dehradun on November 3, 2021.

Ram Lal Jat attended International Webinar on "Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone" at SKRAU, Bikaner on July 17, 2021.

Ram Lal Jat attended National Web Conference on "National Web Conference on Sustaining Pulse Production for Self Sufficiency and Nutritional Security Pulse" (Pulse Web Con 2021) at Kanpur on February 09-11, 2021.

Revanasidda attended National Web Conference on Sustaining Pulse Production for Self-sufficiency and Nutritional Security, organized by ICAR-Indian Institute of Pulses Research, Kanpur, U.P., India on Feb. 9-11, 2021.

Rishikesh Kumar attended National Web Conference on Sustaining Pulse Production for Self Sufficiency and Nutritional Security, Feb. 9-11, 2021 organized by Indian Society of Pulses Research and Development (ISPRD) and ICAR-Indian Institute of Pulses Research (IIPR), Kanpur, U.P.

R.K. Mishra attended National Webinar on Pulses during the January, 2021 at ICAR-IIPR, Kanpur organized by ISPRD, ICAR-IIPR, Kanpur.

R.K. Mishra attended National Conference and Zonal Meeting of Indian Phytopathological Society held at AMU, Aligarh.

Sujayanand, G.K. participated in a National Webinar on "Integrated Pest Management: A Paradigm Shift" (Virtual Mode) during 27-28 August 2021.

Sujayanand, G.K. participated in 2nd International Agrobiodiversity Congress during 15-18 November 2021.

Surendra Kumar Meena attended International Symposium on Coastal Agriculture (ISCA Webinar), on "Transforming Coastal Zone for Sustainable Food & Income Security" organized by ICAR-CSSRI, Karnal on March 16-19, 2021.

Yogesh Kumar participated in Farmers 'Improved Production Technologies of *Rabi* Pulses' organized by Social Science Div, IIPR, Kanpur on Oct. 16, 2021 at Kadhra village of Fatehpur district under Farmers First Project.

Yogesh Kumar participated in Farmers Scientist Interface on 'Climate Resilient Agricultural Technologies for *Rabi* Pulses' organized by Social Science Div on September 28, 2021 at IIPR, Kanpur.

Yogesh Kumar participated in monitored Chickpea Demonstrations conducted in Allapur and Mancha villages (Pukhrayan block), Kanpur Dehat on February 19, 2021 under Seed Hub Project.

Yogesh Kumar participated in monitored chickpea demonstrations conducted in Kusumara village of Hamirpur District, Bundelkhand region on February 22, 2021 under Seed Hub Project.

Yogesh Kumar participated in Farmers-Scientist Interaction on quality seed production techniques of pulses organized by IIPR, Kanpur under Seed Hub from March 19-20, 2021 at IIPR.

Training Programme

Alok Das attended Generic Training on Cyber Security, C-DAC, Pune, 2 May, 2021 (Online).

Devraj, participated "Generic Training Course in Cyber Security" organized by C-DAC, Hyderabad on Sept. 16, 2021.

Hemant Kumar attended online hindi workshop on "Krishi Min Sankhyikiya Modelling Evam Purvanuman" conducted by ICAR-IASRI, New Delhi during June 24-26, 2021.

Meenal Rathore attended TAAS workshop on 26.8.2021: National Workshop on Bridging the Yield Gaps to Enhance Foodgrain Production: A Way Forward.

Monika Punia attended 21 days online training programme on "Plant Genetic Resources Management and Utilization" organized by ICAR-NBPGR, Pusa Campus, New Delhi on July 19 to August 1, 2021.

Neetu S Kushwah attended 10 days training on "Statistical designs and analytical methods for multifactor experiments" organised by ICAR-CMFRI, Kochi, India during 08-17 Dec, 2021.

S.K. Meena attended 10 days online training programme on "Statistical Designs and Analytical Methods for Multifactor Experiments" organized by ICAR-CMFRI, Kochi on December 8-17, 2021.

Uma Sah (course director) , Dr. Hemnat Kumar and Dr. Devraj (Local Course Coordinators) organised 3 days MANAGE, Hyderabad sponsored training programme on

Lectures Delivered

Aditya Pratap delivered a invited lecture on 'Pre breeding and distant hybridization in *Vigna*' in training programme on 'Plant Genetic Resources management and utilization', July 19, 2021 organized by NBPGR, New Delhi between July 19-August 01, 2021.

Jitendra Kumar delivered lecture on Improved varieties of lentil in the Seed Field Day Cum Framers-Scientists Meet, Feb 28, 2021, Allapur, Kanpur Dehat.

Manu B and Dr. Revanappa, attended online training on "PGR management and utilization" organized by ICAR-NBPGR New Delhi during 19th July 2021 to 01 Aug 2021.

Manu B, and Dr. Revanappa, attended online refresher course on "Prequels to plant breeding by design and prediction" Conducted by UAS Bengaluru during 28th Jan 2021 to 18th Feb 2021.

Uma Sah delivered lecture on "ICT-based knowledge resources for empowering farmers" on September 10, 2021 in 10 days training programme on "Effective Extension Methods for Upscaling and Outscaling of Wheat and Barley Production Technologies" for extension professional during September 1-10, 2021 organised by ICAR-IIWBR, Karnal and Extension Education Institute, Nilokheri.

Uma Sah delivered lecture on "Changing paradigms of agricultural extension research with focus on pulse crops" on 9th Sept.2021 in five days faculty development programme (FDP) on "Scaling up Agricultural Research with New Methodologies" from 06th September to 10th September 2021 organized by Faculty of Agricultural Sciences and Allied Industries, Rama University, Uttar Pradesh, Kanpur.

Uma Sah delivered lecture on "ICT mediated knowledge resources for pulse growers " in three on 7th Sept. 2021 in three-day online training program on the topic "ICTs and Mass Media for Agricultural Extension" ,organized by department of Agriculture Extension, Banda Agriculture and University.

Yogesh Kumar delivered talk 'improved varieties of chickpea and their packages & practices'on 16.10.2021 during Farmers training organized by Social Science Div, IIPR Kanpur on 16.10.2021 at Kadhra village from Fatehpur district of UP under Farmers First Project

Yogesh Kumar delivered talk 'Seed production techniques of chickpea'on 28.09.2021 during Farmers Training 'Climate resilient agricultural technologies for *rabi* pulses' organized by Social Science Div, IIPR Kanpur at Kanpur.

Yogesh Kumar delivered talk 'utilization of rice fallows for enhancing pulse production on 3.3.2020 during farmers training by IIPR from 2-6 March 2020 at Kanpur.

Awards & Recognitions

Recognitions

Alok Das acted as Writer and Reviewer of ICAR JRF/SRF Examination for Plant Sciences (Agricultural Biotechnology) Section, National Testing Agency, New Delhi

Alok Das acted as Reviewer, BIRAC BIG Grant Startup Incubation and Innovation Centre, IIT Kanpur (SIIC IIT Kanpur)

Alok Das acted as External Expert, Institutional Biosafety Committee, Rani Lakshmi Bai Central Agricultural University, Jhansi

Archana Singh has acted as an Expert (New Biology) for 36th M.P. Young Scientist Award organized by MPCST, Bhopal and Vikram University, Ujjain during March, 23 – 26, 2021.

Archana Singh acted as an Expert member for a poster judging committee in the Poster session "Crop scenario and policy perspectives " in the Pulse WebCon 2021"Sustaining pulse production for self sufficiency and nutritional security" during Feb. 09-11, 2021, organized by ISPRD, Kanpur.

K R Soren acted as Selected member for Board of Apprenticeship Traning (BOAT,NR)for selection committee for various posts, under Govt.of India, Ministry of Education, Department of Higher Education.

K R Soren acted as Member of the screening commiittee for scrutiny of application received against Ad.NoBOAT (NR)

Meenal Rathore was invited as Chief Guest at FDP on Scaling up agricultural research with new methodologies at Rama University, Kanpur on September 6, 2021

Meenal Rathore was invited as Speaker on September 6, 2021 for New Biotechnologies in Agricultural Research in the FDP Programme at Rama university.

Meenal Rathore acted as External expert at research proposals scrutinizing committee by State Level Biotechnology Centre, MPKV, Rahuri as an expert on 21.7.2021.

Meenal Rathore acted as Chief Guest and Chairman, at workshop on Gender sensitization by Internal Complaint Committee , EPFO on 3.11.2021.

Narendra Kumar received 'Appreciation Certificate' for delivering an excellent presentation in the Faculty Development Programme on 'Scaling Up Agricultural Research with New Methodologies' of Rama University, Kanpur during September 6-10, 2021.

