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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

वार्षिक प्रतिवेदन
Annual Report
2022

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भाकृअनुप-भारतीय दलहन अनुसंधान संस्थान, कानपुर, 208 024

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

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Publication Committee : Dr. Bansa Singh, Chairman
Dr. (Mrs.) Meenal Rathore, Co-Chairperson
Dr. Uday Chandra Jha, Member
Dr. K.K. Hazra, Member
Dr. A.K. Srivastava, Member
Dr. Alok Das, Member
Dr. Mohd. Akram
Dr. Sanjay Bandi, Member
Dr. Rajesh Kumar Srivastava, Member Secretary

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Director's Desk

It gives me immense pleasure to present the Annual Report (2022) of ICAR-Indian Institute of Pulses Research, Kanpur. I feel that it is a privilege to lead a glorious Institute like ICAR-IIPR which has made outstanding contributions in the service of the nation in agriculture sector and has set global standards in making pulses accessible and affordable. It is a pleasure to restate that as per the fourth advance estimates of production of major agricultural crops, total pulse production has reached a record high of 27.69 million tonnes which is higher by 3.87 million tonnes than the last five years' average production of 23.82 million tonnes. This was all possible due to farmer friendly government policies supported by the efforts of farmers and scientists. Indian Institute of Pulses Research, Kanpur has always strived for the development of improved varieties, efficient technologies and package of practices that target enhanced pulse production and productivity. I am happy to present the Annual Report of the Institute that highlights the salient achievements made under different research, extension and training programmes.

This year, seven varieties have been released and notified from IIPR. Under the Crop Improvement Programmes, *kabuli* chickpea variety, IPCK 2013-163 (*Madhav*) was released/notified for cultivation in NWPZ, *desi* chickpea namely, IPC 10-142 (*Kuber*) and *kabuli* chickpea variety IPCK 09-145 (*Kanchan*) were released/notified for cultivation in Uttar Pradesh, IPC 12-108 has also been recommended for cultivation in Uttar Pradesh. Lentil variety IPL 230 derived from IPL 522/DPL 62 cross was released/ notified for cultivation in UP under timely sown conditions. Fieldpea variety IPFD 19-1 (*Shikhar*) and IPFD 19-3 (*Arpan*) have been released for cultivation under NEPZ.

Fieldpea accession EC 0414478 (INGR 21225) with intact funiculus, dwarf and leafy type was registered with ICAR-NBPGR, New Delhi as genetic stock. Also, three fieldpea genotypes *viz*. IPF 2022-19 and IPF 2021-21 for acacia type leaf pattern or tendrilless and IPFD 2018-5 for parsley type leaf pattern were identified by GIC as unique traits and recommended for registration with ICAR-NBPGR, New Delhi. The Committee also recommended 8 new pigeonpea CMS lines namely ICPL 88039A, PAU 881A, ICPL 7148A, ICPL 88034A, AL 201A, Pusa 2002-2A, MN 5A and AL 15A as unique material for registration with ICAR-NBPGR, New Delhi. Digitalization of historical breeding data, development and optimization of breeding pipeline following product profiles designed ecology wise for chickpea and pigeonpea was a major activity of IIPR (under the ICAR-BMGF project).

Attempting holistic understanding of salt tolerant *V. marina,* its genome size documented to be 767.73 Mb. The chromosome spread prepared from root tip of *V. marina* accession revealed 22 chromosomes ($2n=22$). In addition, the putative genes involved in salt tolerance in *V. marina* were identified (NHX gene family 34, HKT gene family 39). Also, in the Division of Plant Biotechnology, genomic resources have been identified/developed- mined Indels from re-sequencing data of 294 mini-core lines of chickpea and developed markers; identified

lncRNAs and micro RNAs in *Fusarium* infected pigeonpea and chickpea; identified 26 microsatellite loci from the 24 RFO metabolism-related genes in pea and identified genes associate to salinity tolerance in chickpea. Genes for dehydration-responsive RD22-like gene (1158bp) from chickpea; the Class V, Herbivory-inducible chickpea chitinase: Car_Chit-15 (with best chitin binding ability) and the Bowman-Birk protease inhibitor from pigeonpea induced in response to *Fusarium udum* infection and a small secreted cysteine rich protein-1 (SSCP-1) from pigeonpea with a putative role in defense have been identified and cloned for further use. Genome editing is underway in chickpea targeting seed size, phytohormones for yield; in pigeonpea for branch number and yield and in grasspea for eliminating/reducing ODAP biosynthesis.

Maximum system productivity under long term fertilizer experiments inclusive of pulses was using RDF and RWMb in lowland rice system and with INM and MWMb in maize system. ZT in pulse inclusive cropping systems under conservation agriculture experiments gave increased productivity and also improved soil physical and biological parameters. Under pigeonpea + sorghum intercropping, across all the cultivars (early medium and late maturing), the highest land equivalent ratio, relative crowding coefficient was registered against *cv.* IPA 203. Among the long-duration genotypes, the highest intercrop pigeonpea yield was registered with the cultivar IPA 15-02 followed by IPA 203, and IPA 206. While soil and foliar zinc responsive genotypes have been identified in chickpea, it was observed that nano zinc oxide spray enhanced yield by 21%, but seed zinc content did not vary significantly. In context of R and D for processing, the IIPR multipurpose grinder has shown 67% higher milling capacity compared to Asian make hammer mill. Calibration of the commercially available seed drill for sowing of mungbean and urdbean has also been done.

Screening of genotypes has led to the identification of donors for tolerance/resistance to *Fusarium* wilt (race 2), *Phytophthora* stem blight and cyst nematode in pigeonpea and tolerance to *Meloidogyne javanica* in pigeonpea, mungbean and fieldpea. Prebreeding lines in lentil have been identified for tolerance to wilt. *Trichoderma* and *Bacillus* based microbial consortia have been developed for stress management in pulse crops. 19 potential isolates of *Trichoderma*, 5 of *Bacillus sp*. and 1 of *Pseudomonas* have been deposited to ICAR-NBAIM, Mau. The talc based formulations DALHANDERMA and DALHANDERMA-1 for disease management and plant growth promotion in chickpea, pigeonpea and lentil and liquid bio-formulation of indigenous *Bacillus thuringiensis* for pod borer management are now being made available for sale. Two *Vigna* germplasms, *Vigna vexillata* (IC 0248326) and *Vigna umbellata* (IC 0251442) have been found highly resistant against *C. maculatus* F. and are registered at ICAR-NBPGR, New Delhi.

Under the aegis of basic studies for abiotic stress, 12 contrasting lentil genotypes have been identified for high temperature tolerance based on Heat Susceptibility Index (HSI) and physiological parameters. Also, pigeonpea genotypes for water logging and urdbean for thermo tolerance have also been identified using different physiological parameters. Higher gibberellic acid (GA_3) and auxin (IAA) content was observed in the flowers of heat-tolerant genotypes of chickpea as compared to heat susceptible genotypes. With *Rajmash* now as a continuous crop for research, biochemical studies on common bean having diverse seed coat colour for their phenolic content, composition, flavonoid content, tannin content, and total antioxidant potential has been initiated. HPLC analysis revealed that gallic acid, catech a hydrate, and ferulic acid are the predominant phenolic compounds present in common bean cultivars. The best *Rajmash* genotype-*Rhizobium* combination for nodulation was identified with the genotype IC 356018 being the highest nodulator.

With emphasis on digitalization for dissemination of knowledge and technologies to the end users, 80 videos modules have been prepared on improved pulse production technologies and success cases of partner farmers and uploaded on youtube channel "ICAR-IIPR Pulse farmer corner". A total of 125 demonstrations on chickpea (71), lentil (16), mothbean(10), clusterbean (20), horsegram (2), cowpea (3) and mungbean (3) were conducted collectively in different villages of Uttar Pradesh, Rajasthan and Madhya Pradesh. Agri-Business Incubation Unit, ICAR-IIPR generated ₹1,76,249/- till December 31, 2022 as total revenue from incubation fee, operational and royalty charges from incubatees. total of 140 Frontline Demonstrations (FLD's) were

conducted during *rabi* 2021-22 that included 66 FLD's on Chickpea (var. GNG 2207), 39 FLD's on Fieldpea (var. IPFD 12-2) and 35 FLD's on Lentil (var. IPL 315) in 07 districts of Uttar Pradesh.

The regional centres and stations of IIPR are strongly associated for advancement of breeding lines, collection and screening germplasm for desirable donors and basic research in the prevalent ecological zone(s). They are equally involved in FLDs, trainings and creating awareness and production of seed. IIPR-Regional Research Station, Bhopal has developed gamma and electron beam irradiated grasspea mutants of M_1 generation and characterized for germination and phenology. A mutant line of grasspea *viz*. GML 2016-6 (0.03%), was validated as low ODAP lines as compared to check variety Mahateora (0.04%) during 2021-22. A unique genotype of grasspea *viz*. IC 296745 was submitted for germplasm registration for larger seed size (15-16.8 gm/100-seed weight) with grey seed coat.

The overall growth and development of the Institute was possible with the able guidance, encouragement and continuous support received from Dr. Himanshu Pathak, Director General, ICAR and Secretary, DARE, Dr. T.R. Sharma, Deputy Director General (Crop Sciences) and Dr Sanjeev Gupta, ADG (O&P), ICAR, which I acknowledge with sincere gratitude and reverence.

I appreciate the efforts of my all Project Coordinators, Drs. G.P. Dixit, I.P. Singh and all Heads of Divisions Drs. Meenal Rathore, P.K. Katiyar, Narendra Kumar, D.P. Patel, Mohd. Akram and Uma Sah for research inputs. I am thankful to all the members of Publication Committee for their praiseworthy efforts in bringing out the Report in time as usual. 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 service of the nation.

(Bansa Singh)
Director

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Executive Summary

Crop Improvement

A. Chickpea

- Two chickpea varieties including *desi* chickpea namely, IPC 10-142 (Kuber) and Kabuli chickpea variety IPCK 09-145 (Kanchan) were released/notified during 2022 for cultivation in Uttar Pradesh. A *desi* chickpea variety namely IPC 10-142 (Kuber) produced yield of 1598 kg/ha and registered 10.5% yield superiority over check KWR 108, matures in 130-140 days with resistance to wilt, moderate resistance to DRR, Ascochyta Blight and BGM. Similarly, *kabuli* variety IPCK 09-145 yielded 1203 kg/ha and registered 15.3% yield superiority over the best check. It matures in 135 days and is moderately resistant to wilt, is creamy white in colour and large seeded (32.2 g/100- seed wt.).
- A *desi* chickpea genotype, IPC 12-108 derived from IPC 94-94/IPC 02-120 cross, has been recommended for identification and release for cultivation in Uttar Pradesh during 2022. It is high yielding genotype producing mean yield of 1630 kg/ha with 6.36% and 21.82% yield superiority over the best check KWR 108 (1533 kg/ha) and KPG 59 (1338 kg/ha), respectively. It matures in 133-136 days, is resistant to wilt and moderately resistant to DRR diseases. It has large seed size (22.4 g of 100-seed weight) with brown seed coat colour
- A *desi* chickpea entry, IPC 15-132 has been promoted to AVT-2 in NEPZ under AICRP. Total six chickpea genotypes including 5 *desi* and a *kabuli* were promoted to AVT-1 for different ecologies in different zones, such as IPC 18-59, IPC 17-351 & IPC 18-39 (Mechanical harvesting) were promoted to NEPZ; IPCB 16-25 (Timely sown) promoted to ECZ; IPC 17-04 (Rainfed) promoted to WCZ and IPCK 16-12 (*Kabuli*) for SZ. These are being evaluated during 2022-23 under AICRP.
- The seeds of ten chickpea entries *viz.*, IPC 18-90 & IPC 18-93 (timely sown), IPC 16-231 & IPC 17-166 (late sown), IPC 17-54 & IPC 17-369 (rainfed), IPC 17-249 & IPC 18-132 (MHT), IPCK 14-125 & IPCK 18-185 (*Kabuli*) were submitted to AICRP for evaluation in IVT trials during 2022-23.
- Total 41 advanced lines of chickpea with 17, 10, 8 and 6 were evaluated in UP, MP, Jharkhand & Chhattisgarh, respectively during 2021-22 for yield performance in the state and their release.
- Total 250 trait specific germplasm lines were evaluated and maintained for hybridization and sharing with NARS partner during 2021-22. A total of 113 wild accessions belonging to 7 *Cicer* species with 42 *C. reticulatum*, 32 *C. judaicum*, 27 *C. pinnatifidum*, 6 *C. echinospermum*, 3 *C. cuneatum*, 2 *C. yamashitae* and 1 *C. bijugum* accessions were maintained in wide hybridization garden. 2354 lines, accessions are being maintained in medium term storage in cold module
- Total 147 crosses including 65, 53, 15 and 10 were developed for yield enhancement and stability, biotic stress resistance, abiotic stress tolerance and pre-breeding/nutritional quality, respectively during 2021-22. Targeted traits were enhance yield, plant type, podding and resistance to biotic/abiotic stresses, pre-breeding/nutritional quality, and adaptability under different niches across the country.
- The F_1 populations derived from 131 crosses were raised and SPS harvested. Single plant selections (SPS), line bulk (LB) and plot bulk (PB) were harvested from F_2, F_3, F_4, F_5, F_6, $F_7$and F_8 derived from 128, 184, 97, 149, 49, 84 and 3, respectively. Total 140 LB and 76 PB were harvested from different generations for sharing with NARS partners.
- Five hundred fifteen ABLs lines including 115 & 400 were evaluated as station trials (ST) and preliminary yield trials (PYTs), respectively under timely sown (TS), late sown (LS), rainfed (RF), pre-breeding (PB), mechanical harvesting (MH) *kabuli*, trait specific. Total 115 entries were evaluated as ST-1 (MHT), ST-2 (PB), ST-3 (TS), ST-4 (RF), ST-5 (LS) and ST-6 (K) at Kanpur, Bhopal, Dharwad. Similarly, 400 lines with 9 PYT were evaluated as PYT-1 (MHT), PYT-2A (PB), PYT-2B (Nutrition), PYT-3 (TS), PYT-4 (RF), PYT-5 (LS), PYT-6 (Wilt disease) and PYT-7 (drought/heat).
- Eleven mapping populations were developed through SSD method for wilt/DRR, drought/heat and nutritional quality including IPC 05-28/BG 212 & JSC 37/BG 212 for Wilt/DRR, [DCP 92-3/ICC 92944 (F_7, 225), JG 315/ICC 92944 (F_7, 232), JG 11/ICC 1205 (F_7, 215), ICC 15614/ICC 4567 (F_5, 270)] for drought/heat and [IPC 04-98/T 39-1 (F_6 305), JAKI 9218/T 39-1 (F_5 200), JG 16/T 39-1 (F_5 188), DCP 92-3/T 39-1 (F_5 189), ICC 4958/T 39-1 (F_5 192) for nutritional quality.
- Sixty chickpea lines with checks were raised on January 05, 2022 for screening to heat (>35°C). Five plants were selected from each lines and screening based on semi-erect plant type, high podding and seed setting in terminal pods

under day temperature >35°C. Total 22 lines including IPC 19-90, IPC 20-94, IPC 16-25, IPC 12-31, IPC 18-59, IPC 16-95, IPC 18-48, IPC 17-129, IPC 20-134, IPC 19-32, IPC 20-143, IPC 19-67, IPC 20-89, IPC 15-48, IPC 17-351, IPC 15-146, IPC 18-111, IPC 18-87, IPC 20-51, IPC 17-256, IPC 20-176, IPC 17-308 were found promising based on (heat tolerant) seed setting and yield.

- Fifty eight chickpea ABLs (F_6) with enhanced seed protein content were evaluated and 11 potential lines were identified with desirable grain quality, protein content ≥26% and yield up to 22 q/ha. Potential entries (GY ≥22 q/ha) identified: DT 19, IPT 4, DT 4, DT 20, ICC 4958, T 4, DT 16, J 16T14, IPT 28, IPT 2 and IPT 14
- Five potential entries were identified against the post-emergence herbicide (Imazethapyr @ 120 g./ha) tolerance based on survival % and lesser yield penalty: IPC 20-73, IPC 20-09, IPC 20-77, IPC 20-40 & IPC 20-158 with respect to checks ICC 12315 and IPC 18-186.

B. Pigeonpea

- Two early pigeonpea genotypes namely IPAE 15-08 and IPAE 15-05 were promoted to AVT-2 under Central Zone (CZ). Similarly, extra early pigeonpea genotype IPAEE 20-5 and two early genotypes namely IPAE 19-4 & IPAE 19-15 were evaluated in AVT-1 under AICRP trial.
- Two long duration pegionpea genotypes namely IPA 19-26 and IPAL 20-24 were evaluated in AVT-2 and AVT-1 trials, respectively during *Kharif* 2022.
- Four entries (IPAEE 19-12, IPAEE 19-21, IPAEE 19-22, IPAEE 20-9) were nominated in extra early group and 3 entries (IPAME 18-06, IPAME 15-06, IPAME 19-15) in mid early duration under AICRP.
- Two long maturing genotypes (IPA 9-1, IPA 13-1) are being evaluated in SAT-2 and five entries (IPA 2014-2, IPA 2014-4a, IPA 7-2, IPA 18-33) are being evaluated in SAT-1 under UPSAT trial. Similarly, 2 entries (IPA 15-21 and IPA 19-26) were also contributed to Jharkhand for adoptive trials.
- A pigeonpea hybrid IPH 21-1 was promoted to AHT-1 under early maturity. Four extra early and early CMS hybrids namely IPH 18-04 (15.6 q/ha), IPH 21-01 (17.5 q/ha), IPH 17-1 (15.9 q/ha) and IPH 18-9 (15.2 q/ha) were evaluated for yield and other traits.
- Institute Germplasm Identification Committee (GIC) of IIPR, Kanpur been recommended 8 new CMS lines namely ICPL 88039A, PAU 881A, ICPL 7148A, ICPL 88034A, AL 201A, Pusa 2002-2A, MN 5A and AL 15A as unique material for their registration with ICAR-NBPGR, New Delhi. The identified new CMS lines will boost the hybrid pigeonpea breeding programme in the country.
- Five early maturing hybrid entries (IPH 21-02, IPH 21-03, IPH 21-04, IPH 21-05, IPH 20-020) were tested with 3 checks (IPH 15-3, IPH 09-5, PAU 881). Entry IPH 21-5 (18.67 q/ha) out yielded all checks. A set of 75 test cross hybrids were evaluated for yield, maturity and yield attributing traits.
- Under long duration, two station trials, station trial-1 (ST-1) and station trial-2 (ST-2) with 25 entries and IPA 15-2, IPA203, MA 6, IPA 206 were conducted during 2021-22. In *ST-1*, Entry IPAL 21-4 (36.3 q/ha) was found top yielder followed by IPAL 21-17 (33.4 q/ha), IPAL 21-1 (32.8 q/ha), IPAL 21-9 (30.8 q/ha), IPAL 21-5 (30.4 q/ha), IPAL 21-11 (29.3 q/ha) and checks MA 6 (29.1 q/ha), IPA 206 (28.9 q/ha), IPA 15-2 (21.0 q/ha) and IPA 203 (23.8 q/ha). In *ST-2*, entry IPAL 21-26 (33.3 q/ha) was outyielded followed by IPAL 21-32 (32.7 q/ha), IPAL 21-27 (31.6 q/ha), IPAL 21-24 (29.9 q/ha), IPAL 21-34 (29.9 q/ha), checks IPA 203 (29.3 q/ha), MA 6 (26.9 q/ha), IPA 206 (24.5 q/ha), IPA 15-2 (22.4 q/ha)
- Under early duration pigeonpea trial, 3 station trials were conducted with 20 entries each in extra early, early and mid-early group. In station trial (extra early), 3 entries IPAEE 21-2 (16.78 q/ha), IPAEE 21-6 (16.75 q/ha) and IPAEE 21-9 (16.27 q/ha) out yielded check Pusa arhar 16 (10.74 q/ha), Pant Arhar 6 (13.68 q/ha). In station trial (early), 5 entries, IPAE 21-5 (19.93 q/ha), IPAE 21-6 (20.01 q/ha), IPAE 21-11 (21.17 q/ha), IPAE 21-13 (22.41 q/ha), IPAL 21-17 (20.17 q/ha) out yielded the checks, UPAS 120 (16.27 q/ha), Pusa arhar 18-2 (16.21 q/ha) and IPA 15-6 (19.87 q/ha).
- In long duration category, 15 crosses were made for wilt, SMD resistant, high yield during 2021-22.
- Under early duration category, a total of 13 F_1 crosses were advanced to F_2 generations and 21 F_2 populations were advanced to next generation. 18 F_3: 298 SPS, 16 F_4: 654 SPS, 20 F_5: 384 SPS, 5 F_6: 241 SPS and 4 F_7: 378 SPS were advanced for generation advancement during 2021-22.
- Under long duration, a total of 8 fresh F_1 generation crosses were developed using diverse donors having wilt, SMD and PSB resistance with climate resilient traits. 14 F_2 generation populations were advanced each population was having around 250-300 plants. SPS from 15 F_3 (403 SPS), in 8 F_4 (315 SPS), in 33 F_5 (676 SPS), in 43 F_6 (1822 SPS) were advanced for generation advancement

- A total of 10 wild species belonging to Gene Pool-II namely 1) *C. acutifolius*, (1 acc.), 2) *C. albicans*, (12), 3) *C. cajanifolius*, (4), 4) *C. lanceolatus*, (1), 5) *C. latisepalus*, (1), 6) *C. lineatus*, (4), 7) *C. sericeus*, (2), 8) *C. trinervius*, (1), 9) *C. scarabaeoides* (75), 10) *C. reticulates* (1) are maintained for use in pre-breeding programme. In addition to this, the gene pool-III and other *genra* wild species are also maintained in pigeonpea wild garden. The F_1 populations derived from 8 crosses developed with wild species were advanced to F_2 generations. 11 F_2 (700 SPS), 6 F_3 (452 SPS), 7 F_4 (315 SPS), 4 F_5 (155 SPS), 4 F_6 (112 SPS), 4 F_7 (85 SPS) were advanced to next generation.
- Under long duration, a set of 384 pure lines selected from different crosses of F_7 generations were subjected for evaluation for yield and yield attributing traits. Total 186 lines have yielded more than 20 q/ha yield. The selected high yielding lines were selected for PYT trials of *Kharif* 2022
- Forty six trait specific donors/parents are being maintained for extra-large seed, extra bold seed water logging tolerant, closed flower, extra early, early, PSB resistance, PSB resistant/ brown seed, PSB resistant/creamy seed, PSB resistant/dark purple seed, wilt resistance, wilt resistant/black seed, dwarf, low chlorophyll and high chlorophyll.
- Total 219 kg nucleus seed of four pigeonpea varieties including IPA 15-6 (94 kg), IPA 203 (60 kg), IPA 206 (40 kg) and IPA 15-2 (25 kg) were produced and handed over to seed unit for breeder seed production. Beside this, total 51 CMS lines including 21 new lines and their contingent B lines and 82 restorer lines are under hybrid maintenance breeding programme. Two hybrids, IPAH 15-3 (A line - 10 kg + B line - 18 kg + R line - 28 kg) and IPAH 09-5 (A line - 0 kg + B line - 0 kg + R line - 21 kg) were conducted. Four hybrid (4,000 seed each) were hand pollination for ensuring genetic purity.
- Digitalization of pigeonpea breeding programme in India was started in 2017 by using Breeding Management System (BMS) software through ICAR-ICRISAT collaborative project. Total 146 lines and diverse parents were uploaded on BMS portal to create studies like nurseries and trials. Total 64 nurseries from 2008 to 2022 and 29 trials from 2013 to 2022 were uploaded. A data from hybrid and station trials of pigeonpea for the period 2013-2022 had been migrated to BMS as part of digitalization. The field layout, experimental design and data sheets of plant breeding trials are being generated through BMS. For more efficient data observation, correct time, date and weather analysis can be quickly recorded by using Palmtop device. Sort, store and retrieve data accordingly will help breeders make data-driven selections of advanced lines for next generation breeding.

C. Lentil

- A lentil variety, IPL 230 derived from IPL 522/DPL 62 cross was released/notified for cultivation in UP under timely sown conditions. It registered 19.5% yield superiority over check KLS 218 and early (110-115 days) with small seeded (2.4 g/100-seeds) and resistance to rust, tolerance to wilt diseases.
- Six entries were evaluated in AVT-1 during 2021-22 and none of them performed well. Among 8 IVT entries, four [IPL 243, IPL 244 (small seed), IPL 349, IPL 350, IPLRS 703, IPLRS 704 (large seed) and IPL 607, IPL 608 (rice fallow)] were promoted in AVT-1 during 2022-23 under AICRP trials.
- Under UPSAT, small seeded (IPLS 241), 2 large seeded (IPL 348, IPL 701) and 2 late sown (IPL 605, IPL 606) entries were promoted to SAT-1 during 2022-23. 8 entries (IPL 242, IPL 243, IPL 244, IPL 702, IPL 801, IPL 542, IPL 607, IPL 608) are being evaluated under UPSAT during 2022-23.
- Two station trials with 15 entries each were evaluated for their yield performance during 2021-22. In ST-I, 2 entries (IPL 1946104, IPL 19-105) with mean yield ranging from 2261 to 2349 kg/ha were identified promising over check IPL 316 (2166 kg/ha). The highest yielding entry IPL 19-105 showed flowering (67 days) and maturity in 127 days, while its harvest index was 0.40. In ST-II, seven small seeded (IPL 19-50, IPL 19-264, IPL 19-181, IPL 131053, IPL 19-258) were identified promising with average yield ranging from 1984 to 2110 kg/ha over check, IPL 220 (1887 kg/ha).
- In PYT, 10 best entries (IPL 20-248, IPL 20-258, IPL 20-260, IPL 20-247, IPL 20-249, IPL 20-253, IPL 20-257, IPL 20-251, IPL 20-252, IPL 20-259) were identified promising over check IPL 534 having average yield ranging from 2524 to 2952 kg/ha. The highest yielded entry IPL 20-259 was small seeded with 2.2 g/100-seed and yield 2952 kg/ha with maturity of 123 days.
- Thirty one 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* 2021-22.
- F_1s seeds derived from 26 lentil crosses including multi-parent crosses and 186 F_1

plants were grown and harvested separately. Altogether, 1374 SPS from 28 F_2 (334 SPS + 3 LB), 26 F_3 (637 SPS), 29 F_4 (293 SPS) and 9 F_5 (110 SPS) were done based on the targeted traits and harvested separately. A total of 250 line bulks derived from 21 F_6 were harvested for yield evaluation.

- Trait specific RIL mapping populations for root traits (IPL 98/193/EC 208362) having 200 RILs has also been maintained and evaluated for yield traits.
- Total 635 kg nucleus seed of 7 lentil varieties (IPL 526, IPL 220, IPL 321, IPL 315, IPL 534, IPL 225 & IPL 329) were produced and 6,800 SPS were selected for nucleus seed production in next year.
- Total 206 accessions of active germplasm were maintained and 94 diverse accessions were maintained during 2021-22. Total 121 accessions of 5 wild species (*L. orientalis*: 78, *L. tomentosus*: 10, *L. odemensis*: 13, *L ervoides*: 13, *L. nigricans*: 7) were maintained. In addition, 12 SPS were selected in F_4 population derived from wide cross (IPL 316/ILWL 118), while 36 SPS were selected from $3F_5$ populations of wide crosses. Total 47 pre-breeding lines were bulked from 4 F_6 populations. 23 pre-breeding entries were evaluated in PYT. Small seeded entry IPL 19-02 identified promising based on yield (1991 kg/ha) and early flowering (62 days) for evaluation in rice fellow trial. 149 pre-breeding lines evaluated for drought tolerance and wilt resistance.
- The seed samples of lentil genotypes (IPL 220, IPL 406, IPL 227, and ILL 6002) have been treated with different doses of gamma radiation. These samples will be grown during ensuing *rabi* season (2022-23) for generating M_1 generations. The plant samples affected with stemphylium blight disease were collected from disease infected field. These samples were used for pure culturing of disease inoculum for developing the disease under controlled conditions

D. Urdbean

- A urdbean variety IPU 17-2 was released and notified for cultivation in Madhya Pradesh. It produced yield superiority of 18.33% over the best check. It is early maturing (73 days), black seed colour, medium large seeded (4.9 g/100-seeds) with seed protein content of 22.14%. It is resistant to MYMV, ULCV, LCV, WB, BLB, PM, CLS, white fly and pod bug insects under field conditions.
- A urdbean genotype IPU 18-02 was identified by the UP identification committee for release in the cultivation during spring in Uttar Pradesh.
- Based on yield performance, entry IPU 13-6 has been promoted to AVT-1 under NEPZ. Eight entries are being tested in IVT under AICRP for their yield performance.
- Twenty crosses were obtained involving diverse parents under genetic enhancement. F_1 population derived from 22 crosses were harvested during *Kharif* 2022.
- Single Plant Selections (SPS) were harvested from F_2, F_3, F_4, F_5, F_6 and F_7 populations derived from 32, 8, 12, 18, 54 and 7 crosses, respectively. Similarly, line bulks from F_8 population from 19 crosses harvested based on the targeted traitsfor field evaluation as PYT in the next year.
- Three station trials comprises with 44 urdbean entries including station trial-1 (17) and station trial-2 (10) and station trial-3 (17) were evaluated during *Kharif* 2022. The yields ranged from 800 to 1427 kg/ha were recorded. Similarly, 79 urdbean entries were tested under PYT and those will be promoted to station trials on the bases of yield performance in the next *Kharif* season.
- An inter-specific mapping population for agronomic traits advanced to F_5 generations emanating from cross IPU 11-02/PM 6 (Urdbean/Mungbean). Beside this, five populations advanced to F_4 generations segregating for MYMIV, Powdery Mildew resistance and photothermo sensitivity.
- The seed quality and resistance to MYMIV are the important traits in urdbean. Five crosses with contrasting traits were attempted to understand inheritance of seed traits (seed lusture, seed colour, and mosaic on seed surface, MYMIV reaction using intra- and inter-specific bi-parental populations). F_1 seed were grown along with their parents and advanced to F_2 & F_3 generation. The inheritance pattern of seed quality traits was studied in each generation and revealed that DPU 88-31/LBG 685 population, shining seed registered dominance over dull trait, while green seed colour exhibited dominance over brown seed colour. However, inter-specific F_2 population derived from IPU 11-02/PM-6 deviated significantly from Mendelian ratios and supported severe segregation distortion for seed trait. Mosaic on seed coat or mottling trait studied in interspecific population demonstrated a dominant digenic inheritance pattern. In 5 inter and intra-specific F_2 populations, MYMIV resistance demonstrated monogenic dominant inheritance which was validated in F_3 generations. Linkage analysis exhibited an association between seed lustre and seed colour while no association was

noticed between seed traits and MYMIV resistance. The seed width and 100-seed weight were controlled by few major genes while other traits governed by many genes with small additive effects. The skewness suggested that complementary gene interactions were present among genes controlling 100-seed weight in intra-specific cross, while duplicate gene interactions were involved in inter-specific cross. The identified monogenic traits and linked morphological marker after further enrichment of linkage group could be used as an important tool in the regular breeding.