Sudhir Kumar acted as Convener, 6th National Youth Convention, organized by ICAR, AIASA and PJTSAU, Hyderabad on 20-21 February 2021.

Awards

Banwari Lal received "Young Scientist Award" of Agro Environmental Development Society (AEDS) of Uttar Pradesh during 5th International Conference on "Advances in Agriculture, Environmental and Biosciences for Sustainable Development" in online mode during 5-7th August, 2021.

Banwari Lal received "ISA Associate Award" of Indian Society of Agronomy, New Delhi in 5th International Agronomy Congress on "Agri innovations to combat food and nutrition challenges" held at PJTSAU, Hyderabad (India) from 23-27 November, 2021.

C.S. Praharaj, received Reviewer Excellence Award (2021) Indian Journal of Agricultural Research and Legume Research- Editors of ARCC Journals of Agricultural Research Communication Centre, Karnal, Haryana).

C.S. Praharaj, received ISA Gold Medal Award 2018 for outstanding contribution in research in Agronomy Discipline by Indian Society of Agronomy conferred during 5thInternational Agronomy Congress held at PJTSAU, Hyderabad during November 23-27, 2021.

Jitendra Kumar, received Best Poster Award in Pulse WebCon, Feb 10-11, 2021, ICAR-IIPR-Kanpur

M. Senthilkumar received Fulbright-Nehru Academic and Professional Excellence Award 2021-2022

Raghavendra Singh, Principal Scientist, received "ISA Fellow 2018" award for outstanding contribution in research in Agronomy by

Indian Society of Agronomy and was conferred on him during 5th International Agronomy Congress held at PJTSAU, Hyderabad during November 23-27, 2021.

Sujayanand, G. K. got Fellow of Society for Biocontrol Advancement, Bengaluru, India- 2021.

Sujayanand, G. K. recieved "The Young Entomologist Award" from *Vigan Varta* (e-magazine) in collaboration with Om Shanti Narayan Foundation Trust.

Best Oral Presentation Award

Sujayanand, G.K., Sonika Pandey, Jyotirmay Dubey, Anup Chandra and Jagadeeswaran, R. Phylogenetic analysis of native *Bacillus thuringiensis* strains based on gyrase gene and their nematicidal potential by chitinolytic activity. In: *Sixth National Conference on Biological Control: Innovative Approaches for Green India*, ICAR-NBAIR, Bengaluru, 3 - 5 March, 2021.

Best Poster Award

Jyotirmay Dubey, Sonika Pandey, Sujayanand GK and R. Jagadeeswaran.2021. Chitinolytic activity of Nematophagous fungi, *Trichoderma* spp isolated from pulses rhizosphere, In 6th National Conference on Biological Control during 3-5 March 2021 at NBAIR, Bengaluru.

Man Mohan Deo, Prasoon Verma and CS Praharaj awarded The Best Poster award in National Web Conference on *Sustaining Pulse Production for Self-sufficiency and Nutritional Security* in the *Pulse WebCon- 2021* organized by *ISPRD and ICAR-IIPR, Kanpur* during *February 09-11, 2021* for an article "*Status of Farm Mechanization for Different Operations in Pulses*"

Revanasidda, Sanjay M. Bandi, Prasoon Verma and Bansa Singh. 2021. Assessment of bruchid field infestation and the impact of field-carry-over infestation during storage in mungbean. In National Web Conference on Sustaining Pulse Production for Self-sufficiency and Nutritional Security at ICAR-Indian Institute of Pulses Research, Kanpur, U.P., India.

Surendra Kumar Ghritlahre 2021. "Status of Area, Production and Productivity of Pigeonpea over last 15 years in Madhya Pradesh" in the National Web Conference on "Sustaining Pulse Production for Self Sufficiency and Nutritional Security" February 9-11, 2021 organized at IIPR, Kanpur.

Manu B., Aditya pratap, T.N. Tiwari, P.S. Basu and Revanappa received The Best Poster Award as co- author in Pulse Webcon 2021 on "Physiological evaluation of mungbean genotypes for drought and heat tolerance" authored.

Vaibhav Kumar and Dr. Krishnashis Das received The Best Poster Award as co- author in Pulse Webcon (2021) Sustaining Pulse Production for Self Sufficiency and Nutritional Security organized by ISPRD during Feb, 9-11, 2021. Prasoon Verma, Vaibhav Kumar, Krishnashis Das, Deepshikha and Manisha Parashar (2021). Biochemical studies of chickpea grain, dal and milling byproducts.

Best Article Award

C.S. Praharaj, Principal Scientist & Head received SRIRAM AWARD 2020 (Certificate and First Prize) from FAI 2020 for Best Article in *Khad Patrika,* India.