- Flow cytometer based estimation revealed diploid nuclear content (2C DNA content) of *V. marina* to be 1.57 pg. The genome size of *V. marina* was 767.73 Mb. The chromosome spread prepared from root tip of *V. marina* accession revealed 22 chromosomes (*2n=22*). In addition, the putative genes involved in salt tolerance in *V. Marina* were identified (NHX gene family 34, HKT gene family 39)

E. Fieldpea

- A fieldpea variety IPFD 19-1 (Shikhar), derived from IPF 5-19/MDP 2 cross, released/notified during 2022 for the cultivation under NEPZ. It is a dwarf, semi-leafless type, white flower colour and creamish white seed color fieldpea variety. It has mean yield of 1917 kg/ha and registered 24.72% & 28.83% yield superiority over checks SKNP 04-9 & HFP-4, respectively. It is resistant to PM and moderatly resistance to rust. It takes 120-125 days to mature with medium large seed size (18.0 g).
- Two dwarf entries, IPFD 19-1 & IPFD 19-3 were evaluated in AVT-2 trials under NEPZ during 2021-22 with 13.83% and 16.78% yield superiority over the best check, HFP-4. Similarly, one tall (IPF 20-17) and two dwarf entries (IPFD 20-3 & IPFD 20-9) were promoted to AVT-1 trials under NHZ. Two tall entries (IPF 20-17 & IPF 20-21) were promoted to AVT-1 under NWPZ. In addition to NHZ & NWPZ, tall genotype (IPF 20-17) is also promoted in CZ in AVT-1. Similarly, two dwarf entries IPFD 20-2 & IPFD 20-8 were promoted to AVT-1 trial under NEPZ and Rice fallows, respectively. Total 6 fieldpea entries *viz.*, IPF 21-13, IPF 21-16, IPF 21-21, IPFD 21-5, IPFD 21-7 & IPFD 21-4 were evaluated in tall and dwarf category in IVT trials during 2021-22. In case of rice fallow trials, 4 entries *viz.*, IPFD 21-2, IPFD 21-6, IPF 21-17 & IPF 21-14 were tested under AICRP.
- Total 12 entries including five new entries (IPFD 18-1, IPFD 18-9, IPF 19-18, IPF 19-11 & IPF 20-20) are being evaluated in UP State Adaptive Trials (UP SATs) during *Rabi* 2022-23.
- Two station trials (ST) including 13 dwarf and tall fieldpea entries with respective check were conducted. In *ST-1* (Dwarf), entries IPFD 2022-6 (3986 kg/ha) and IPFD 2022-9 (3811 kg/ha) were outperformed to the best check IPFD 10-12. In *ST-2* (Tall), entries, IPF 2022-18 (2697 kg/ha), IPF 2022-22 (2869 kg/ha), IPF 2022-24 (2731 kg/ha) were registered superiority over the best check IPF 5-19.
- In PYT (Tall), 39 breeding lines with three checks and of which 16 entries demonstrated yield superiority over the best check IPF 5-19. In PYT (Dwarf), 32 entries were tested and of which 10 entries outperformed the best check IPFD 10-12. In PYT (Extra Early), 32 entries were tested with 3 checks and 7 entries registered yield superiority over the best check, IPFD 99-13. During 2022-23 in station trial, 16 entries in each dwarf and tall categories are being evaluated with 3 checks. In PYTs for dwarf (40) and tall (32) genotypes, respectively are being evaluated with checks.
- Total 25 crosses were made possessing specific traits (large seed size, seed number per pods, pod length, pod number, earliness, powdery mildew resistant and rust tolerant) during 2021-22. In addition, crosses also were made to develop MAGIC population and work out genetics of various traits. Similarly, during 2022-23, crosses will be attempted using trait specific donors
- Forty crosses were raised in F_1 generation. Segregating generations of 40 F_2, 38 F_3 and 32 F_4 were evaluated and superior SPS were selected considering targeted traits (earliness, seed size, pod length, resistant to powdery mildew, rust, and yield/plant). In F_5, F_6 and F_7 generation 638, 742 and 40 single lines were evaluated, respectively. Total 22 F_1 have been raised for further advancement during 2022-23. In case of segregating population in 35F_2, 40 F_3, 84 F_4, 31 F_5 (306 single lines), F_6 (594 single lines) and F_7 (495 single lines) have been planted for advancement.
- The RIL population (310) of rust (HFP 4(S) x FC1(R)) harvested and evaluated for rust incidence. During 2022-23, SPS has been raised for evaluation.
- The nucleus seed production of fieldpea varieties developed by IIPR, Kanpur was taken during 2021-22. These are: IPFD 12-2 (216 kg), IPFD 11-5 (112 kg), IPFD 10-12 (190 kg), IPFD 2014-2 (205 kg), IPFD 13-2 (104 kg), IPFD 12-8 (127 kg), IPFD 6-3 (81 kg), IPFD 9-2 (149 kg), IPF 16-13 (160 kg), IPF 5-19 (52 kg), IPFD 1-10 (22 kg), IPFD 99-13 (25 kg), IPF 4-9 (20 kg), IPF 99-25 (20 kg) and IPFD 16-3 (26 kg). Similarly, during 2022-23. nucleus seed production for all

IIPR released varieties is being taken based on DAC indent. In national breeder seed indent IIPR varieties total share was 70%. IPFD 10-12 had the highest share (17.39%) followed by IPFD 12-2 and IPFD 2014-2.

- A RIL population of fieldpea (n=310) developed for rust has been phenotyped for rust incidence during 2021-22. For phenotyping, standard scale was used and based on that 19 lines, demonstrated resistance reaction and 27 lines showed moderately resistance reaction to rust. Overall normal distribution was obtained for rust in RIL population.
- Fieldpea is highly affected by weed incidence and 196 genotypes were further screened to topramezone @ 20.6 ml a.i./ha (60 ml/ha) during 2021-22. Phytotoxicity was recorded on 0-10 scale (0-10 scale: 0=complete tolerance; 10=Susceptible)at 7, 15 and 30 days after herbicide spray. Considering visual phytoxicity genotypes, KSP 23, KSP 11, JP 67, JP 885, P 3, ET 5120, ET 5112, ET 5101, IP2K107 were found promising with minimal phytotoxicity.

F. Cowpea

- Twenty five crosses were made using different donors with traits (determinate to semi-determinate plant type, Yellow mosaic disease, powdery mildew, bruchid tolerance, pod length, pod number, grain size and colour during *kharif* 2022. Total 10 crosses were raised in F_1 for further advancement during 2022. In segregating generations, superior SPS were selected taking into consideration desirable traits (earliness, seed colour, pod length, resistant to YMV, plant type). Total 31 F_2 (356 SPS), 20 F_3 (728 SPS), 14 F_4 (578 SPS), 5F_5 (95 line bulk) and F_6 (40 line bulk) were evaluated.
- In summer 2022, a set of 60 genotypes with two checks were raised in PYT to assess performance of growth habit, disease reaction and yield. Similarly, Total 16 extra early germpalsm accessions including checks were evaluated for earliness and other yield attributing traits. Besides, a set of 11 promising lines were evaluated for yield with checks.
- Four hundred ten germplasm accessions were planted for maintenance and rejuvenation. one hundred thirty two lines were vitiated due to rains within two days of sowing. Besides, these, accessions were evaluated for qualitative and quantitative traits. Abundant amount of variability was noticed for studied traits like days to maturity, seed size, pod length, seed coat colour *etc*. In addition, 30 released varieties and 22 wild accessions of cowpea were also maintained.

G. *Rajmash*

- Total 1,946 *rajmash* germplasm accessions has been procured and maintained at Kanpur. Total 500 common bean genotypes were characterised collected from CIAT, Colombia with respect to morphological traits, including plant growth, leaf colour/size/shape, flower colour/stripping on outer petal), pod shape, seed colour/shape and quantitative morphological traits.
- Twenty nine exotic lines were selected from previous germplasm evaluation and characterization study of 1,200 common bean lines based on superior agronomic performance (flowering time, maturity duration, pod nos, yield). These accessions were evaluated under diverse production environment for 3 consecutive years during 2019-22 at Kanpur and one experiment at NBPGR-RS, Shimla during *Kharif* 2021. Based on multi-seasonal field evaluation, identified two super early maturing lines namely, EC 932021 & EC 932189 in comparison to checks Arun, Uday and Utkarsh.
- Few crosses for desired traits (BCMV resistance, *Anthracnose* resistance, high yield with enhanced micronutrients) were attempted during 2021. The F_1 were evaluated at NBPGR-RS, Shimla. F_1 derived F_2 segregating seed materials were harvested and same segregating materials were evaluated and generation advancement at IIPR, Kanpur during 2022.
- One hundred twenty Andean and Mesoamerican germplasm and indigenous common bean germplasm and checks (Arun, Uday, Utkarsh, HUR 15) were examined in 3 years (2019-22) at Kanpur. Agronomical traits (pod morphological traits and seed attributes) data were gathered. The germplasm EC 931924 & EC 931925 had extra-large pod length (14.4-16.05 cm) in comparison to control Utkarsh (12.3 cm), Arun (13.9 cm) and Uday (11.8 cm) and the highest 100-seed weight of 54.95 g and yield of 1656 kg/ha). This germplasm line was determined to be promising in terms of pod length and high 100-seed wt.
- One hundred six common bean germplam and 8 wild accessions were supplied to NBPGR for ongoing project activity between Alliance Bioversity International-CIAT, IIPR, Kanpur and NBPGR, New Delhi during 2021. A set of 110 diverse bean germplasm were utilized in germplasm characterization and identification of trait specific germplasm accessions.

Seed technological studies in pulses

- To understand the effect of growing season on occurrence of hard seededness, the freshly

harvested seed of 131 urdbean lines and 107 mungbean lines produced during *kharif* and summer 2022 were subjected to germination assay for 4 days. The hard seeds in *kharif* grown urdbean lines ranged from 8-78% with mean of 56%, while summer ranged from 0-28% with mean of 3%. Likewise, the hard seeds in *kharif* grown mungbean lines ranged from 14-76% with mean of 43%, while in summer, lines ranged from 0-24% with mean of 6%. The occurrence of hard seededness in freshly harvested seeds of mungbean and urdbean was more during *kharif* as compared to summer.

- Forty four pigeonpea wild accessions were used to overcome hard seedeness following various pre-treatments. The treatments included hot air treatment (HAT) for 3, 5, 7 & 14 days, hot water treatment (HWT) for 30 & 60 minutes, concentrated H_2SO_4 treatment (SAT) for 2 & 5 minutes and partial incision in distal end of seed (PSCI). All treatments reduced hard seededness and improved germination over control with PSCI being best treatment for all species recorded 70-98% germination except for *R. aurea* (30%) and *C. cajanifolius* (59%). The HWT for 30 & 60 minutes was best treatment for *C. cajanifolius* recording germination of 66-70% as compare to 11% in control. The SAT for 2 m was the best pre-treatment for overcoming dormancy and improving germination in *R bracteata* with PSCI & HAT3D, *R. rothii* and *R. rufescens* with PSCI.
- Quality seed production of high yielding varieties of different pulse crops namely, mungbean (Shikha and Virat) & urdbean (IPU 13-1) and pigeonpea (IPA 203) during *kharif* 2022 were conducted at farmers' field of Kanpur Dehat and IIPR, Kanpur with an objective to easy dissemination of quality seed production technology and easy reach of quality seed to the farmers'. While, quality seed production of chickpea, field pea and lentil during *Rabi* 2021-22 were taken on farmers' field, BNPG College, Rath, Hamirpur and IIPR, Kanpur realized in the month of June 2022, following the mandate of the project. The production under the project, a total of 100.15 qtls mungbean (foundation seed with two varieties Shikha and Virat) and urdbean 54.60 qtls were produced. However, during *Rabi* 2021-22, chickpea (IPC 06-77 and yield about 90 qtls), fieldpea (yield 441 qtls as per the assessment of UP Seed Certification), lentil (yield 18 qtls as per the assessment of UP Seed Certification Agency) and pigeonpea (IPA 203 yield 43.00 qtls) were sown on farmers field of Kanpur Dehat and Hamirpur districts. Total quality seed produced under Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India is 746.75 qtls during the year.

Biofortification in Mungbean and Urdbean

- Two high zinc uptake lentil genotypes, IPL 220 (55.30 ppm), IPL 6002 (63.60 ppm) were grown along with two low uptake lentil genotypes, L 57 (40.10 ppm), T36 (43.10 ppm). External foliar application was applied to treatment and control plants were treated with water spray without any foliar zinc application. The field experiment was carried out during 2019-21 at IIPR, Kanpur. For both control and treatment, plants were analysed for zinc concentration in root, stem, seed coat, leaf, seed and pod.
- Estimation of Zn content in different plant parts of lentil genotypes under control and foliar spray in 2020-21. The high Zn genotypes (IPL 220, ILL 6002) had high seed zinc in both control and treatment in both years. High zinc genotypes (IPL 220, ILL 6002) had lower per cent increase in seed zinc.
- Estimation of Fe and Zn concentration in a panel of 105 mungbean genotypes and Zn concentration ranged from 9-34 ppm in this set of mungbean genotypes with a mean value of 18 ppm and Fe concentration ranged from 11-80 ppm with a mean value of 40 ppm.
- Two station trials with 20 urdbean entries each were tested for Zn and Fe concentrations. Marker trait analysis identified SSR markers linked to Fe & Zn concentration in lentil. Based on pooled data, SSR 9-4, SSR 57-5, SSR 135, SSR 59-2 linked to Fe and SSR 57-5 & SSR 167 linked with Zn concentration.
- Mapping populations available in biofortification programme for iron and zinc concentration are as following: HPU 120/IC 560408 (F_5), WBU 108/Shekhar-2 (F_5), Azad-3/T-9 (F_5).