On going Research Projects

DIVISION OF CROP IMPROVEMENT (3)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
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	RPP I: 23.02.21
	SP 1	Genetic enhancement of *desi* chickpea for higher grain yield and wider adaptability	Dr. Yogesh Kumar	Dr. B. Mondal, Dr. U.C.Jha, Dr. Revanappa SB Dr. K.R. Soren, Dr. Rishikesh Singh,		
	SP 2	Breeding for high yielding chickpea with multiple biotic stress resistance	Dr. A.K. Srivastava	Dr. Yogesh Kumar, Dr. K.R. Soren, Dr. Manjunatha		
	SP 3	Development of high yielding genotypes of chickpea having combined resistance against drought and heat stress tolerance.	Dr. U.C. Jha	Dr. D. P. Patel Dr. Archana Singh, Dr. Yogesh Kumar,		
	SP 4	Genetic enhancement for grain quality and milling attributes of chickpea.	Dr. B. Mondal	Dr. Prasoon Verma, Dr. Yogesh Kumar Dr. Vaibhav Kumar,		
	SP 5	Genetic enhancement of *kabuli* chickpea for higher grain yield and wider adaptability and better quality	Dr. Archana Singh	Dr. Yogesh Kumar, Dr. Gritlehre S.K.		
	SP 6	Long duration pigeonpea	Dr. Satheesh Naik SJ	Dr. Dibendu. Datta, Dr. Farindra Singh, Dr. R.K. Mishra Dr.Abhishekh Bohra,		
	SP 7	Medium duration pigeonpea	Dr. S.K. Ghritlehre	Dr. Archana Singh Dr. Farindra Singh, Dr. R.K. Mishra		
	SP 8	Short duration pigeonpea	Dr. Dibendu Datta	Dr. Abhishek Bohra, Dr. Satheesh Naik S.J. Dr. R.K. Mishra,		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	SP 9	Harnessing of CMS based hybrid technology for yield stability and stress tolerance in pigeonpea	Dr. Abhishek Bohra	Dr. Satheesh Naik S.J. Dr. S.K. Ghritlehre		
	SP 10	Genetic enhancement of mungbean (*Vigna rediada* L) towards development of superior plant types for different agro-ecological regions	Dr. Aditya Pratap	Dr. Mohd. Akram, Dr. Revanappa, Dr. Basavaraja, T., Dr. Ram Lal Jat		
	SP 11	Mungbean (Abiotic stresses)	Dr.Basavaraja. T	Dr. Aditya Pratap Dr. T N Tiwari		
	SP 12	Urdbean: Genetic enhancement-Biotic Stress	Dr. P.K. Katiyar	Dr. Debjyoti Sen Gupta, Dr. Archana Singh, Dr. A.K. Singh, Dr. Manu B., Dr. PR Saabale, Dr. Anup Chandra		
	SP 13	Urdbean: Abiotic stresses	Dr. A.K. Singh	Dr. P.K. Katiyar, Dr. Debjyoti Sen Gupta, Dr. Manu B., Dr. Vijaya Laxmi Dr. Kuldeep Kumar		
	SP 14	Lentil	Dr. Jitendra Kumar	Dr. Naimuddin, Dr. Debjyoti Sen Gupta, Dr. D.P. Patel,		
	SP 15	Fieldpea	Dr. A.K. Parihar	Dr. R.K. Mishra, Dr. Anup Chandra		
	SP 16	Bio fortification in urdbean and Mungbean for Fe and zinc concentration,	Dr. Debjyoti Sen Gupta	Dr. Asik Datta, Dr. Aditya Pratap,		
	SP 17	Genetic enhancement in arid pulses for abiotic and biotic stresses: Moth bean and Cowpea:	Mrs. Monika Punia	Dr. A. K. Parihar, Dr. Surendra Kumar Meena		
2.	**CRSCIIPRSIL 202000200157**	**PGR Management and utilization**		**Dr. Shiv Sewak**		**RPP I: Not Submitted**
	SP 1	Chickpea (IIPR)	Dr. Shiv Sewak	Dr. Yogesh Kumar, Dr. B. Mondal, Dr. Amrit Lamichaney, Dr. Revanappa S.B.		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	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 Gupta, Dr. P.K. Katiyar, Dr. B. Manu		
	SP 8	Fieldpea	Dr. A. K. Parihar	Dr. RK Mishra		
	SP 9	Horsegram	Dr. Revanappa S. E.	Dr. Manu B., Dr. P.R. Saabale		
	SP 10	Cowpea (Dharwad)	Dr. B. Manu	Dr. Revanappa S. B. Dr. AK Parihar Dr. P.R. Sabaale		
	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	RPP I: 23.02.21
	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	RPF Position (Approved by The Director)
4.	CRSCIIPRSIL 202000400159	**Genomics, Genetic Engineering and New Breeding Technologies for Pulses Improvement.** **Dr. Meenal Rathore**			2020-25	RPP I: 23.02.21 RPP II (2020-21):28.09.2021
		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 Kr. 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 Kr. Konda Dr. R. K. Mishra Dr. Manjunath L		
	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		
	SP 5	Identification of genes/QTL for salinity tolerance in urdbean and earliness in Lentil	Mr. Kuldeep Kumar	Mr. Sudhir Kumar Dr. Awnindra Kr. Singh, Dr. Manu B.S, Dr. Jitendra Kumar	Oct. 2020 to Sept. 2025	**RPP I: 20.09.2021**
		Theme II. Pulse Improvement through genetic engineering and new breeding technologies				
	SP 6	Precision Plant Breeding and Rapid Generation Advancement in Chickpea	Dr. Alok Das	Dr. Meenal Rathore Dr. Neetu Singh Kushwah		
	SP 7	Molecular approaches for improving the nutritional quality of grasspea. **Revised**:Molecular approaches for improving the nutritional quality of grasspea (*Lathyrus sativus*) and field pea (*Pisum sativum*)	Dr. Neetu Singh Kushwah	Dr. Meenal Rathore Dr. Alok Das Dr. Archana Singh		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	SP 8	Transforming *Vigna* for tolerance to whitefly (*Bemisiatabaci*)	Dr. Meenal Rathore	Dr. Neetu Singh Kushwah Dr. Alok Das		
	SP 9	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	RPF Position (Approved by The Director)
5.	**CRSCIIPRSIL 202000500160**	**Development of Climate Smart Agro-technologies for Pulses under Diversified Agro-ecological Regions of India:** **Dr. Narendra Kumar** (w.e.f. 01.10.2021)		**Dr. C. S. Praharaj** (till 30.09.2021)	**2020-25**	RPP I: 23.02.21 RPP II (2020-21):28.09.2021
	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 (till 30.09.2021) Dr. Narendra Kumar (w.e.f. 01.10.2021)	Dr. Narendra Kumar (till 30.09.2021) 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		
	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		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	SP 7	Enhancing input use efficiency and productivity of pulses production system in central India	Dr. Narendra Kumar (till new Scientist join at IIPRRC Bhopal)	Dr. Narendra Kumar		
	SP 8	Enhancing input use efficiency and productivity of pulses in arid ecosystem	Dr. Ram Lal 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 IIPRRS 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) till July 2021	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		
	SP 13	Zinc accounting and enrichment in chickpea through agronomic management practices	Ms. Mrunalini Kancheti	Mr. Asik Dutta Mr. K K Hazra	**2020-23**	
	SP 14	Sustainable intensification of rice-fallows with inclusion of pulses in Eastern India	Dr. Raghavendra Singh	Dr. C.S. Praharaj, Mr. K.K. Hazra, Dr. P.K. Panda (ICAR-IIWM)		
	SP 15	Improving soil health and minimizing the yield gap in pulses through resource conservation technologies in arid ecosystem	Dr. Lalit Kumar Rolaniya	Dr. R.L. Jat, Dr. S.K. Meena Dr. Narendra Kumar		
	SP 16	Enhancing input use efficiency and productivity of pulses production system in central India	Dr Sandeep Kumar	Dr Narendra Kumar, & Scientist from IISS, Bhopal)		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
6.	CRSCIIPRSIL 202000600161	**Post harvest management of pulses, value addition and by-product utilization: Dr. Prasoon Verma**			2020-25	RPP I: 23.02.21 RPP II (2020-21):18.08.2021
	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) till July 2021		
	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 Er. Man Mohan Deo		

DIVISION OF CROP PROTECTION (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
7.	CRSCIIPRSIL 202000700162	**Biotic stresses management through bio-intensive and novel eco-friendly approaches in pulse crops. Dr. Bansa Singh**			2020-25	RPP I: 23.02.21 RPP II (2020-21):20.10.2021
	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 Kr. 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.		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	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		
	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. Sabaale			
8.	**CRSCIIPRSIL 202000800163**	**Epidemiology and characterization of major and emerging pests and diseases of pulses and diagnostics for seed borne viruses.** **Dr. Naimuddin**			**2020-25**	RPPI : 13.04.21
	SP 1	Validation and diagnostics of races for *Fusarium oxisporum* f. sp. *ciceris* and development of screening facilities for *Rhizoctonia bataticola*	Dr. Rishikesk Kumar	Dr. Manjunatha, L. Dr. Khela Ram soren		
	SP 2	Epidemiology of major fungal pathogens of pigeonpea	Dr. RK Mishra	Dr. Naimuddin Dr. Archana Singh		
	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		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	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	RPF Position (Approved by The Director)
9.	**CRSCIIPRSIL 202000900164**	**Physio-biochemical intervention for improving climate resilience and nutrition enriched pulses. Dr. D. P. Patel**			**2020-25**	RPP I: 30.06.2021 RPP II (20-21): 30.06.2021
	SP 1	Physiological Characterization of pigeonpea Genotypes for Water Logging Tolerance	Dr TN Tewari	Dr D Datta Dr Kalpana Tewari		
	SP 2	Biochemical responses of chickpea to heat stress and identifying key factors limiting its productivity	Dr Vaibhav Kumar	Dr Kalpana Dr Biswajit Mondol		
	SP 3	Identification of donors & physiological traits for high temperature & drought tolerance in lentil	Dr. D P Patel	Dr. J Kumar	Extended upto2021	
	SP 4	Identification of donors and physiological traits for drought and heat tolerance in legume crops (Mungbean, Moth bean and Pigeonpea) under arid environments	Dr. S K Meena	Dr. Ram Lal Jat		

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
	SP 5	Strategies for improving yield stability in Urdbean through photothermo–insensitivity	Dr. Vijay Laxmi	Dr. AK Singh	Extended upto2021	
	SP 6	Exploring common bean (*Phaseolus vulgaris)* genotypes for bioactive components associated with health promoting properties and flatulence	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**	RPP I: 23.03.21
	SP 1	Unravelling of molecular basis for variations in nodulation and symbiotic efficiency of chickpea	Dr. M. Senthil Kumar	Dr. Shanmugava divel PS Dr. Kalpana Tewari		
	SP 2	Deciphering the root signals for effective nodulation of Rajmash	Dr. Krishnashis Das	Dr. Senthilkumar Dr. Vaibhav Kumar		

Division of Social Science (2)

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
11.	**CRSCIIPRSIL 202001100166**	**Innovative extension approaches for livelihood and nutritional security through Pulse Production Technology in India:** **Dr. Rajesh Kumar**			**2020-25**	RPP I: 23.02.21 RPP II (2020-21):28.09.2021
	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, MH Dr. Ram Lal Jat, Dr. C.P. Nath, Mr. K. Ravi Kumar,		
	SP 2	Development and Evaluation of e Learning Platform for Pulse production technologies (*eLeaP-Pulse*)	Dr. Uma Sah	Dr. Hemant Kumar Mr. K. Ravi Kumar		
	SP 3	Impact assessment of Pulse based Bio-village sustainable model project of IIPR in Uttar Pradesh	Mr. K. Ravi Kumar	----		