Plant Biotechnology

- Mined 13,55,754 InDels in 8 chromosomes, 2,88,686 in all contigs, and 31 InDels in chloroplast sequences of chickpea from re-sequencing data of 294 mini-core lines of chickpea and designed 200 InDel flanking primers.
- Identified genomic resources in pigeonpea (5829 lncRNAs and 124 conserved micro-RNAs) and chickpea (4169 long-noncoding RNAs and 195 conserved micro-RNAs) genotypes inoculated with *Fusarium*.
- Identified 489 effector proteins in refined genome assembly of *Fusarium udum.*
- Identified 26 microsatellite loci from the 24 RFO metabolism-related genes in pea.
- Cloned the identified dehydration-responsive

RD22-like gene (1158 bp) from chickpea in pBI121 binary vector and mobilized to Agrobacterium stain GV3101 for plant transformation.

- Identified various genes (phosphoinositide phospholipase C 6-like) associated to the different SNPs localized in distinctive regions of the genomic region on Chromosome CaLG02 (4 Mb region spanning interval of 30 to 34 Mb) associated to salinity tolerance.
- Yellow Mosaic Disease of black gram (*Vigna mungo*) has been detected and classified using deep learning models, and the results obtained for different deep learning architectures DarkNet-19, SqueezeNet, AlexNet, and GoogLeNet showed validation accuracy and loss scores of 96.09, 60.74, 94.41, and 93.85%, and 0.2319, 0.6923, 0.2429 and 0.1399, respectively.
- Higher expression of different stress-related genes, TFs (WRKY), and enzyme activity (SOD, Peroxidase) was found in resistant genotypes, indicating their role in imparting resistance against the MYMIV attack in *Vigna mungo*.
- A total of 32 early, 21 medium, and 2 late-flowering lines were identified among the black gram panel of 98 genotypes. Similarly, 13 photoperiod insensitive and 8 photoperiod sensitive lines were identified for further validation and studies.
- Developed a blueprint for establishment of state of the are speed Breeding Facility.
- Developed protocol for rapid generation advancement of chickpea combining environmental simulation and plant tissue culture.
- Reconstructed and confirmed single guide and dual guide based gene construct using *In Fusion* cloning technique for CRISPR/Cas9 based gene editing in chickpea.
- Developed and validated *Agrobacterium rhizogenes* mediated root induction in chickpea embryonic axis for functional genomics and reverse genetic approaches.
- Developed robust and routine direct genetic transformation protocol for chickpea.
- Cloned GH-18, Class V, Herbivory-inducible *Cicer arietinum* chitinase: Car_Chit-15 (with the best chitin binding ability) and the Bowman-Birk protease inhibitor from *Cajanus cajan* induced in response to *Fusarium udum* infection.
- Synthesis and validation of gene, Vip3 for development of gram pod borer resistance in chickpea.
- Identified, cloned and confirmed protein expression of a novel small secreted cysteine rich protein-1 (SSCP-1) from *Cajanus cajan* with a putative role in defense.

Crop Production

- In LTFE study under rice-based (lowland) system, maximum system productivity and net returns were recorded in RDF (chemical fertilizers) and RWMb. Further, 10-15% higher grain yield of rice and wheat recorded under RWMb than RW. Yields of cereals were higher in RDF whereas, pulses yields were higher in INM. The available K was higher under INM & RWRC>RWMb>RW. Inclusion of pulses and INM in rice – wheat system resulted in improvement in soil quality index and SOC.
- Similarly, LTFE study under maize-based system, significantly higher system productivity recorded in INM and MWMb over control and MW, respectively. Also, under *bajra* based system, significantly higher system productivity recorded in INM and BWMb over control and BW, respectively.
- Among different cropping systems under conservation agriculture (CA) in NWPZ, R+GM-W-Mb, M+GM-C-Mb & M-W-Mb gave significantly higher system productivity and profitability. Increase in crop yield was recorded due to retention of crop residue and *in-situ* green manuring (*dhaincha*).
- In another study under CA, ZT-ZT increase the yields of component crops (maize & chickpea) and system over CT-CT. 100% RDF + CWM (Post) & GM + 75% N + 50% P + CWM (Post) resulted in reduced weed density than PRE+POST application. The treatment also had significantly higher productivity, net returns and B:C ratio.
- In a CA study under maize-wheat-mungbean system, soil physical (macro-aggregate) & biological (soil dehydrogenase, SMBC & phosphatase) parameters were improved under ZT, residue & mungbean variety 'IPM 205-7'.
- Conservation agriculture in rice-chickpea system resulted in higher system productivity and profitability. Zero till direct seeded rice – ZT chickpea (ZTDSR-ZT) (~CA system) gave significantly higher rice and chickpea yields over the puddled rice – conventional till chickpea system (PTR-CTC). Pendimethalin - bispyirbac-Na in rice and oxyfluorfen – propaquizafop-p-ethyl in chickpea was found effective for managing weeds. ZTDSR-ZT resulted in higher sustainable yield index in

rice, chickpea and system after five years.

- Selectivity and dose/time were optimized with topramezone 20.6 g/ha at 14 DAS in chickpea and clodinafop-propargyl + Na-acifluorfen 122.5 g/ha at 10-15 DAS in mungbean.
- Summer *Sesbania* cultivation and halosulfuron-methyl (70 WG) 67.5 g/ha application after irrigation (stale bed method) in summer reduced the purple nutsedge (*motha*) and total weed density in subsequent crop rotation (pearlmillet-chickpea & pigeonpea-wheat).
- 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 production system. Results indicated that IPC 2006-77, IPC 2004-98, IPC 2004-01 could be the potential cultivars for the intercropping system.
- In a study to evaluate the field efficacy of foliar spray of osmolytes to alleviate terminal stress in urdbean crop, an increased response to urea treatment (2% foliar spray) was observed, while the efficacy of $MgSO_4$, Thiourea and $CaCl_2$ was marginal as compared to control treatment.
- In a study of crop establishment methods under rice fallow study, significantly higher growth and yield of rice was observed under puddled transplanting (PT) compared to ZT-DSR and CT-DSR rice. Further, significantly higher seed yield of lentil was recorded under DSR-ZT compared to DSR-CT and PT-CT. Among the varieties of lentil, Kota Masoor 1, DPL 62 and IPL 316 had significantly higher yield over others. Kota Masoor 1 under DSR-ZT had noticed significantly maximum seed yield (632 kg/ha) compared to others.
- Organic practices with foliar application of biophos and biozinc significantly increased *Cyperus rotundus, Chenopodium album, Coronopus didymus, Medicago denticulata* than inorganic fertilization in wheat. Organic practice (FYM) had higher total narrow-leaved, broad-leaved and total weed density than inorganic fertilization in wheat.
- In a study on soil phosphorus dynamics and release kinetics, system productivity is higher *i.e* 10% (pigeonpea-wheat) and 9% (pearl millet-chickpea) with crop residue (50%) + PSB application over control. Soluble P-fraction and labile: non-labile P fraction was higher in the crop residue + PSB plots and poultry manure added plots by 30-40% irrespective of cropping system. The effect was more prominent in the pulses than the cereals.
- In Zn biofortification study, a higher yield (11-14%) was obtained with foliar spray of 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage) which was significantly higher over the remaining treatments. Likewise, the same foliar spray treatment of 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage) resulted in 20 - 30% higher seed Zn concentration than control in both the genotypes, IPC 11-112 and JG 14.
- Chickpea genotypes, JG 16, GNG 2171, IPC 10-62 are classified under soil zinc responsive genotypes; GNG 469, Vijay, GNG 2171 under foliar zinc responsive genotypes and Vijay, GNG 469, JAKI 9218, GNG 2171, RSG 888 were classified under both soil and foliar zinc responsive genotypes.
- Nano-zinc oxide spray @ 50 mg/l (at Pre-F and Pod F) has recorded a higher yield of 2,300 kg/ha which is 21% higher than the control. However, among all the tested treatments, nano-zinc oxide didn't show any significant increase in seed zinc content in chickpea.
- In a performance evaluation study of IIPR multipurpose grinder and hammer mill, the milling capacity of IIPR multipurpose grinder was 36.50 kg/h, whereas it was 21.83 kg/h for Asian make hammer mill for *besan* making. IIPR multipurpose grinder has shown 67% higher milling capacity compared to Asian make hammer mill.
- Calibration of the commercially available seed drill for sowing of mungbean and urdbean was done. The field capacity and the field efficiency of the machine were obtained as 0.48 ha/h and 83%, respectively when the machine was operated at 3.2 km/h speed.
- Preliminary studies were conducted on lentil grains stored in jute bags, PP Woven bags, Metal Bins, LDPE, HDPE and laminated bags for period of six months. Maximum change in moisture content was observed in jute bag and the least in the laminated plastic bags, followed by HDPE bags.

Crop Protection

- Promising genotypes of pigeonpea (IPAC 66, IPAC 67, IPAC 68, IPA 10w12, IPA 20-2, IPA 10w1-8, and IPA 12w26-1) were identified as donors for *Fusarium* wilt (*F. udum*, race-2) and KPBR 80-2-1, IPAC-3, IPAPB 7-2-1-7, IPAPB-7-2-1, IPAC-3, IPAB-2019-1-6 and IPA 16E-7) were identified as donor for *Phytophthora* stem blight.
- Out of 160 pre breeding lines of lentil, two (IPL 406 x IG 136667-1 and Wild F_4 1594-3) were recorded as resistant with 9.23 and 10.00% wilt

incidence, respectively.

- Thirty seven leaf samples of mungbean (n=8), urdbean (n=8), cowpea (n=15) and *Rajmash* (n=6) were processed to detect the YMD causing viruses (MYMIV, MYMV, HgYMV and DoYMV) using species specific primers. Two mungbean samples were found infected with MYMIV and DoYMV and six with MYMIV. One cowpea sample was found infected with two viruses (MYMIV and MYMV), two samples were infected with three viruses (MYMIV, MYMV and DoYMV) and three samples having the infection of two viruses (MYMIV and DoYMV) among the 15 samples of cowpea tested.
- Two pigeonpea genotypes (GJP 1915 and BDN 2013-2), two lines of mungbean (IIPM 20-2 and SML 2015) and two fieldpea lines (Pant P 498 and TRCP 9) were found resistant against *Meloidogyne javanica* and one line of pigeonpea (BDN 716) was highly resistant against pigeonpea cyst nematode.
- *Trichoderma* and *Bacillus* based microbial consortia {*Trichoderma* (IIPRTH-23 + IIPRTh-33 + IIPRTh-4 + IIPRTg-3) and Bacterial (*Bacillus subtilis*-IIPRSHEP-6)} was developed for stress management in pulse crops. 19 potential isolates of *Trichoderma*, and 5 isolates of *Bacillus* sp. and 1 isolate of *Pseudomonas* were deposited to ICAR-NBAIM, Mau.
- Developed a talc based formulation of DALHANDERMA (*T. asperellum*, IIPRTh-31) and DALHANDERMA-1 (*T. afroharzianum*, IIPRTh-33) for wilt and root rot management and plant growth promotion in chickpea, pigeonpea and lentil and liquid bio-formulation of indigenous *Bacillus thuringiensis* for pod borer management.
- Five different bruchid species (*C. chinensis*, *C. maculatus*, *C. analis*, *A. obtectus*, and *C. serratus*) were identified infesting collected grain samples and among them, three species belonging to *Callosobruchus* genera are common across samples.
- In long duration pigeonpea, the pod damage due to pod borer (*H. armigera*) and pod fly was ranged from 2–18% and 4–22% in IPA- 203, while it was 4–16 and 6–34% in Bahar variety.
- Two germplasms, *Vigna vexillata* (IC 0248326) and *Vigna umbellata* (IC0251442) found highly resistant against *C. maculatus* F. were registered at ICAR-NBPGR, New Delhi.
- Plant volatile oil extracsts exhibiting insecticidal activities (Fumigant and ovicidal properties) against pulse beetle were identified.

Basic science

- In lentil, it was observed that higher crop vigour, MSI, canopy temperature, high pollen viability, pod formation in terminal branches, pod development, and grain filling rate are the most important parameters which were severely affected when temperature increased beyond 30°C. Twelve promising contrasting lines (IG 2507, IG 2543, IG 2598, IG 2821, IG 2559, IG 2960, IG3522, IG 4112, IG 4253, IG5128, WBL 58 and IG 4258) were identified based on Heat Susceptibility Index (HSI) and physiological parameters.
- Pigeonpea genotypes ICPL 20241, ICPL 87091, ICP 5028, MA 6, NDA 1, Bahar, IPA 203 and IPAC 211 showed tolerance to water logging stress whereas IPAC 202, RCM/DD 17, WB 2019/25, WB 2019/26, WB 2019/27 and IPAC 212 showed susceptibility against water logging stress. The tolerant group showed the formation of adventitious roots but the susceptible group showed no adventitious roots.
- Urdbean genotypes PGRU 95014 and PGRU 95016 were found to be putatively thermo tolerant and LBG 20, and IPU 99-123 were found to be thermo sensitive using Temperature Induction Response (TIR) technique.
- Higher gibberellic acid (GA_3) and auxin (IAA) content was observed in the flowers of heat-tolerant genotypes of chickpea as compared to heat susceptible genotypes. Under late sown conditions (High temperature), the GA_3 and IAA content decreased in chickpea flowers of heat tolerant as well as heat susceptible genotypes.
- Fifty cultivars of common bean having diverse seed coat color were screened for their phenolic content, composition, flavonoid content, tannin content, and total antioxidant potential. Out of these fifty cultivars, the dark-seeded exotic collection EC 932147 was found to have the highest phenolic content and antioxidant potential. Another white-seeded exotic collection EC 931871 has the least phenolic content and antioxidant potential.
- HPLC analysis revealed that gallic acid, catechin hydrate, and ferulic acid are the predominant phenolic compounds present in common bean cultivars.
- An analytical method for analysis of imazethapyr was standardized using HPLC-PDA. Residues analysis of imazethapyr was done initially in the soil and it was observed that residues persisted beyond 75 days after application. The half-live values of

imazethapyr ranged from 53.75 to 59.02 days in the soil.

- An ortholog of *Medicago truncatula* cytokinin response regulator 9 has been identified in chickpea (Locus LOC 101490264). SNP in the exonic region causes creation of stop codon in ICC 1230 and ICC 1710 genotypes and produces non-functional protein product further led to poor nodulation. Start lost variant caused by InDel is observed in the locus LOC101500280 of ICC20183 genotype which encodes Medicago truncatula ortholog VAPYRIN. This genotype is also a poor nodulator.
- Two best *Rajmash* genotype-*Rhizobium* combinations (*Rajmash* genotype IC 356018, EC 150250, and Rhizobia isolate IIPR-RR17, IIPR-RR40) were re-evaluated for their nodulation potential under sand and hydroponics system. Both the combinations were found positive for nodulation with genotype IC 356018 being the highest nodulator.