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period	RPF Position (Approved by The Director)
12.	**CRSCIIPRSIL 202001200167**	**IT enabled data management in pulses for policy support system.** **Dr. Devraj**				RPP I: 23.02.21
	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 (10)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
1	AICRP on Seed (Crops)	ICAR-IISS, Mau	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	2005-06 to March 2022	Plan Scheme of ICAR
2	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 To March 2023	Rs. 80 lakh
3	CRP on hybrid technology in Pigeonpea	ICAR	Dr. Abhishak Bohra	Dr. Satheesh Naik S.J. Dr. Alok Kumar	2015-16 To 2022-2023	Rs. 88.00 lakh
4	Establishing International Mungbean Improvement	ACIAR, Australia	**Prog. Coordinator** : Dr. N.P. Singh (till 31.10.2021) **PI**: Dr. Aditya Pratap	Dr. Sanjeev Gupta	2017-December 2021	150.10 Lakh
5	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
6	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
7	Development of improved Indian common bean (*Phaseolus vulgaris* L.) lines resistant to Anthracnose diseases by employing molecular breeding.	SERB (DST)	Dr. Basavaraja T	-	2019-22	35.085 lakh

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
8	Application of next generation breeding, genotyping and digitalization approaches for improving the genetic gain in Indian 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	-
9	Pre-breeding and genetic enhancement of germplasm of common bean	Alliance Bioversity International – CIAT & IIPR	Dr. Basvaraja T	-	July 2021 to June 2024	25.00 Lakh
10	Detection of genetic loci associated with yield attributes and seed quality traits under high temperature exposure in field pea (*Pisum sativum* L.)	SERB (DST)	Dr A. K. Parihar	Dr. K. R. Soren	Dec. 2021 to Nov. 2024	-

Division of Bio-Technology (5)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
11	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. Mondal	2015 to 2022	15-16 : 26.35lakh
12	Development of early flowering chickpea genotype using CRISPR/Cas9 technology	SERB (DST)	Dr. Alok Das	Dr. Biswajit Mondal	2021-24	33.529
13	Development of pod borer resistant transgenic chickpea and pigeon pea (Project Code 3040)	-	Dr. Alok Das	Dr. SUJAYANAND G K	2005-21	-

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
14	Genetic mapping of Fusarium wilt and SMD in Pigeonpea	-	Dr. Shanmugavadivel, P.S	Dr Saable PR Dr. Abhishek Bohra	2015-21	-
15	ICAR-Network project on NPTC Genomics	-	Dr Soren KR	Dr. Shanmug-avadivel, P.S,	2005-21	-

Crop Production Division (2)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate/Co-PI	Period	Budget ₹ (in lakh)
16	Utilization of pulse milling by-product for edible use	Min. of Food Processin Industries (GOI)	Er. Prasoon Verma	1. Er. Man Mohan Deo (on Study Leave) 2. Mr. Vaibhav Kumar 3. Dr. Krishnashi sh Das	Dec. 2018 to March. 2022	54.00
17	Integrated management of fieldpea (*Pisum satium* L) through conservation tillage and sprinkler irrigation under limited resources.	CST, UP (DST, Govt. of Uttar Pradesh)	Dr. Raghavendra Singh (w.e.f 01.10.2021), Dr. C. S. Praharaj (till 30.09.2021)	Dr. C. P. Nath	2021-2023	7.80

Crop Protection Division (3)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
18	Bio-prospecting plant essential oils for insecticidal properties against pulse beetle infesting stored legumes	DST-SERB New Delhi	Dr. Sanjay M. Bandi	Dr. Revana Sidha	2018-2021	29.0
19	Innovative and contextual agromet advisory services for climate smart	IITM (Indian Instt. of Tropical Metrology)	Dr. R. K. Mishra	Dr. Sanjay M. Bandi Dr. Uma Sah	2018-2022 Extd up to 30.11.2022	80.7984
20	Management of wilt disease in pulse crops using bio-formulations	UPCAR	Dr. Naimuddin	Dr. R. K. Mishra Dr. Mohd. Akram	2021-2024	16.39

Basic Science Division (1)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
21	Identification and characterization of nodule –specific Cysteine Rich (NCR) Peptide in Chickpea	DBT	Dr. M. Senthilkumar	Dr. PS Shanmugavadivel, Mr. Arvind Kumar	2018-2021 Extend up to 13.03.2022 within budget	56.30

Social Science (2)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
22	Integrated approaches for food, nutrition and livelihood security for rural household in Fatehpur district of Uttar Pradesh (**Farmers FIRST**)	ICAR	Dr. Uma Sah (from 01.10.2021) Dr. Rajesh Kumar (till 30.09.2021)	1. Dr. C. P. Nath (from May 18) 2. Dr. Subhash Chandra (CSAUAT) 3. Dr. M. P. S. Yadav (CSAUAT) 4. Mr. ShripadBhat (upto Jul. 2020) 5. Dr. K. Ravi Kumar (July 2018 to Nov. 2020)) 6. Dr. Purshottam (upto June 2018) 7. Dr. Ummed Singh (up to April 18) **Additional Team of Scientists since 29.10.2021** 8. Dr. R.K. Mishra, Pr. Scientist (PP.), CO-PI 9. Dr. A.K.Parihar, Sr. Scientist (PB), CO-PI 10. Dr. Sujayanand, G.K., Scientist (Agril. Entomology), CO-PI 11. Dr. Rekha Rani, Scientist (Agril. Economics)	2016-23	256.67
23	Value chain analysis of pulse crops in Bundelkhand region of Uttar Pradesh State	ICSSR	Dr. Uma Sah	Dr. Shripad Bhat (upto Jul. 2020)	2019 To Oct. 2021	10.50

Institute Mega- Projects (8)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
24	Implementation of PVP legislation, DUS test.	Chickpea	Dr. G.P. Dixit	Dr. A. K. Srivastava	2007 to Continued Project)	PPV & FRA Budgets
25	Implementation of PVP legislation, DUS test.	Pigeonpea	Dr. I.P. Singh	Dr. Satheesh Naik	2007 to Continued Project)	PPV & FRA Budgets
26	Implementation of PVP legislation, DUS test.	MULLaRP	Dr. Shiv Sewak	Dr. A.K. Parihar	2007 to Continued Project)	PPV & FRA Budgets
27	Creation of Seed hubs for increasing indigenous production of pulses in India	ICAR & DAC (NFSM)	**National Coordinator :** Dr. N.P. Singh (till 31.10.2021) **Nodal Officer:** Dr. P.K. Katiyar	**Kanpur:** Dr. A. K. Singh **Bhopal:** Dr. Archana Singh **Bhubneswer:** Dr. Raghwendra Singh	2016-2020 (Continued Project from revolving fund)	22531.08 Lakh
28	Enhancing Breeder Seed Production for Increasing Indigenous Production of Pulses in India.	ICAR & DAC (NFSM)	**National Coordinator :** Dr. N.P. Singh (till 31.10.2021) **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
29	Genetic enhancement of minor 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 pulses**	DBT (Min of Science & Technology)	PI : Dr. Aditya Pratap (From 01.11.2021) Dr. N.P. Singh (till 31.10.2021)	Dr. Aditya Pratap Dr. Mohd. Akram, Dr. Meena lRathore 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	2018-2022	441 Lakh
30	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 & Technology)	Dr. N.P. Singh (till 31.10.2021)	Dr. Archana Singh Dr. G. P. Dixit Dr. Surendra K. Ghritlahre	2020-2025	718.725 Lakh

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
31	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)	Dr. Aditya Pratap Dr. Uma Sah	Dr. Aditya Pratap Dr. P. K. Katiyar Dr. R. K. Mishra Dr. Prasoon Verma Dr. Senthilkumar M	2016- Plan Scheme 2019- Plan Scheme	Plan Scheme of ICAR

Young Scientist Project (1)

32	Agrobacterium tumefaciens-mediated gene editing 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 31.12.2021

Dr. Shiv Sewak Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
Director Agriculture, U.P.	Member
Director Agriculture, M.P.	Member
Director Research, Rani Laxmi Bai Central Agriculture University, Jhansi, U.P.	Member
Sh. Rakesh Shukla Noida, U.P.	Member
Sh. Gulbeer Singh Aligarh, U.P.	Member
Dr. C. S. Praharaj Principal Scientist, ICAR-DGR, Junagadh	Member
Dr. C. Bharadwaj Principal Scientist (Genetics) ICAR-IARI, New Delhi	Member
Dr. Ramavtar Sharma Principal Scientist ICAR-CAZRI, Jodhpur	Member
Dr. V. K. Yadav Principal Scientist ICAR-IGFRI, Jhansi	Member
ADG (O&P), ICAR Krishi Bhawan, New Delhi	Member
Finance & Accounts Officer ICAR-Indian Institute of Farming Systems Research, Modipuram	Member
Senior Administrative Officer ICAR-IIPR, Kanpur	Member Secretary