Social Science

- E-learning platform of pulse production technologies is being created for purpose of dissemination of pulse production technologies among potential stakeholders. A total of 80 videos modules have been prepared on improved pulse production technologies and success stories of partner farmers have been prepared and uploaded on youtube channel "ICAR-IIPR Pulse farmer corner", created for the purpose.
- A total of 125 demonstrations on chickpea (71), lentil (16), mothbean (10), clusterbean (20), horsegram (2), cowpea (3) and mungbean (3) were conducted collectively in Marundasuchit village of Unnao, Badrasar & Nagasar villages of Bikaner and Narendra from Dharwad district, Padli village of Sehore, Madhya Pradesh state.
- Mahodhya Agriworks, Kanpur signed MoU for incubation support for preparing "High fiber and protein rich biscuits from pulse byproducts" on July 29, 2022. Delemeo brand of high fiber and protein rich handmade cookies prepared by Mahodhya Agriworks under incubation support was unveiled on Institute. Incubation support on "Protocols on pulse milling" of existing incubatee "MamtaAgro India" was renewed for 2nd phase. The firm could sell 2916.56 kg processed pulses (Pigeonpea, Chickpea, Mungbean Urdbean, Lentil *dal* and Chickpea flour) and generated ₹ 3.01 lakh as gross returns.
- Agri-Business Incubation Unit, ICAR-IIPR generated ₹ 1,76,249/- till 31/12/2022 as total revenue from incubation fee, operational and royalty charges from incubatees.
- Workshop on "Agribusiness Opportunities in Pulses" was organized on 27th September 2022, wherein 200 students of Rama University, Kanpur and 11 faculty members participated.
- Demonstration on Chickpea (var. GNG 2207) were conducted in Khadra, Delemau, Shahpur, Karchalpur and Mirai villages of Fatehpur in partnership of 60 farmers covering 9.10 ha area. partner farmer received average of 16.76 q/ha yield in comparison to prevailing variety (12.02 q/ha). The partner farmers received 39.43 per cent yield advantage and 39.43 per cent economic advantage from the demonstration plots. Besides yield superiority, farmers preferred the variety for bold seeds, seed coat color, plant vigour and resistance to wilt.
- Mungbean interventions were implemented in project villages (Khadra, Shahpur, Karchalpur, Delemau and Holapur) in partnership with 113 farmers covering 23.56 ha area in summer 2022. The technology package demonstrated included quality seed of mungbean variety Virat, seed treatment with Imidacloprid 17.8% SL and use of plant protection chemical (chlorantraniliprole 18.5% SC) for timely management of *Spodoptera litura* infestation in the crop. High yielding hybrid of Okra Navya was introduced among partner farmers of Khadra, Karchalpur, Delemau, and Shahpur villages of Fatehpur district.
- Demonstrations (35) on high yielding hybrid of paddy (NDR 20-65) were conducted in Delemau, Khadra, Karchalpur, Mirai, Shahpur villages of Fatehpur district covering 13 ha area. Partner farmers received 61.89 q/ha yield in comparison to local varieties (40.62 q/ha). Partner farmers received yield advantage of 21.91 q/ha and gained income advantage ₹ 39,438.00.
- For developing entrepreneurial skills and generating additional income by 11 women member of *Namami Gange Mahila Krishi Udyog Samiti* were given hands on training in pulse processing and value addition. In addition, I.I.P.R. Mini *dal mill* was provided to the women group and women group were also supported for marketing of their produce.
- A total of 140 Frontline Demonstrations (FLD's) were conducted in *rabi* 2021-22 that included 66 FLD's on Chickpea (var. GNG 2207), 39 FLD's on Fieldpea (var. IPFD 12-2) and 35 FLD's on Lentil (var. IPL 315) in 07 districts of Uttar Pradesh. Partner farmers received yield advantage of 3.67 q/ha, 1.51 q/ha and 1.90 q/ha in fieldpea, lentil and chickpea demonstration plots, respectively.
- Network project on impact assessment of agricultural technology was initiated at

Institute as one of the cooperating center (CC) while ICAR-NIAP, New Delhi is the lead centre of the project. Two varieties of chickpea *viz*; and IPA-203 varieties of pigeonpea were selected for impact assessment. Maharashtra, Madhya Pradesh and Rajasthan for chickpea and Uttar Pradesh for pigeonpea were selected for study.

IIPR Regional Research Station, Bhopal

- Advance breeding lines and germplasm of *kabuli* chickpea procured from national and international institutes were evaluated for yield parameters and donors for large seed size (FLIP 09-346C, FLIP 09-104C) and earliness (ICCV 181302, ICCV 181316) were identified for their use in breeding programme.
- Two chickpea advance lines namely, PA 03716R developed by ICRISAT and IPC 2019-05 developed by ICAR-IIPR, Kanpur exhibited early flowering and pod bearing in multi-location trial conducted at IIPR, RS, Bhopal.
- One thousand chickpea germplasm were grown at ICAR-IIPR, RS, Bhopal in the late sown condition under heat stress condition to identify the heat tolerant genotypes. Promising genotypes namely, ICC 4410, ICC 6471, EC 267221, ICC 4409 & ICC 6462 were identified on the basis of filled and unfilled pods and climatic data.
- A set of 30 *Fusarium* wilt resistant lines (developed in the pre-breeding programme or selections made from explored germplasm collections and screened at IIPR, Kanpur wilt sick plot for at least 3 years) were characterized for agronomic and yield attributing traits at IIPR, RS, Bhopal for further screening in the central zone.
- Two previously identified drought tolerant lines namely, RVK 275 and IPAD 5 were characterized for agronomic and yield attributing traits at IIPR RS, Bhopal for further evaluation and validation of drought tolerance.
- Thirty one accessions of pigeonpea germplasm, collected from 3 districts of Madhya Pradesh and two districts of Chhatisgarh, were characterized for quantitative and qualitative traits. The accession IC 637068 had the highest yield per plant and IC 637029 showed maximum 100-seed weight.
- Four hundred seven accessions of pigeonpea obtained from ICAR-NBPGR were characterized for 29 quantitative and qualitative traits (NBPGR descriptor) during *Kharif* 2021-22 at IIPR RS, Bhopal. Genotypes namely, IC 523649 had earliness, IC 634397 had large seed size and IC 245484 showed early maturity.
- A unique genotype of grasspea *viz.* IC 296745 was submitted for germplasm registration for larger seed size (15-16.8 gm/100-seed weight) with grey seed coat.
- A set of 41 germplasm of pigeonpea, chickpea, lentil, mungbean, urdbean and *Vigna unguiculata* collected through exploration in association with NBPGR,RS, Akola from Harda and Betul districts of Madhya Pradesh submitted in ICAR-NBPGR for allotment of IC number.
- Two hundred eighty five accessions of wild species of pulses crop are maintained at IIPR, RS, Bhopal in the wild garden.
- Total 203.39 q of breeder seed of pulse crops namely, chickpea, pigeonpea, blackgram, lentil and fieldpea were produced under BSP and EBSP programme during 2021-2022.
- About 1040 q of quality seed of pulses crop namely, chickpea, pigeonpea, green gram, black gram, lentil and fieldpea were produced under seed-hub project during 2021-2022.
- Wilt sick plot of chickpea, lentil and pigeonpea are under development.
- Thirty five frontline demonstrations of chickpea, pigeonpea, black gram and lentil were undertaken during 2021-2022.
- Three hundred 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. Knap sac sprayers (100) were distributed under SC sub plan in two phases on 25.03.2022 to 33 farmers and on 11.03.2022 to 67 farmers.
- Twenty one trainees of Raisen district visited IIPR RS, Bhopal under ATMA programme.

IIPR-Regional Research Station, Dharwad

- During off-season, chickpea breeding materials received from six AICRP centres and IIPR were advanced during *kharif* season and the seed materials were sent back to the centres and IIPR. Total 240 accessions of horsegam, 280 accessions of cowpea, 296 accessions of mungbean and 210 accessions of urdbean were maintained and evaluated for different agronomic traits.
- Wild *Vigna* species (*Vigna trilobata*, *Vigna stipulacea*, *Vigna umbellat* and *Vigna aconitifolia*) were maintained for their utilization in pre-breeding programme.
- Total 80 advance breeding lines of chickpea, 48 lines of mungbean, 20 lines of urdbean, 10 lines of cowpea and horsegram were evaluated for yield and its related traits during *rabi*/spring

summer season.

- Chickpea (IPC-2020-143, IPC-20-84 and IPC-20-199) and mungbean (IPM-21-15-2, IPM-21-23-1 and IPM-1711-1) genotypes were found promising for cultivation during *rabi*/spring/summer.
- Promising entries of mungbean (IPM 14-10, IPM 1205-2 and IPM 1604-1), urdbean (IPU 19-202, IPU 18-228, IPU 18-217, IPU 19-227, IPU 19-223 and IPU 18-212) and *desi* chickpea (IPC 18-59, IPC 17-292, IPC 19-222) were evaluated in state multi-location trials to assess their suitability for cultivation in Karnataka.
- Total 600 kg of breeder seed of *kharif* pulses and 750 kg of truthful labelled seeds of different *rabi* pulse crops were produced.
- Total 296 mini-core set and 90 germplasm lines of mungbean were screened against mungbean yellow mosaic virus during summer sesaon.
- Total of forty entries of cowpea, DC-15, Pant Lobia 3 and Pant Lobia 4 entries and 15 entries of horsegram, VLG-54 and VLG-15 entries were identified as moderately resistant against powdery mildew.
- Total 184 entries of pigeonpea were evaluated against SMD disease.
- The highest incidence of YMV disease (47.66%) was recorded in DDGV-2 sown in second fortnight of March. The average YMV disease in IPM 2-14 was around 0.20% as compared to susceptible check variety DGGV-2 (42. 33%).
- The pod damage and seed damage by emerging pest cowpea seed moth *Cydiaptychora* was around 47.11% and 52.67%, respectively. Two larval parasitoids of Braconid wasp were found to parasitize the larvae of seed moth to the extent of 33.3 to 75%.
- In urdbean, out of 48 entries, the lowest pod weevil (less than two adults per plant) was recorded in 11 entries. The per cent pod damage by weevil ranged between 14.19 to 100. The lowest (less than 20%) pod damage was observed in three urdbean entries (UKE-22-36, UKE-22-22 and UKE-22-14).

IIPR-Regional Research Center, Bikaner

- In mungbean IPM 410-3 (*Shikha*), IPM 1103-1 and IPM 312-20 were found more tolerant to drought stress.
- Out of 19 mothbean genotypes, three cultivars RMO-2251, RMB-25 and RMO-40 were identified as the drought tolerant cultivars as indicated by their drought susceptibility index.
- There mungbean genotypes identified as thermo tolerant were IPM 2-3, IPM 2K-14-9 and MH-421 with higher survival of seedling percentage.
- Out of 300 mothbean accessions, IC-8851, IC-370508, IC-415116, IC-415127, IC-415139 IC-415143 IC-415155, IC-415164, IC-120963, were identified early type and IC-402285, IC-11352, IC-315520, IC-329051, IC-370508 were exhibited yield advantage over the check varieties. Two accessions IC-39734 and IC-39827 high resistance to yellow mosaic virus, leaf crinkle virus and *Cercospora* leaf spot.
- In cowpea, three accessions EC 738156, EC 738206 and EC 738093 were identified early type (50% flowering < 45 days), EC 725017, EC 738236, EC 402180, EC 458425, EC 472271, EC 528393, EC 472271 were high yielding (>20 g).
- Exogenous application of growth supplements especially potassium sulphate, thiourea and acetic acid significantly improved growth, plant water status and seed yield of clusterbean and mothbean under rainfed situations.
- Pulses based intercropping systems in *kharif* season (PM+CB: 1:1) were more productive and profitable, where growing season is short and rainfall is low with long dry spells in between.

IIPR-Regional Research Station, Khordha

- Five genotypes of urdbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check urdbean (MDU 1) were screened against YMD during *kharif* season & found that the YMD was observed only in IPU 13-3, susceptible check (MDU-1) with DI of 100%, DS of 73% & rest others urdbean line were free from YMD.
- Five genotypes of urdbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check MDU 1 & DGGV 2 were evaluated against YMD during *rabi* and in summer season only. MDU 1 was used as susceptible check YMD was observed only in IPU 13-3, susceptible check (MDU 1) with DI of 100%, rest others urdbean line and were free from YMD.
- Eighteen genotypes of mungbean (IPM 1718-1, 2/8 IPM 312-18, IPM 1732-2, IPM 205-7, 2/5 IPM 312-18, IPM 1704-14, IPM 512-1, IPM 14-12-12, IPM 1703 -1, IPM 1732-1, IPM 1718-3, IPM 2K -14-9, IPM 1715-2, 2/10, IPM 312-18, IPM 11/2 (M×U) IPM 03-1× SPS-5, IPM 16-5, IPM 410-3, IPM 1704-18), with susceptible check MDU 1 were evaluated against YMD during *kharif*, *rabi* and summer season. YMD was observed in susceptible check (MDU-1) with a disease incidence of 100% and all the lines of mungbean were free from YMD.
- Seed production of mungbean (Virat- 3.0 q; Shikha – 1.0 q), urdbean (IPU 2-43 -0.5 q; IPU 11-2- 0.5 q) in *rabi* season and rice seed 140 q in *kharif* season.

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) was started in 1966 at the Indian Agricultural Research Institute (IARI), New Delhi. Later in 1978, its headquarters 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 centres across the country.