Research Advisory Committee

As on 31.12.2021

Dr. P.M. Salimath Ex. Vice-Chancellor University of Agriculture Science, Raichur (Karnataka)	Chairman
Dr. B.B. Singh Ex-ADG(OP), ICAR	Member
Dr. P. Ananda Kumar, Ex-PD, NRCPB, New Delhi	Member
Dr. (Mrs.) OM Gupta Extension, JNKVV, Jabalpur	Member
Dr. Masood Ali Ex-Director IIPR-Kanpur	Member
Dr. R.P.S. Rattan Ex-Director Extension, BAU, Ranchi	Member
Director IIPR, Kanpur	Member
Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
Sh. Ravi Dixit R/o Pipri Road, Chaubepur, Kanpur Nagar (UP)	Member
Smt. Geeta Shakya R/o Jawahar Nagar, Achhalda Road, Sukhchainpur Lane, Bidhuna, Auraiya (UP)	Member
Dr. Mohd. Akram PS (One senior level Scientist as nominated by the Director of the Institute)	Member Secretary

Institute Research Council

As on 31.3.2021

Dr. Shiv Sewak 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 31.12.2021

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
5.	Purchase Advisory Committee (PC)	**Chairman**	:	Dr. Naimuddin, Principal Scientist
		Members	:	Dr. T.N. Tiwari, Dr. (Er.) Prasoon Verma, Dr. A.K. Singh, Dr. D.P. Patel Dr. Narendra Kumar, Dr. Senthil Kumar, Dr. Devraj Mishra Dr. Alok Das, Sr. AO. and F&AO
		Member Secretary	:	AAO (S)
6.	Results Framework Document Committee	**Chairman**	:	Director
		Members	:	Dr. Farindra Singh, Dr. C.S. Prahraj, Dr. Meenal Rathore, Bansa Singh, Dr. P.S. Basu, Dr, Rajesh Kumar, Sr. AO and F&AO
		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
	Members	:	Dr. Mohd. Akram, Dr. (Mrs.) Minal Rathore, Dr. Neetu Singh, Kushwaha, Dr. Jonaki Sen, IIT, Kanpur, Dr. Sanjeeb Kumar, IISR, Lucknow Dr. P.K. Singh, Govt. Medical College, Ambedker Nagar
	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

Celebration of 3rd World Pulses Day

The 3rd World Pulses Day (WPD) was celebrated on February 10, 2021 at IIPR, Kanpur through video conferencing following Covid-19 pandemic protocol as per MHA guidelines. The celebration of WPD, led by the Food and Agriculture Organization of the United Nations (FAO), aimed at increasing public awareness of the nutritional and environmental benefits of pulses as a part of sustainable food production.

The Hon'ble Union Minister of Agriculture and Farmers' Welfare, Rural Development and Panchayati Raj, Govt. of India, Sh. Narendra Singh Tomar was the Chief Guest and Sh. Kailash Choudhary, Hon'ble Minister of State for Agriculture and Farmers' Welfare was the Guest of Honour on this occasion. Several eminent scientists, research scholars and farmers participated in this function.







The Chief Guest congratulated pulse scientists for achieving an all time high (> 25 million tonnes) production of pulses. He showed keen interest in the activities going on in the production and productivity of pulses and widely applauded the efforts of Director, IIPR and pulses scientists. He urged the to work for all round benefits of farmers since the Government is making maximum possible expenditure for their all round upliftment. He urged that farmers ought to be partners in various research based programmes and research outcomes, if adopted on their fields', will surely deliver better results. He also emphasized on the all round efforts made by the government for enhancing profits and income of farmers. He extended his best wishes for the grand success of Conference on Pulses being held at IIPR, Kanpur. The Guest of Honour, Sh. Kailash Chaudhary also highlighted the importance of pulses in human nutrition. He expressed happiness on the research advancements in achieving self sufficiency in pulses in the country.

The Secretory DARE and DG ICAR, Dr. T. Mohapatra and DDG(CS), ICAR , Dr. T.R. Sharma were among those gracing the occasion.

The Laboratory-cum-Office Buildings of Regional Centres of the Institute at Bhopal (M.P.) and Bikaner (Rajasthan) were virtually inaugurated by Sh. Narendra Singh Tomar ji, and foundation stone was laid down for the Regional Station, Khordha, Bhubaneswar (Odisha). IIPR and ISPRD commemorated the occasion by jointly organising a National Symposium Pulse WebCon 2021 on "Sustaining Pulse Production for Self-sufficiency and Nutritional Security" during February 9-11, 2021 to discuss the research advancements for achieving self sufficiency in pulses in the country. On this occasion, Farmers' Training and Visit programmes were also organised at Regional Centres/Stations of IIPR, Kanpur and institute publications were also released by the Chief Guest.

Dr N.P. Singh, while thanking audience emphasized upon sustenance of pulses focused on future plannings of the research programmes. He briefly discussed the IIPR research activities and advancements in achieving self sufficiency and nutritional security in pulses in the country. He assured that all research in pulses will be deployed efficiently to reach the goals set for 2030.

Scientist-Farmer interaction meeting

A scientist-farmer interaction meeting was organized at IIPR, RC, Bikaner on 9th February, 2021. Dr. P.L. Saroj, Director, ICAR-CIAH, Bikaner was the Chief Guest and Dr. A. Sahoo, Director, ICAR-NRCC, Bikaner was the Guest of Honour, while scientists from IIPR and ICAR Institutes located at Bikaner were present. About 50 farmers from nearby villages of Bikaner district

attended the celebration. The function started with welcome address by Dr. Narendra Kumar, Nodal Officer, IIPR, RC, Bikaner. Sri Narendra Singh Tomar, Hon'ble Union Minister of Agriculture inaugurated the Office-cum-Lab Building through virtual mode. Seeds of improved varieties of moth bean (RMO-2251) and guar (RGC-1033) was distributed under SC sub-plan to 15 farmers. Farmers also visited Technology Park and Research Farm at the Centre which was coordinated by Dr. Surendra Kumar Meena and Dr. (Mrs.) Monika Punia. The function ended with vote of thanks by Dr. Ram Lal Jat while Dr. Banwari Lal coordinated the programme at the centre.

National meats Conference : Pulse WebCon-2021

The Indian Society of Pulses Research and Development and ICAR-Indian Institute of Pulses Research, Kanpur in association with the Indian Council of Agricultural Research, organized a three days' National Web Conference (Pulse WebCon 2021) on "Sustaining Pulse Production for Self Sufficiency and Nutritional Security" during February 9-11, 2021. The web conference was organized in virtual mode and was attended by an impressive presence of > 860 registered participants.

The conference was inaugurated by Sh. Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers' Welfare, Government of India in the august presence of Sh. Kailash Choudhary, Hon'ble Minister of State for Agriculture & Farmers and Welfare; Dr. T. Mohapatra, Secretary, DARE and DG, ICAR; Dr. T.R. Sharma, Deputy Director General, Crop Sciences, ICAR; Dr. N.P. Singh, Director, ICAR-IIPR, Dr. Sanjeev Gupta, ADG (O&P), ICAR and many other dignitaries from ICAR Headquarters, New Delhi; ICARDA, ICRISAT and World Vegetable Centre. In his inaugural address, Hon'ble Union Minister lauded the sincere efforts of pulses research community in the country towards an unprecedented growth of indigenous pulses and leading the country to march towards near self-sufficiency within a short span of 7-8 years. Sh. Kailash Choudhary expressed his happiness over the recent developments in indigenous pulse production and hoped that India will soon achieve complete self-sufficiency. Earlier, Dr. T. Mohapatra, Secretary, DARE and DG, ICAR welcomed the guests and apprised the audience with the latest developments in pulses.