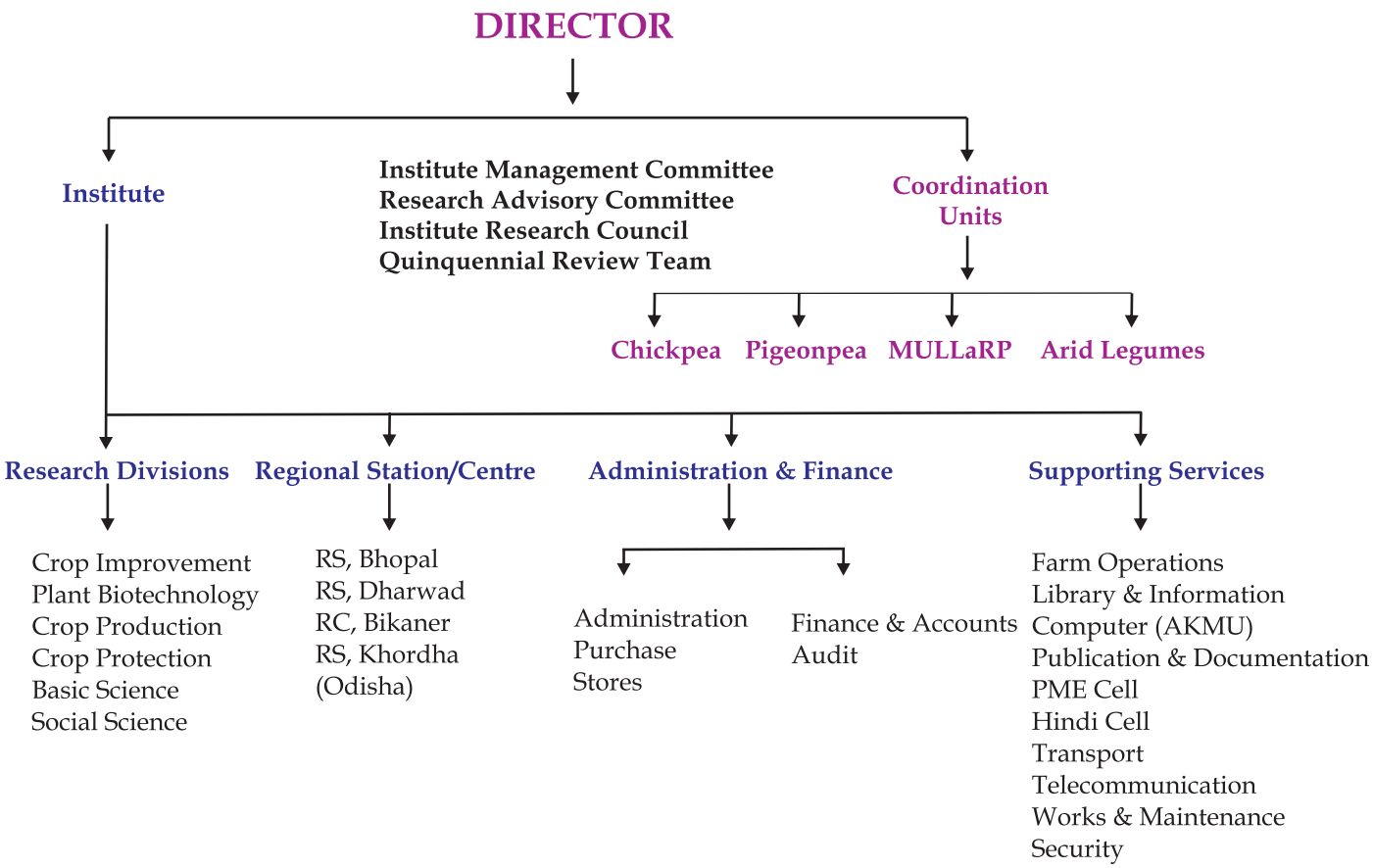
The Institute is located at Kanpur, Uttar Pradesh at $26^{0}27'$N latitude, $80^{0}14'$E longitude and 152.4 meter above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central Railway Station towards New Delhi.

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

Multi-disciplinary research of both strategic and basic nature is conducted under six Divisions namely, Crop Improvement, Plant Biotechnology, Crop Production, Crop Protection, Basic Science and Social Science. For region specific and strategic research, the Institute has one Regional Station *cum* Off-Season Nursery at Dharwad in Karnataka and one Regional centre at Bhopal in Madhya Pradesh. Two more station/centre, *viz.*, Bikaner is Rajasthan & Bhubaneshwar in Odisha have been established recently to cater to region specific research needs in pulses. To cater to the need 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 scientists, 59 technical, 63 administrative and 31 supporting personnel.

Organizational Set-up



Staff Strength

As on 31.12.2022

Category	Sanctioned strength 2022-23	In position on 31.12.2022	Vacant Posts as on 31.12.2022 (Col. 3-4)
RMP	01	-	01
Scientist	100	74	26
Technical	59	31	28
Administrative	63	19	44
Skilled Support Staff	31	14	17
Total	**254**	**138**	**116**

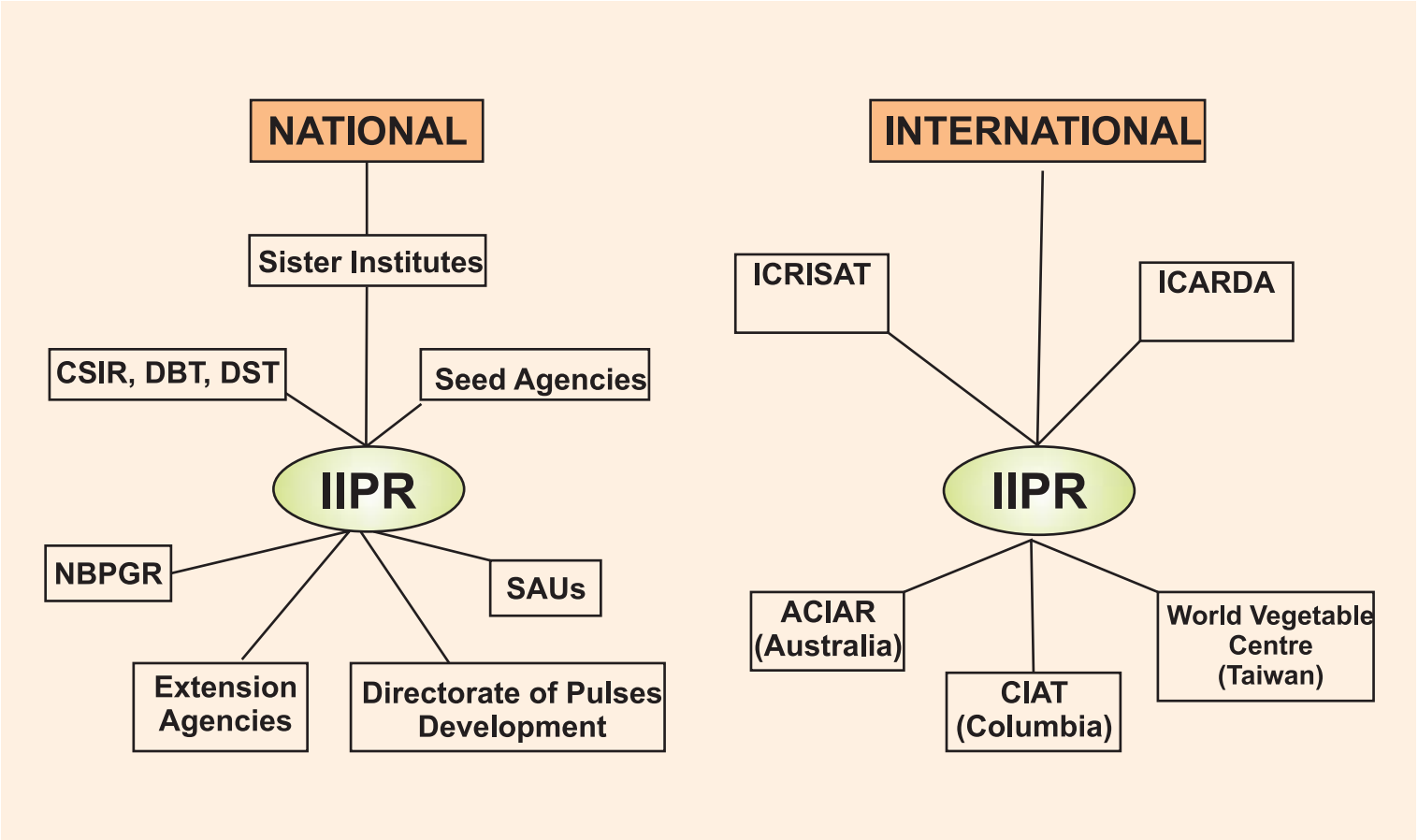
Mandate

- 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 2022-23

(As on 01.04.2022 to 31.12.2022)

		₹ in lakh
A.	**Receipt**	3380.57
B.	**Expenditure**	
	Plan	2915.08
C.	**Pension and other retirement benefits**	415.53
D.	**AICRP on *Rabi* Pulses**	
	a. Coordination Unit	194.94
	b. Grant-in-aid	1533.70
E.	**AICRP on *Kharif* Pulses**	
	a. Coordination Unit	189.25
	b. Grant-in-aid	1344.46

Status of Implementation of SFC 2017-20 Three Year Plan (Upto 31.03.2022)

(₹ in lakh)

Head	Approvd outlay (B.E.)	Expenditure (31.03.22)
A. Recurring		
Pay & Allowances/Wages & Pension	3310.00	2536.69
TA	40.00	24.61
HRD	2.00	4.37
Contingency	658.00	607.69
Total	**4010.00**	**3173.36**
B. Non-Recurring		
Equipment, Information Technology	40.00	12.49
Furniture & Fixture Other	100.00	17.51
Works	150.00	117.86
Library	10.00	0.87
Total	**300.00**	**148.73**
C. TSP	**30.00**	**8.52**
TOTAL (A+B+C)	**4340.00**	**3330.60**

Crop Improvement

Institute Funded Project

Project 1: Development of biotic and abiotic stress resistant 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. **Variety developed:** Five chickpea varieties including three *desi* (IPC 2007-28, IPC 2010-134, IPC 2010-142) and two *kabuli* type (IPCK 2013-163, IPCK 09-145) varieties have been released and notified during 2021-22 for cultivation in NWPZ and Uttar Pradesh State.

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

1.2. **IPC 2010-134 (*Shiva*):** It is a *desi* chickpea variety derived from GNG 469/FG 711 cross and released/notified during 2021 for cultivation in Western and Bundelkhand of Uttar Pradesh under timely sown condition. It produced mean yield of 1706 kg/ha with registered of 13.0% yield superiority to the best check KWR 108. It matures in 125-135 days with resistant to wilt, moderately resistant to DRR, Ascochyta blight and BGM disease. It is medium seed size (23.0 g/100 - seed wt) with brown seed

1.3. **IPC 2007-28 (*Atal*):** It is a *desi* chickpea variety derived from DCP 92-3/JG 16 cross and released/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.

1.4. **IPC 2010-142 (*Kuber*):** It is a *desi* chickpea genotype derived from RSG 143-1/IPC 94-94 cross and release/notified during 2022 for cultivation in Western and Eastern region of Uttar Pradesh under timely sown condition. It 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 with resistance to wilt and moderately resistance to DRR, Ascochyta blight and BGM diseases. It has medium seed size (29.1 g of 100 - seed weight) and semi-erect growth with tall (65-75 cm PH).

1.5. **IPCK 2009-145 (*Kanchan*):** It is a *kabuli* chickpea variety derived from JGK 1/ ICC 17109 cross and and release/notified during 2022 for cultivation in Uttar Pradesh under timely sown conditions. It produced mean yield of 1203 kg/ha with registered of 15.23% yield superiority to the best check K 3256 (1044 kg/ha). It matures in 130-135 days with moderately resistant to wilt. It has large seed size (32.2 g of 100 - seed wt.) with creamy white seed colour.

2. **Proposal invited for release in Uttar Pradesh:**

2.1. **IPC 2012-108 (*Krishna*):** It is a *desi* chickpea genotype derived from IPC 94-94/IPC 02-120 cross and recommended for identification and release in Uttar Pradesh. The SATs were conducted under timely sown during 2019-21 at nine locations. It produced mean yield of 1630 kg/ha with registered of 6.36% & 21.82% yield superiority to the best checks KWR 108 (1533 kg/ha) & KPG 59 (1338 kg/ha), respectively. It matures in 133-136 days with resistance to wilt and moderately resistacet to DRR. It has large seed size (22.4 g of 100 - seed wt) with brown seed colour.

3. **Performance of breeding lines in AICRP trials:** A *desi* chickpea genotype IPC 15-132 has been promoted to AVT-2 (NEPZ). Total six chickpea genotypes with 5 *desi* and a *kabuli* were promoted to AVT-1 under different zones, such as IPC 18-59, IPC 17-351, IPC 18-39 (MHT) under NEPZ; IPCB 16-25 (TS) under ECZ; IPC 17-04 (RF) under WCZ and IPCK 16-

12 (*Kabuli*) under SZ. The seeds of ten chickpea entries *viz.*, IPC 18-90 & IPC 18-93 (TS), IPC 16-231 & IPC 17-166 (LS), IPC 17-54 & IPC 17-369 (RF), IPC 17-249 & IPC 18-132 (MHT), IPCK 14-125 & IPCK 18-185 (*Kabuli*) were nominated for evaluation under AICRP during 2022-23.

4. **Performance of breeding lines in different States:** Total 41 chickpea enties including 17, 10, 8 & 6 were evaluated in UP, MP, Jharkhand and Chhattisgarh, respectively during 2021-22.

✓ ***UP State trial:*** Total 17 ABLs (IPC 10-62, IPC 11-28, IPC 11-30, IPC 12-108, IPC 13-70, IPC 14-10, IPC 14-51, IPC 14-120, IPC 15-12, IPC 15-17, IPC 15-116, IPC 15-123, IPC 15-165, IPC 15-267, IPC 16-44, IPC 16-107, IPCK 11-37) are being evaluated under in UP SVT during 2022-23.

✓ ***Jharkhand trial:*** Total ten chickpea ABL (IPC 07-28, IPC 07-56, IPC 10-62, IPC 10-72, IPC 11-28, IPC 11-141, IPC 12-108, IPC 13-70, IPC 15-123, IPC 16-44) were evaluated at IARI-Jharkhand, Ranchi, Chiyanki. Based on mean yield, Entry IPC 10-62 (2322 kg/ha) was found top yielder followed by IPC 07-28 (2318 kg/ha), IPC 15-123 (2064 kg/ha), IPC 16-44 (2043 kg/ha), IPC 13-70 (2015 kg/ha), IPC 10-72 (1888 kg/ha), the best check BG 372 (1868 kg/ha) and yield superiority registered to the best check of 24.3%, 24.1%, 10.5%, 9.4%, 7.9% & 1.1%, respectively.

✓ ***Chhattisgarh trial:*** Total eight ABLs (IPC 15-12, IPC 16-107, IPC 16-44, IPC 10-134, IPC 15-123, IPC 11-28, IPC 15-133, IPC 15-17) were evaluated at IGKV, Raipur. Entry IPC 11-28 (855 kg/ha) was found top yielder followed by IPC 15-12 (853 kg/ha), IPC 15-123 (758 kg/ha), IPC 16-44 (745 kg/ha), the best check IPC 06-77 (760 kg/ha) and registered 12.3% yield superiority to the best check.

✓ ***Madhya Pradesh trial:*** Total six ABLs (IPC 05-62, IPC 10-134, IPC 15-12, IPC 15-17, IPC 15-133 and IPC 16-107) were evaluated during 2021-22 at Indore. Entry IPC 16-107 (1764 kg/ha) was found top yielder followed by IPC 10-134 (1333 kg/ha), the best check JG24 (1319 kg/ha) and registered 33.7% yield superiority to the check

5. **Evaluation of trait specific germplasm/wild relatives:** Two hundred fifty trait specific germplasm lines were evaluated and maintained. One hundred thirteen wild *Cicer* accessions belonging to 7 species with 42 *C. reticulatum*, 32 *C. judaicum*, 27 *C. pinnatifidum*, 6 *C. echinospermum*, 3 *C. cuneatum*, 2 *C. yamashitae* and 1 *C. bijugum* accessions were maintained in wide hybridization garden. Two thousand three hundred fifty four lines accessions are being maintained in medium term storage in cold module.