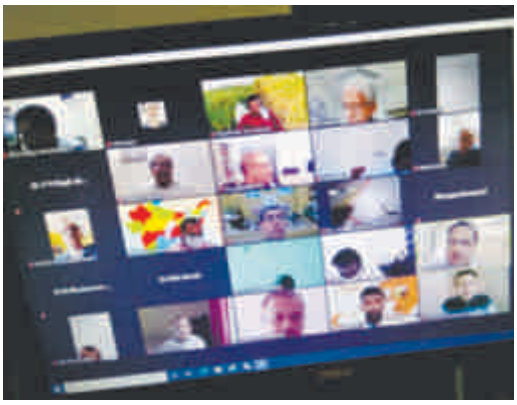


The web conference witnessed presence of global pulse researchers as well as research managers who delivered their invited talks in six technical sessions including crop scenario and policy perspectives, accelerating genetic gains through breeding and genomics; crop intensification, diversification and resource conservation; biotic stress and its management; abiotic stress and its management; and post-harvest technology and secondary agriculture. Each session comprised one lead and two invited lectures followed by a panel discussion by 5-6 eminent scientists in each session. Virtual poster session was also organized on each theme of the conference. More than 430 research abstracts were published and 274 presented as posters across the six themes. Best poster awards were given under each theme. Dr. Jacqueline Huges, DG, ICRISAT and Dr. Aly Abousabaa, DG, ICARDA also addressed the web conference. Other eminent participants included Dr. A.K. Singh; Dr. S.K. Sharma, Dr. Masood Ali, Dr. N.K. Singh, Dr. Michael Baum; Dr. Shiv Kumar; Dr. Rajeev Varshney, Dr. Pooran Gaur, Dr. Kadambot Siddique, Dr. P.K. Joshi, Dr. H.C. Sharma, Dr. Harsh Nayyar and several others. Dr. N.P. Singh, Director, ICAR-IIPR, Kanpur was the Organizing Chairman while Dr. I.P. Singh, President, ISPRD was the Organizing Vice-President of the web conference. Dr. Aditya Pratap and Dr. Meenal Rathore were involved as the Organizing Secretaries and Dr Devraj Mishra was Technical Coordinator for the pulse web conference.

26th Annual group meet of *Kharif* pulses

The annual group meet of *Kharif* pulses Pigeonpea, MuLLaRP and Arid legumes, was organized on May 27-28th, 2021 at ICAR-IIPR, Kanpur through video conferencing. Chairman of the inaugural session, Dr. T. R. Sharma, DDG (Crop Sciences), appreciated the scientists working under AICRP for bringing pulses production in India towards self-sufficiency. He praised the efforts being made towards digital communication to deliver outcomes amid the Covid 19 pandemic. He reviewed the annual progress

made in AICRPs and stressed upon accelerating development of varieties with climate resilience traits such as salinity tolerance, and better agronomic practices to achieve the genetic potential of new pulse varieties. He emphasized that new avenues should be explored to improve quality traits of pulse crops such as protein content and a benchmark to be set for major quality traits in pulses. Screening of disease and pest resistance of the entries evaluated in AICRP was also highlighted.



The Co-chairman Dr. Sanjeev Gupta, ADG (Oilseeds and Pulses), ICAR suggested aligning research in AICRPs with the stakeholders' needs. He remarked upon the need of exploring novel traits suitable for mechanical harvesting and intensifying research on intercropping systems based on pulse crops. He emphasised that criteria for promotion of pigeonpea hybrids in AICRP trials needs to be revisited, and breeding materials particularly pertaining to pre-breeding should be shared on regular basis genotyping and phenotyping of the mapping populations should be done. Efforts should be undertaken towards maximization of acceptance of trial data. Dr Gupta also emphasized on need of label claim expansion for the registered insecticides. Dr. N.P. Singh, Director, ICAR-IIPR, Kanpur apprised about how the availability of modern technologies in pulses research and development delivered by pulses AICRPs led to self-sufficiency in pulses production.

Experts on pulses including Dr. Masood Ali, Dr. S.K. Sharma, Dr. P.M. Shalimath, Dr. B.B. Singh and Dr. (Mrs.) Om Gupta also provided valuable suggestions for further improvement in pulses research.

Dr. I.P. Singh, Project Coordinator, ICAR-AICRP on Pigeonpea and Dr. Shiv Sewak, Project Coordinator, ICAR-AICRP on MuLLaRP and Nodal officer AINP on Arid Legumes briefed about the progress made during 2020-21 under the respective AICRPs and also finalized the technical programmes for coming *Kharif* season. They also presented the progress of promising entries for identification as varieties to the Varietal Identification Committee (VIC). Down the line, three pigeonpea varieties (Pusa Arhar 2018-4, IPA 15-06 and TDRG 59) were identified by the VIC. The annual group meet was attended by scientists from AICRPs centres across the country.

Celebration of Foundation Day at ICAR-IIPR

ICAR-Indian Institute of Pulses Research, Kanpur celebrated its Foundation Day online on 05th September, 2021. Dr. Trilochan Mahapatra, Secretary, DARE & 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 (CS), ICAR, New Delhi. Other esteemed participants were Dr. R.C. Agarwal, DDG (Education), ADG (O&P), ICAR, New Delhi, DDGs & ADGs of ICAR, Hon'ble Vice Chancellors of State Agril. Universities, Dr. N.P. Singh, Director ICAR-IIPR, Kanpur, scientists of ICAR and IIPR, Kanpur and its regional stations, Directors and dignitaries of ICAR Institutes, farmers, and Press and Media.

The Chief Guest praised the achievements of the Institute under the able guidance of Dr. N.P. Singh, Director, IIPR. He congratulated the pulse scientists for achieving the record production of 24 million tonnes of pulses. He stressed on the fact that we have achieved three major goals in this endeavour viz., short duration varieties, hybrid pigeonpea, and biofortified (high Zn, Fe and protein) varieties of pulses. However, in order to achieve our target of 32 MT by 2030, we have a challenge of increasing the production @1-1.5 MT/year. Expressing satisfaction over release of 18 pulses varieties during 2020-21, he stressed upon extending the benefits to the farmers.

The Foundation Day Lecture was delivered by Professor (Dr.) Kadambot H.M. Siddique, Hackett Professor of Agriculture Chair and Director, University of Western Australia, who highlighted strategies for enhancing phosphorus use efficiency (PUE) in pulses especially in chickpea as its availability is becoming limited. He emphasized on development of chickpea core collection which can provide useful genetic resource for improving PUE. He reiterated that novel genes and genetic loci associated with root traits, P acquisition efficiency and PUE could be used in breeding programmes.

Dr. T.R. Sharma, Deputy Director General (CS), ICAR widely applauded the remarkable works and efforts made by the present Director, Dr. N.P. Singh in all round development of the Institute. He justified that the fruits of R & D has also penetrated to the growers in form of seeds of <10 years old varieties in seed chain and

production of >18,000 q breeder seed in the country and >1.8 lakh quintals of quality seeds in pulses per year. Earlier, in the welcome address, Director of the Institute, Dr. N.P. Singh highlighted the achievements of the Institute and stressed on the fact that this could be possible due to our collective endeavours leading in >70-80% variety replacement rate (VRR) and >30% seed replacement rate (SRR) along with >32,000 cluster demonstrations on pulses organized by >500 *Krishi Vigyan Kendras* (KVKs) every year.

A virtual inauguration of Technology Information and Dissemination Centre (TIDC) Building was also held. Besides, three publications and one e-







knowledge platform on pulses were also released. On this occasion, farmers' training and visit programmes were also organized at five centres of the institute.

While delivering his remarks, Dr. N.P. Singh, Director, IIPR discussed the research activities and advancements in achieving the self - sufficiency and nutritional security of pulses in the country. He briefed on the research activities going on in the Institute and stressed upon the importance of pulses as a building block for sustaining both crop and human/ animal life on a long-term basis. He emphasized 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 .

Ten progressive farmers belonging to different states were also felicitated on the occasion. During the function, Dr. Aditya Pratap, Principal Scientist was awarded with the Best Scientist Award 2021 in senior category and Dr. Satheesh Naik SJ, Scientist in the young scientist category. Mr. H.N. Maurya was awarded as the Best Technical Officer. Mr. Mayank Mishra was awarded as the Best Worker in administrative category and Mr. Ramesh Chandra was awarded as the Best Worker in supporting staff and Best Team Award was given to pigeonpea team incharge Dr. Abhishek Bohra, Dr. Raj Kumar Mishra, Dr. Satheesh Naik S.J., Dr. Farindra Singh, Dr. Dibendu Datta and Dr. I.P. Singh.

Dr. G.P. Dixit, Project Coordinator (Chickpea) offered vote of thanks. The programme was conducted by Dr. Aditya Pratap & Dr. (Mrs.) Meenal Rathore while the overall coordination was done by Dr. (Mrs.) Uma Sah, Principal Scientist, IIPR, Kanpur.

Brainstorming meeting organized on 'Pulses in North Hill Zone'

One day brainstorming meeting on "Intensification and Sustenance of Pulses in North Hill Zone of India" was organized on 24th September 2021 at CSK Himachal Pradesh Krishi Vishvavidyalaya (CSKHPKV), Palampur. The meeting was organized jointly by ICAR-Indian Institute of Pulses Research, Kanpur and CSKHPKV. It was chaired by Dr. T.R. Sharma, DDG (Crop Science), Co-Chaired by Prof. H.K. Chaudhary, Hon'ble Vice Chancellor, CSKHPKV and attended by eminent pulse researchers including Dr. S.K. Sharma, Chairman QRT, pulses and former VC, CSKHPKV; Dr. Sanjeev Gupta, ADG (Oilseeds and Pulses), ICAR; Dr. N.P. Singh, Director, ICAR-IIPR; Dr. Shiv Sewak, Project Coordinator MULLaRP and Arid Legumes, Deans and Directors of CSKHPKV besides a galaxy of eminent researchers working in pulses research and development across the North Hill Zone. At the outset, Dr. N.P. Singh presented a brief scenario of pulses in the NHZ and highlighted the major constraints towards their growth and development. This was followed by a presentation of Dr. Shiv Sewak who elaborated the role and activities of AICRP on Pulses in the zone.

Dr. T.R. Sharma, Chairman, advised that varieties developed at IIPR should be shared with CSKHPKV as well as other Universities/Institutes in NHZ for their evaluation and suitable varieties, thus, identified should be recommended for cultivation. He emphasized upon developing a visual action plan by including the activity, milestones, output and products and their impact on doubling the farmer's income. He stressed upon identification of trait-specific germplasm and need to get it registered with NBPGR. He was optimistic about the scope of pulses

expansion in the hills and desired that 'specialty' and 'organic pulses' should be the catch words to effectively market and promote pulses grown in the hills. He opined that there is a strong need of inter-institution collaboration with a handholding from ICAR-IIPR and therefore, research networks should be formed. Prof. H.K. Chaudhary expressed that farmers need quality seed, feed, farm mechanization, assured marketing and storage. Since rajmash, urdbean and horsegram are important crops in Himachal Pradesh, there is a strong need for inter-institutional and multi-disciplinary research. Distant hybridization is necessary for disruptive breeding. He further emphasized that all Institutes should have genetic resource networks and must share their germplasm.



Earlier, Dr. Sanjeev Gupta urged to prepare a roadmap to make the hilly regions self sufficient in pulses by assuring timely availability of quality seed of good varieties having resistance to major diseases, promoting quality seed production and distribution through seed hubs located in NHZ, ensuring safe storage of seeds, developing acidic soil tolerant varieties, cold and frost tolerant varieties, mechanization of post-harvest processes and value addition of pulses. Dr. S.K. Sharma desired that the scientists need to prioritize the pulse crops depending on their production base. He emphasized that there should be separate breeding programmes for hills *versus* other regions and specific centres should be designated for making crosses in particular crops to utilize limited resources. Later brief presentations were made by representatives from different centres across NHZ followed by a detailed panel discussion. The major recommenda-tions included identification of specific lead centres in each state to focus on one or two crops, research prioritization with each centre, generating a large number of crosses deploying trait-specific donors, distant hybridization in all pulse crops and identification of niche specific specialty pulses. Dr. Aditya Pratap, Principal Scientist, IIPR and Dr. R.K. Mittal, CSKHPKV coordinated the programme as Organizing Secretaries.

हिंदी दिवस का आयोजन

भाकृअनुप–भारतीय दलहन अनुसंधान संस्थान में दिनांक 30 सितम्बर, 2021 को हिन्दी दिवस विडियो कांफ्रेंसिंग के माध्यम से मनाया गया। लोकप्रिय कवि एवम लेखक डॉ सुरेश अवस्थी इस समारोह के मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक डॉ नरेन्द्र प्रताप सिंह ने की। विडियो कांफ्रेंसिंग के माध्यम से संस्थान के सभी वैज्ञानिक, तकनीकी, प्रशासनिक एवं सहायक वर्ग के कर्मचारियों ने भाग लिया।

अपने उद्‌बोधन में मुख्य अतिथि डॉ सुरेश अवस्थी ने कहा कि आज विकास की गति में हमारी राजभाषा हिन्दी एक मजबूत सूत्रधार का कार्य कर रही है अतएवं एकता की इस कड़ी को और अधिक मजबूत करना प्रत्येक भारतीय का कर्तव्य है। देवनागरी लिपि में लिखी गई हिन्दी, हमारी राजभाषा है और हम उसका प्रचार–प्रसार देश के प्रशासनिक कार्यों में ही नहीं, अपितु ज्ञान–विज्ञान एवं तकनीकी के सभी क्षेत्रों में कराने हेतु संकल्प बद्ध रूप से प्रयासरत हैं। यदि हमें भारत वर्ष को उन्नत राष्ट्रों की श्रेणी में लाना है तो इसकी एक राष्ट्र व्यापी भाषा का होना उतना ही आवश्यक है जितना की नवीन प्रौद्योगिकियों का।



अध्यक्षीय उद्‌बोधन में संस्थान के निदेशक डॉ नरेन्द्र प्रताप सिंह ने कहा कि हिन्दी को हमारे संविधान में राजभाषा के रूप में घोषित किया गया है। राजभाषा अर्थात सम्पूर्ण राष्ट्र की भाषा। हिन्दी एक समृद्ध भाषा है और इसकी सम्प्रेष्णीयता भी उच्च कोटि की है। 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। संस्थान में राजभाषा हिन्दी के प्रचार–प्रसार एवं प्रयोग को आगे बढ़ाने के लिए बहुआयमी प्रयास किए गए हैं। इसी क्रम में हिन्दी में, मौलिक वैज्ञानिक लेखन, कार्यालीन पत्राचार और सृजनात्मक अभिव्यक्ति को बढ़ावा दिया गया है। संस्थान में राजभाषा हिंदी का भरपूर प्रचार–प्रसार 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 जी पी दीक्षित, परियोजना समन्वयक, चना ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन डॉ राजेश कुमार श्रीवास्तव, सचिव, राजभाषा ने किया।

As on 31.12.2021

Personnel

A. Research Management

1. **Dr. Shiv Sewak**	**Director (From 01.11.2021)**
Dr. N.P. Singh	Director (Upto 31.10.2021)

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	PS & 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	Sr. Scientist (Sr. Scale)
15. Dr. Debjyoti Sen Gupta	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
16. Dr. Abhishek Bohra	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
17. Dr. Ashok Kumar Parihar	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
18. Dr. Biswajit Mondal	Genetics & Plant Breeding	Scientist (Sr. 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	PS & Head (In-charge)
23. Dr. Khela Ram Soren	Biotechnology	Senior Scientist
24. Dr. Alok Das	Biotechnology	Senior Scientist
25. Dr. P.S. Shanmugavadivel	Biotechnology	Scientist (Sr. Scale)
26. Mr. Arvind Kumar Konda	Biotechnology	Scientist
27. Dr. Neetu Singh Kushwah	Biotechnology	Scientist (Sr. Scale)

28. Mr. Sudhir Kumar	Biotechnology	Scientist
29. Mr. Kuldeep Kumar	Biotechnology	Scientist
Crop Production		
30. Dr. Narendra Kumar	Agronomy	PS & Head (In-charge) (From 01.10.2021)
31. Dr. C.S. Praharaj	Agronomy	PS & Head (In-charge) (Upto 30-09-2021)
32. Dr. Raghavendra Singh	Agronomy	Principal Scientist
33. Dr. Prasoon Verma	ASPE	Senior Scientist
34. Dr. Kali Krishna Hazra	Agronomy	Scientist
35. Dr. Chaitanya Prasad Nath	Agronomy	Scientist
36. Mr. Man Mohan Deo	FMP	Scientist
37. Mr. Asik Dutta	Soil Science	Scientist
38. Ms. Kancheti Mrunalini	Agronomy	Scientist
Crop Protection		
39. Dr. Bansa Singh	Nematology	PS & Head (In-charge)
40. Dr. Mohd. Akram	Plant Pathology	Principal Scientist
41. Dr. Naimuddin	Plant Pathology	Principal Scientist
42. Dr. R.K. Mishra	Plant Pathology	Principal Scientist
43. Dr. R. Jagdeeswaran	Nematology	Scientist
44. Dr. Sujyanand G.K.	Entomology	Sr. Scientist
45. Dr. Bandi Sanjay Maruti	Entomology	Scientist
46. Mr. Devindrappa	Nematology	Scientist (Study Leave)
47. Dr. Manjunatha L.	Plant Pathology	Scientist
48. Mr. Ravanasidda	Entomology	Scientist
49. Dr. Rishikesh Kumar	Plant Pathology	Scientist
50. Dr. Anup Chandra	Entomology	Sr. Scientist
Basic Science		
51. Dr. D.P. Patel	Plant Physiology	PS & Head (In-charge)
52. Dr. M. Senthilkumar	Microbiology	Principal Scientist
53. Dr T.N.Tiwari	Plant Physiology	Principal Scientist
54. Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
55. Dr. Kalpana Tiwari	Biochemistry	Scientist
56. Dr. Vaibhav Kumar	Biochemistry	Scientist
57. Mr. Krishnashis Das	Microbiology	Scientist
58. Ms. Namrata Lashkav	Agril. Chemicals	Scientist
Social Science		
59. Dr. (Mrs.) Uma Sah	Agril. Extension	PS & Head (In-charge)
60. Dr. Rajesh Kumar	Agril. Extension	Principal Scientist
61. Dr. Dev Raj Mishra	Computer Application	Principal Scientist
62. Dr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)
63. Dr. (Mrs.) Rekha Rani	Agril. Economics	Scientist