6. **Generation of breeding material:** The chickpea breeding material including trait specific donor, advanced lines, released varieties utilized in crossing. **Agronomic base** (BG 3043, GNG 1581, GNG 2144, GNG 2207, GJG 0814, GG 2, IPC 05-62, IPC 06-77, IPC 17-351, JAKI 9218, JG 11, JG 16, Vijay, PG 0405, RVG 202), **earliness** (IPC 08-83, ICC 96029, BGD 9971), **drought** (ICC 4958, RSG 888, Vijay), **heat** (JG 14, ICC 1205, ICC 15614), **salinity** (CSG 8962), **wilt** (GJG 0814, IPC 07-28, IPC 12-100, IPC 10-134, ICC 12237, GJG 0921, SA 1, JG 315), **DRR** (IPC 10-134, JSC 37), **AB** (ICC 3935, ICC 8933, ICC 9001, ICC 111321), **MHT** (HC 5, IPC 17-351, NBeG 47), **herbicide** (IPC 18-186, ICC 1205, ICC 11101, ICC 12315), **Zn/Fe** (ILWC 257), ***protein*** (T 39-1, ICC 8396), ***wild lines*** (ILWC 21, ILWC 142, ILWC 263), ***Kabuli*** (IPCK 02, PG 0517, KAK 2, IPCK 09-145, IPCK 12-143, IPCK 11-179, IPCK 13-163) were used to broaden genetic base.

✓ Fourty five crosses (JG 14/GNG 2207//IPC 17-351/GNG 0814, JG 14/GNG 0814//IPC 17-351/GNG 2207, IPC 17-351/GNG 2207//JG 14/JG 0814, IPC 17-351/GJG 0814//JG 14/GNG 2207, IPC 17-351/JG 14//IPC 06-77/Vijay, IPC 17-351/Vijay//IPC 06-77/JG 14, IPC 06-77/IPC 17-351//Vijay/JG 14, IPC 06-77/ GJG 0814//Vijay/GNG 2207, IPC 06-77/Vijay//IPC 17-351/JG 14, IPC 06-77/Vijay//IPC 17-351/JG 14, Vijay/GNG 2207//IPC 06-77/GJG 0814, Vijay/GJG 0814//IPC 06-77/GNG 2207, Vijay/IPC 17-351//IPC 06-77/JG 14, IPCK 09-145/KAK 2, IPCK 12-143/KAK 2, IPCK 11-179/KAK 2, GNG 1958/ RVG 203, E 100YM/ICC 15925, IPC 10-62/ICC 9001, HC5/GNG 469, HC 5/DCP 92-3, IPC 17-351/ E 100YM, E 100YM/IPC 17-35, ICC 5002/ICC 14447, IPC 20-98/E 100YM, E 100YM/JAKI 9218, HC5/CSG 8962, IPC 17-04/ICC 14872, IPC 06-77/BGD 9971, IPC 17-351/ICC 5168, IPC 06-77/PG 0405, IPC 17-351/ICC 14447, IPCK 02/PG 0517, JAKI 9218/ICC 5168, IPC 17-351/ICC 14334, ICC 14334/ICC 14872, ICC 14340/JAKI 9218, IPC 17-351/E 100YM, IPCK 02/IPCK 13-163, IPCK 02/ IPCK 09-145, RVG 203/ICC 5168, ICC 96030/BGD 9971, JAKI

9218/ICC 14340, IPC 07-28/ICC 14335, Flip 9-217C/EC 1097378) were made during 2021-22 at Kanpur.

✓ Total 20 crosses (IPC 19-139/IPC 19-250, IPC 20-198/ICC 14334, IPC 18-55/BGM 10216, IPC 20-198/ICC 14340, IPC 08-103/ICC 4969, IPC 19-250/ICC 12315, IPC 10-121/IPC 05-28, JAKI 9218/ BGD 9971, IPC 06-77/BGD 9971, GNG 469/IPC 05-59, BGD 9971/IPC 20-198, JSC 37/IPC 05-28, HC5/IPC 20-198, HC 5/IPC 05-62, HC 5/GNG 1958, JG 24/IPC 05-62, IPC 11-112/BGD 9971, IPC 10-62/ICC 8397, IPC 05-62/ICC 5168, IPC 10-62/IPC 10-121) were made during *Kharif* 2022 at ICAR-IIPR, RRC, Dharwad

7. Generation advancement: The generations were advanced during *Kharif* 2022 and *Rabi* 2021-22 at Dharwad and Kanpur, respectively. Total 60 F_1's derived from different crosses were raised for advancement and 236 SPS were harvested. Total **760** SPS including **43** F_2: 2 Line Bulk (LB) + 41 Plot Bulk (PB), **63** F_3: 313 SPS + 2 LB + 17 PB, **2** $4F_4$: 167 SPS + 6 PB, **65** F_5: 264 SPS + 9 LB, **13** F_6: 4 SPS + 27 LB; **17** F_7: 4 SPS + 49 LB + 12 PB, **3** F_8: 8 SPS + 1 LB were harvested based on targeted traits. Total 90LB and 65 PB were harvested for sharing with NARS partners

8. Evaluation of advance breeding lines: Total 372 breeding lines including 115 and 245 entries were evaluated and harvested as station trials (ST) & PYTs, respectively under timely sown (TS), late sown (LS), rainfed (RF), pre-breeding (PB), mechanical harvesting (MHT) *kabuli*, trait specific trials. A total of 115 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, 245 lines with 7 PYT were evaluated as PYT-1 (MHT), PYT-2A (PB), PYT-2B (Nutrition), PYT-3 (TS), PYT-4 (RF), PYT-5 (LS), PYT-6 (*Kabuli*). Total six Station trials (ST) with 115 ABLs were evaluated at Kanpur, Bhopal and Dharwad and 245 ABLs in 7 PYTs and trait specific trial were evaluated during 2021-22 at Kanpur, Bhopal and Dharwad. The details of trials are given below:

8.1. ST-1 (MHT): Total 23 entries with checks were tested at Kanpur, Bhopal, Dharwad. Based on mean yield, entry IPC 18-87 (3084 kg/ha, 66.7 cm) was top yielder followed by IPC 18-80 (3034 kg/ha, 68.7 cm), IPC 20-84 (2987 kg/ha, 73.1 cm), IPC 18-111 (2947 kg/ha, 59.7 cm), IPC 20-97 (2823 kg/ha, 66 cm), IPC 18-55 (2813 kg/ha, 71.2 cm), check JG 16 (2206 kg/ha, 55.4 cm).

8.2. ST-3 (TS): Total 23 entries with checks (GNG 2207, BG 3043, IPC 11-112) were evaluated during 2021-22. Entry IPC 19-93 (3500 kg/ha) was found top yielder followed by IPC 20-63 (3478 kg/ha), IPC 19-243 (3422 kg/ha), IPC 20-64 (3418 kg/ha), IPC 20-48 (3322 kg/ha), IPC 18-55 (3289 kg/ha), IPC 19-19 (3250 kg/ha) and the best check BG 3043 (3189 kg/ha).

8.3. ST-4 (RF): Total 23 entries with respective checks were evaluated during 2021-22 at Kanpur, Bhopal, Dharwad. Based on mean yield, entry IPC 19-250 (2628 kg/ha) was found top yielder followed by IPC 20-94 (2631 kg/ha), IPC 20-143 (2491 kg/ha), IPC 19-90 (2467 kg/ha), IPC 20-51 (2427 kg/ha), IPC 19-202 (2415 kg/ha) and the best check RSG 888 (1439 kg/ha).

8.4. ST-5 (LS): Total 23 entries with checks (KPG 59, BG 372, IPC 05-62) were evaluated during 2021-22. Entry IPC 19-32 (1994 kg/ha) was found top yielder followed by IPC 19-58 (1989 kg/ ha), IPC 20-77 (1850 kg/ha), IPC 19-126 (1839 kg/ha), IPC 20-88 (1767 kg/ha), IPC 19-47 (1750 kg/ha), IPC 20-51 (1744 kg/ha) and the best check IPC 05-62 (1656 kg/ha).

8.5. ST-6 (*Kabuli*): Total 18 entries with checks were tested at Kanpur, Bhopal, Dharwad. Based on mean yield, entry IPCK 10-124 (2755 kg/ha, 31.5 g/HSW) was found top yielder followed by IPCK 19-231 (2290 kg/ha, 36 g/HSW), IPCK 18-185 (2123 kg/ha, 38.1 g/HSW), IPCK 20-190 (2084 kg/ha, 40.9 g/HSW), IPCK 19-206 (2057 kg/ha, 34 g/HSW), IPCK 18-177 (2054 kg/ha, 39.8 g/HSW), IPCK 19-232 (2048 kg/ha, 39.5 g/HSW), check KAK 2 (1852 kg/ha, 36.6 g/HSW).

8.6. PYT–1 (MHT): Total 42 entries with checks (HC 5, GNG 2207, BG 3043) were evaluated during 2021-22. Entry IPC 20-158 (2433 kg/ha, 90 cm) was found top yielder followed by IPC 20-128 (2400 kg/ha, 77 cm), IPC 20-159 (2133 kg/ha, 68.3 cm), IPC 20-97 (2067 kg/ha, 85.7 cm), IPC 20-104 (2000 kg/ha, 56 cm) and the best check HC 5 (1933 kg/ha, 86 cm).

8.7. PYT-3 (TS): Total 23 entries with check (IPC 11-112, GNG 2207, BG 3043) were tested. Entry IPC 21-106 (2700 kg/ha) was found top yielder followed by IPC 21-105 (2500 kg/ha), IPC 20-

63 (2333 kg/ha), IPC 20-48 (2217kg/ha), IPC 21-104 (2200 kg/ha), the best check GNG 2207 (2083 kg/ha)

8.8. **PYT–4 (RF):** Total 53 entries with checks (IPC 11-112, RSG 888, BG 3043) were tested. Entry IPC 21-37 (2333 kg/ha) was found top yielder followed by IPC 20-130 (2000 kg/ha), IPC 21-41 (1967 kg/ha), IPC 21-42 (1933 kg/ha), IPC 21-13 (1833 kg/ha) and check BG 3043 (1633 kg/ha).

8.9. **PYT–5 (LS):** Total 39 entries with checks (BG 372, KPG 59, IPC 05-62) were tested and entry IPC 20-115 (1933 kg/ha) was found top yielder followed by IPC 20-123 (1900 kg/ha), IPC 20-143 (1833 kg/ha), IPC 21-14 (1817 kg/ha), IPC 20-135 (1733 kg/ha), check IPC 05-62 (1700 kg/ha).

8.10. **PYT–6 (*Kabuli*):** Total 18 entries with checks (KAK 2, IPC 02-29, PG 0517) were tested. Entry IPCK 20-219 (3100 kg/ha, 47.4g/HSW) was found top yielder followed by IPCK 20-223 (2317 kg/ha, 29.9 g/HSW), IPCK 14-125 (2283 kg/ha, 32.5 g/HSW), IPCK 20-18 (2200 kg/ha, 38.3 g/SW), IPCK 20-222 (2183 kg/ha, 37.9 g/HSW), the best check IPCK 02-29 (2083 kg/ha, 32.3 g/HSW).

9. **Development of mapping population for drought/nutritional quality:** Five populations for drought/nutritional quality, IPC 04-98/T 39-1 (F_6 305), JAKI 9218/T 39-1 (F_5 200), JG 16/T 39-1 (F_5 188), DCP 92-3/T 39-1 (F_5 189), ICC 4958/T 39-1 (F_5 192) were harvested

10. **Phenotyping against biotic stresses:** Total 81 ABLs were screened for wilt (race-2) under sick plot and three entries (IPC 20-52, IPC 21-54, T 39-1) showed resistant and while 22 lines (IPC 20-181, IPC 94-94, IPC 20-115, IPC 97-29, IPC 20-124, IPC 20-58, IPC 20-123, IPC 20-146, IPC 21-110, IPC 21-31, IPC 21-46, IPC 21-49, IPC 21-104, IPC 21-21, IPC 21-64, IPC 21-47, IPC 21-38, IPC 21-103, IPC 21-108, IPC 21-109, IPC 21-113, Sadabahar) exhibited moderatly resistant to wilt. 10 lines (IPC 07-28, IPC 08-69, IPC 08-11, IPCK 13-163, IPC 10-134, IPC 16-134, IPC 17-10, IPC 15-185, IPC 15-48, IPC 14-133) were showed resistance to wilt under AICRP. Eight lines and wild *Cicer* (ICC 17151, ICC 182, ILWC 30, ILWC 95, ILWC 50, ILWC 182, ILWC 188, ILWC 223) showed resistance to Ascochyta blight. Similarly, 5 lines (IPC 17-303, IPCK 18-187, IPC 15-185, IPC 14-133, IPC 05-28) were showed moderately resistance to DRR in AICRP.

11. **Phenotyping against heat stress:** Total 60 chickpea breeding lines with checks (JG 14, DCP 92-3) were raised on 05 January, 2022 for screening to heat (>35°C). Five plants were selected from each lines and screening based on semi-erect plant, high podding and seed setting in terminal pods of plant under day temperature >35 C. Twenty two lines were found promising and tolerant to heat with regards of seed setting and yield ranged from 1646 to 2188 kg/ha (IPC 19-90, IPC 20-94, IPC 16-25, IPC 12-31, IPC 18-59, IPC 16-95, IPC 18-48, IPC 17-129, IPC 20-134, IPC 19-32, IPC 20-143, IPC 19-67, IPC 20-89, IPC 15-48, IPC 17-351, IPC 15-146, IPC 18-111, IPC 18-87, IPC 20-51, IPC 17-256, IPC 20-176, IPC 17-308).

12. **Evaluation of International Nurseries:** ICVT (*desi*) was evaluated during 2021-22 and entry ICCV 211104 (1839 kg/ha) was found top yielder followed by ICCV 211105 (1719 kg/ha), ICCV 211113 (1703 kg/ha), ICCV 211116 (1688 kg/ha), check RVG 204 (1495 kg/ha) with registered of 23.0% yield superiority to check.