G. Regional Station-cum-Off-Season Nursery, Dharwad (Karnataka)		
64. Dr. M.H. Kodandaram	Entomology	Principal Scientist & Station In-charge
65. Dr. M.S. Venkatesh	Soil Science	Principal Scientist
66. Dr. Revanappa	Plant Breeding	Sr. Scientist
67. Dr. P.R. Saabale	Plant Pathology	Sr. Scientist
68. Dr. Manu B.	Genetics & Plant Breeding	Scientist
H. Regional Centre, Bhopal (Madhya Pradesh)		
69. Dr. (Mrs.) Archana Singh	Eco. Botany & P.G.R.	Principal Scientist & Station In-charge
70. Dr. Surendra Kumar Ghritlahre	Genetics & Plant Breeding	Scientist
71. Mr. Alok Kumar	Seed Science & Technology	Scientist (Study Leave)
72. Dr. Sandeep Kumar	Agronomy	Scientist
73. Sh. Chandra Mouli Sharma		AAO (on deputation)
I. Regional Centre, Bikaner (Rajasthan)		
74. Dr. Banwari Lal	Agronomy	Sr. Scientist & I/C Farm
75. Dr. Ram Lal Jat	Agronomy	Scientist
76. Dr. Surendra Kumar Meena	Plant Physiology	Scientist
77. Dr. Lalit Kumar Rolaniya	Agronomy	Scientist
78. Dr. (Mrs.) Monika Punia	Genetics & Plant Breeding	Scientist
79. Sh. M. V. Vanvi		AAO (on deputation)
J. Regional Station, Khordha (Odisha)		
80. Sh. Sunil Kumar Sunani	Plant Pathology	Scientist

K. Technical	
81. Dr. M.P. Singh	Chief Technical Officer (T-9)
82. Mr. R.S. Mathur	Chief Technical Officer (T-9)
83. Dr. G.K. Srivastava	Chief Technical Officer (T-9)
84. Dr. Omkar Nath	Chief Technical Officer (T-9)
85. Mr. S.K. Garg	Chief Technical Officer (T-9)
86. Mr. Radha Krishan	Chief Technical Officer
87. Mr. A.P. Singh	Assistant Chief Technical Officer (T-7-8)
88. Mrs. Rashmi Yadav	Assistant Chief Technical Officer (T-7-8)
89. Dr. Rajesh Kumar Srivastava	Assistant Chief Technical Officer (T-7-8)
90. Mr. Krishna Autar	Senior Technical Officer (T-6)
91. Mr. Lakhan	Senior Technical Officer (T-6)
92. Mr. R.K.S. Yadav	Technical Officer (T-6)
93. Mr. R.K. Singh	Senior Technical Officer (T-6)
94. Mr. Rakesh	Senior Technical Officer (T-6)
95. Dr. Kanhaiya Lal	Technical Officer (T-5)
96. Mr. Malkhan Singh	Senior Technical Officer (T-6)
97. Mr. Ashraf Khan	Technical Officer (T-5)
98. Mr. Arvind Singh Yadav	Technical Officer (T-5)
99. Mr. R.M. Pal	Technical Officer (T-5)

100. Mr. H.N. Maurya	Technical Officer (T-5)
101. Mr. K.S. Meena	Technical Officer (Driver) (T-5)
102. Mr. Arvind Kumar	Technical Officer (T-5)
103. Mr. Hasmat Ali	Technical Officer (T-5)
104. Mr. S.N. Hatiya	Technical Officer (Driver) (T-5)
105. Mr. Satish Kumar Singh	Technical Officer (Driver) (T-5)

L. Administrative	
106. Mr. Kumar Vivek	Senior Administrative Officer
107. Mr. Kunal Kalra	Senior Finance & Accounts Officer (18-10-2021)
108. Mr. D.K. Agnihotri	Finance & Accounts Officer (15-10-2021)
109. Mr. Sukhdeo Mahto	Assistant Administrative Officer
110. Mr. Rajendra Kumar Nigam	Assistant Administrative Officer
111. Mr. Brij Kishore	P.S. to Director

Appointment, Transfer, Promotion, *etc.*

Appointments

Name	Post	Discipline/Division	Date of joining
Ms. Namrata Laskar	Scientist	Agricultural Chemicals	11/01/2021

Promotions

(*All results declared in 2021*)

Name	Promoted to	W.e.f.
Dr. Prasoon Verma, Scientist (APSE)	Senior Scientist	07/12/2018
Dr. Hemant Kumar, Scientist (Agril. Statistics)	Senior Scientist	10/01/2015
Sh. R.K. Singh, Tech. Officer (T-5)	Sr. Tech. Officer (T-6)	01.01.2019
Sh. Malkhan Singh, Tech. Officer (T-5)	Sr. Tech. Officer (T-6)	01.01.2019
Smt. Rashmi Yadav, Tech. Officer (T-5)	Sr. Tech. Officer (T-6)	07.01.2013
Sh. Radha Krishna, ACTO (T 7-8)	Chief Tech. Officer (T 9)	01.01.2018
Smt. Rashmi Yadav, STO (T 6)	Asst. Chief Tech. Officer (T 7-8)	07.01.2018
Dr. Rajesh Kumar Srivastava, STO (T 6)	Asst. Chief Tech. Officer (T 7-8)	29.06.2020
Sh. Hasmat Ali, STA (T-4)	Tech. Officer(T-5)	27.07.2021

Transfers

Name	Designation	From	To	W.e.f.
Sh. Sunil Kumar Sunani	Scientist (Plant Pathology)	ICAR-RC, Kolasib, Mizoram	ICAR-IIPR, Khordha (Odisha)	15/02/2021
Dr. Kiran Gandhi B.	Scientist (Agril. Entomology)	ICAR-IIPR, Kanpur	ICAR-NRRI RS, Naira	30/01/2021
Dr. S.L. Patil	Principal Scientist (Agronomy)	ICAR-IISWC RC, Bellari	ICAR-IIPR RS, Dharwad	31/03/2021
Sh. R.K.P. Sinha	Asstant (Administration)	ICAR-IIPR, Kanpur	ICAR-ATARI, Kanpur	01/04/2021
Dr. C.S. Praharaj	Principal Scientist (Agronomy)	ICAR-IIPR, Kanpur	ICAR-DGR, Junagadh	30.09.2021
Dr. Rajesh Kumar	Principal Scientist (Social Science)	ICAR-IIPR, Kanpur	ICAR-ATARI-VI, Guwahati	30.09.2021
Dr. Sandeep Kumar	Scientist (Agronomy)	ICAR-IIPR Regional Centre Phanda, Bhopal	ICAR-IARI Regional Station, Karnal	11/10/2021
Dr. Rekha Rani	Scientist (Agril. Economics)	ICAR-CIAH, Bikaner	ICAR-IIPR, Kanpur	11/10/2021

Retirements

Name	Post held	Date of retirement
Dr. P.S. Basu	Principal Scientist	30/06/2021
Sh. Ganesh Shankar Sharma	STA (Driver)	30/09/2021
Sh. Ram Swaroop Kushwaha	LDC	30/09/2021
Dr. M.P. Singh	Chief Tech. Officer (T-9)	31/12/2021

Obituaries

- Smt. Chameli, SSS left for Heavenly Abode on 14/04/2021.
- Sh. S.N. Hatia, Tech. Officer (Driver) left for Heavenly Abode on 16/04/2021.
- Sh. Ram Kishan, SSS left for Heavenly Abode on 21/04/2021.
- Sh. Rajendra Kumar Srivastava, Stenographer left for Heavenly Abode on 04/05/2021.

May the departed soul rest in peace.

स्वच्छ भारत

एक कदम स्वच्छता की ओर



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