13. **Maintenance breeding:** A total of 1926 SPS were harvested from 12 chickpea varieties for maintaining genetic purity. Total 1626 kg nucleus seed of chickpea varieties including IPC 06-77 (357.9 kg), IPC 05-62 (235.3 kg), IPC 04-98 (53.8 kg), IPC 04-01 (66.4 kg), IPC 11-112 (333.2 kg), IPC 07-28 (109.2 kg), IPC 10-134 (120.5 kg), IPCL 4-14 (75.0 kg), IPCK 13-163 (119.4 kg), IPCK 02-29 (43.2 kg), IPCK 04-29 (43.6 kg), DCP 92-3 (69.1 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. **Breeding material:** Total 53 crosses among parents possessing resistance to soil borne (Wilt, DRR) and foliar diseases (AB), GNG 2171/IC 275447//CSJ 515/DKG 964, GNG 2207/DKG 964// CSJ 515/IC 218147, BG 3022/IC 248147, CSJ 515/IC 275447, GNG 2171/IC 248147, L 550/PBG 8, GNG 2171/PBG 8, L 550/IC 117744, L 550/IC 248147, AKG 1303/CSJ 556, AKG 1303/JG 24, BGD 99-71/JG 24, CSJ 556/PG 0405, IPC 05-28/AKG 1303, JAKI 9218/CSJ 556, JAKI 9218/IPC 05-28, JAKI 9218/JG 24, JAKI 9218/JSC 37, JG 24/AKG 1303, PG 0405/JG 24, JSC 37/JAKI 9218, PG 0405/ CSJ 556, CSJ

515/IPC 15-48, GNG 2372/IPC 10-121, GNG 2171/IPC 16-136, GNG 2171/IPC 14-51, GNG 2171/DKG 964, CSJ 515/IPC 16-148, GNG 2461/IPC 10-121, GNG 2461/IPC 08-69, GNG 2461/DKG 964, GNG 2372/JG 315, IPC 14-51/GNG 2171, IPC 16-136/GNG 2171, GNG 2207/IPC 15-122, GNG 2207/IPC 07-28, GNG 2461/JG 315, GNG 2264/IPC 10-121, GNG 2264/IPC 16-156, GNG 2299/DKG 964, GNG 2299/IPC 08-69, JG 16/GJG 0814, JG 24/ICC 14340//ICC 14340, JG 24/ ICC 14340//JG 24, JG 24/ICC 14872/ICC 14872, JG 24/ICC 14340, JG 24/ICC 14872//JG 24, PG 0405/GJG 0921/ /AKG 1303/BGM 20213, AKG 1303/BGM 20212, JG 24/ICC 14872, BGM 20212/PG 0405, JAKI 9218/BGM 20212, PG 0405/BGM 20212 were made

2. **Generation advancement:** Total 45 F_1 were advanced to F_2 and SPS from each cross harvested separately. Total 1709 SPS including 42 $\mathbf{F_2}$: 395 SPS, 57 $\mathbf{F_3}$: 515 SPS, 31 $\mathbf{F_4}$: 270 SPS, 31 $\mathbf{F_5}$: 227 SPS and 50 line bulks from 32F_7 crosses were harvested separately. During off season, 12 fresh crosses among parents possessing stable resistance against DRR and wilt were developed and 9 F_1 crosses were advanced to F_2 and 21 F_2 crosses were advanced to F_3.

3. **Evaluation of breeding lines:** Entry IPC 19-222 is nominated for IVT (RF) under AICRP during 2021-22. A Station Trial (RF) was conducted with 20 entries and checks at Kanpur, Bhopal, Dharwad. Entry IPC20-208 performed well at Kanpur and Bhopal and selected for nomination to IVT (RF). PYT was conducted with 49 entries under irrigated condition at Kanpur and 36 entries under rainfed condition at Kanpur, Bhopal, Dharwad. The following entries were selected for station trial *viz*., IPC 21-117, IPC 21-123, IPC 21-130, IPC 21-137, IPC 21-128, IPC 21-150 (TS); IPC 21-162, IPC 21-148, IPC 21-146, IPC 21-155, IPC 21-152 (MHT) and IPC 21-157, IPC 21-153, IPC 21-118, IPC 21-134, IPC 21-147, IPC 21-126 (RF) to be conducted in 2022-23.

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_6 for developing mapping populations for dry root rot resistance

5. **Phenotyping to biotic stresses:** Total 204 wilt resistant plants selected from 31 crosses in F_3 & F_4 from wilt sick plot. Total 101 resistant plants from 20 crosses in F_3, GL 13001/DKG 964, GL 13001/IPC 08-69, GL 13001/IPC 12-98, GNG 2207/DKG 964, GNG 2207/IPC 08-69, GNG 2207 /IPC 12-98, GNG 2264/DKG 964, GNG 2264/IPC 08-69, JAKI 9218/MABCWRSA 1, GNG 2299/ DKG 964, GNG 2299/IPC 10-134, GNG 2299/IPC 07-28, JAKI 9218/GJG 0814, PG 0405/MABC 66-266, JAKI 9218/SGPWR 30, JG 16/DKG 964, JG 16/GJG 0922, PG 0405/GJG 0904, PG 0405/GJG 0921, JG 16/GJG 0814. One hundred three plants from 11 crosses in F_4, JG 37//(IPC 06-88/ILWC 179), (IPC 10-134/JG 24)//IPC 07-28, JG 315/RSG 888, IPC 07-28//(IPC 10-134/JG 24), DKG 964//(GNG 1958/ JSC 37), IPC 10-134/IPC 07-28, IPC 07-28//(IPC 10-134/DKG 964), (GNG 1958/IPC 05-28)//DKG 964, (IPC 10-134/DKG 964)//(IPC 05-28/JSC 37), IPC 10-134/GNG 2226, IPC 05-28/JSC 37 were selected. Similarly, 49 ABL were screened for wilt (race-2) under sick plot and three entries (IPC 21-144, IPC 21-143, IPC 21-142) showed resistance, while seven lines (IPC 21-131, IPC 21-146, IPC 21-159, IPC 21-130, IPC 21-145, IPC 21-132, IPC 21-150) exhibited moderately resistant to wilt. Likewise, 49 ABLs were screened for *Ascochyta* blight resistance under controlled condition and 11 entries (IPC 21-120, IPC 21-145, IPC 21-114, IPC 21-116, IPC 21-146, IPC 21-121, IPC 21-142, IPC 21-115, IPC 21-122, IPC 21-143, IPC 21-149) showed moderately resistant to Ascochyta blight.

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

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

2. **Generated breeding material:** Total 15 crosses IPC 06-77/IPC 17-351)//(Vijay/JG 14), (IPC 06-77/JG 14)//(Vijay/IPC 17-351), (IPC 06-77/GNG 2207)//(Vijay/GJG 0814), (IPC 06-77/GJG 0814// (Vijay/GNG 2207), (IPC 17-351/ICC 8397)//(JG 14/PG 0405), (BG 372/ICCV 92944)//BG 372, HC5 /CSG 8962, (JG 11/ICC 15925)//JG 11, (GG 2/ICC 4958)//(JG 11/RVG 203), 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* 2021-22.

3. **Generation advancement:** Total F_1 population derived from 15 crosses were advanced to F_2 and SPS and harvested separately. The generation advancement of F_2, F_3, F_4, F_5, F_6 & F_7 population derived from 30, 50, 30, 18, 10 & 15 crosses and SPS & line bulk were harvested.

4. **Evaluation of advance breeding lines:** A station trial with 27 entries was evaluated under normal and late sown condition, two entries (IPC 14-55, IPC 15-33) showed superior to checks (JG 14, KWR 108, GNG 2207, BGD 372, KPG 59) under normal, while three entries (IPC 15-44, IPC 14-88, IPC 11-78) under late sown condition. Other physiological and phenological traits also recorded for these genotypes. Similarly, PYT trials with 40 entries were evaluated. Entry IPC 21-04 (4277 kg/ha) was found top yielder followed by IPC 21-16 (4250 kg/ha), IPC 21-26 (4055 kg/ha), IPC 21-31(4016 kg/ha), IPC 21-35 (3955 kg/ha), IPC 21-39 (3900 kg/ha), IPC 21-37 (3872 kg/ha), IPC 21-13 (3638 kg/ha), IPC 21-17 & IPC 21-24 (3444 kg/ha) and the best check GNG 2207 (3100 kg/ha). Total 15 genotypes were evaluated under rainfed rice-fallow. Based on yield and other traits, four genotypes (IPC 11-92, IPC 11-78, IPC 14-55, IPC 14-88) were found promising.

5. **Development of mapping population:** Four mapping populations, DCP 92-3/ICC 92944 **(F_7, 225)**, JG 315/ICC 92944 **(F_7, 232)**, JG 11/ICC 1205 **(F_7, 215)**, ICC 15614/ICC 4567 **(F_5, 270)** for heat tolerant were advanced. The mapping populations *viz.*, JG 315/ICCV 92944, JG 11/ICC 1205, DCP 92-3/ICC 1205, ICC 15614/ICC 4567 have been characterized for various phenological and yield related traits under normal and late sown conditions during 2021-22. QTL seq of selected 10 heat tolerant and heat sensitive lines uncovered three major heat tolerant QTLs *CaqH5.1, CaqH5.2, CaqH6.1* were uncovered. Selected underlying candidate genes (*Ca_02170, Ca_16631, Ca_23016, Ca_09743, Ca_25602, Ca_08536, Ca_17680*) were also validated through RT-PCR for expression of genes in normal and late sown. The genes showed upregulation under heat stress condition suggesting their important role in controlling in heat stress tolerance.

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

1. **Genetic stocks registered:** Chickpea genotype **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 NBPGR. Morphologically distinct lines identified in landrace T 39-1 (ICC 5912), a high protein line with heat susceptibility were evaluated and selected lines to be tested for protein content.

2. **Generation of breeding material:** Ten crosses were made during 2021-22 for enhancement of grain quality in chickpea targeting traits (grain quality traits): Soaking time (2), Potential *dal* recovery (3), high protein (4) and green seed (1). F0 (10): HC 5/CSG 8962, GNG 1958/RVG 203, HC 5/DCP 92-3, ILWC 21/GNG 469, HC 5/GNG 469, IPC 08-103/ICC 4969, IPC 05-62/ICC 5168, IPC 17-351/ICC 5168, JAKI 9218/ICC 5168, RVG 203/ ICC 5168.

3. **Generation advancement:**

- ✓ **F_1 (6):** 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)
- ✓ **F_2 (8):** IPC 08-103/T 39-1, GNG 2207/IPC 05-62, T 39-1/T 1-A, IPC 05-62/ILWC 257, IPC 06-77/ ILWC 257, T 1-A/ILWC 257, T 39-1/ILWC 257, (KWR 108/ILWC 257)//(ICC 96030/ICCV 96029)
- ✓ **F_3 (3):** IPC 10-134/T 39-1, CSG 8962/T 39-1, CSG 8962/T 1-A
- ✓ **F_4 (4):** ICC 4958/T 39-1, BGD 9971/T 39-1, CSG 8962/T 39-1, CSG 8962/T 1-A
- ✓ **F_5 (10):** CSG 8962/T 39-1, T 39-1/NEC 755, BG 372/T 39-1, NEC 755/T 1-A, IPC 04-98/T 39-1, HC 5/T 39-1, P 3318/T 39-1, ICC 4958/T 39-1, P 3719/ P 3318, T 39-1/T 1-A
- ✓ **F_6 (12):** T 39-1/ICC 5912, CSG 8962/T 39-1, T 39-1/ICC 4958, T 39-1/T 1-A, T 1-A/P 3318, T 39-1/ P 3318, T 1-A/T 39-1, IPCK 02-29/P 3318, ICC 4958/T 39-1, NEC 755/T 1-A, JAKI 9218/T 39-1, T 39-1/ICC 4958, (DCP 93-2/ T 39-1)/JG 130

✓ **F_7 (3):** IPC 04-98/T 39-1, JG 130/T 39-1, DCP 92-3/T 39-1

4. **Evaluation of advanced breeding lines:** Fifty eight ABLs (F_6) of *desi* chickpea with enhanced seed protein content were evaluated during 2021-22. Eleven potential lines identified with desirable grain quality, protein content ≥26% and yield up to 22 q/ha. Potential entries (GY≥ 22q/ha) identified: DT 19, IPT 4, DT 4, DT 20, ICC 4958, T 4, DT 16, J 16T14, IPT 28, IPT 2, IPT 14.

4.1. **PYT–2B (Nutrition):** Total 39 ABLs with improved grain quality (high protein content and retention of greenness on cooking) and checks were evaluated. Five lines succeeded over the best check and two entries (IPC 21-53, IPC 21-114) with yield >20 q/ha. Potential ABLs identified in PYT 2 (Nutrition/grain quality): IPC 21-53, IPC 21-73, IPC 21-78, IPC 21-80, IPC 21-54, IPC 20-133, IPC 21-77, IPC 20-07, IPC 20-11, IPC 20-14, IPC 21-55, IPC 21-76, IPC 20-03.

5. **Development of mapping population:** Five mapping populations were developed for nutritional quality in chickpea *viz., Grain Protein:* JAKI 9218/T 39-1 (F_6, n=356), JG 16/T 39-1 (F_6, n=210), DCP 92-3/T 39-1 (F_6, n=260), ICC 4958/T 39-1 (F_6, n=228), *Grain protein and Bulk density:* IPC 04-98/T 39-1 (F_7, n=354). Similarly, 58 advanced lines (F_6) with enhanced seed protein content were evaluated under field conditions. Eleven potential lines identified with desirable grain quality, protein content ≥26% and yield up to 22 q/ha. Potential entries (GY≥ 22 q/ha) identified: DT 19, IPT 4, DT 4, DT 20, ICC 4958T 4, DT 16, J 16T14, IPT 28, IPT 2, IPT 14.

B. Pigeonpea

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

1. **Promising entries in AICRP and UP SATs:** During reporting period, entry IPA 19-26 has been evaluated in AVT-2 and IPAL 20-24 in AVT-1 trial of AICRP. During *Kharif* 2022 four entries have been nominated for multi-location testing. Similarly, under UP state adoptive trials, IPA 9-1 and IPA 13-1 are in AVT-2 and five entries *viz.,* IPA 14-2, IPA 14-4a, IPA 14-6, IPA 7-2 and IPA 18-33 were tested under AVT-1. Four new entries were nominated for UP SAT and two entries namely IPA 15-21 and IPA 19-26 were also contributed to Jharkhand state adoptive trials.

2. **Station trials conducted:** Two trials with 19 test entries and checks (IPA 15-2, IPA 203, MA 6, IPA 206) were conducted. In ST-1, 6 entries IPAL 21-1 (32.8 q/ha), IPAL 21-4 (36.3 q/ha), IPAL 21-5 (30.4 q/ha), IPAL 21-9 (30.8 q/ha), IPAL 21-11 (29.3 q/ha), IPAL 21-17 (33.1 q/ha) were out yielded checks IPA 15-2 (21.02 q/ha), IPA 203 (23.8 q/ha), MA6 (29.1 q/ha), IPA 206 (28.9 q/ha). Likewise in station trial-2 conducted at NRC, 5 entries IPAL 21-24 (29.9 q/ha), IPAL 21-26 (33.3 q/ha), IPAL 21-27 (31.6 q/ha), IPAL 21-32 (32.7 q/ha), IPAL 21-34 (29.9) were out yielded the check,, IPA 15-2 (22.4 q/ha), IPA 203 (29.3 q/ha), MA 6 (26.9 q/ha), IPA 206 (24.5 q/ha)

3. **Evaluation of breeding lines for yield and yield traits:** A set of 384 pure lines selected from different crosses of F_7 generations were subjected for evaluation of grain yield and yield attributing traits. Of the total lines, 186 lines have yielded more than 20 q/ha grain yield. The selected high yielding lines were selected for PYT trials of *Kharif* 2022.

4. **Generation advancement:** Total 8 F_1 crosses were developed using diverse donors having wilt, SMD and PSB resistance with climate resilient traits. Fourteen F_2 generation populations were advanced each population was having around 250-300 plants. SPS from 15 F_3 (403 SPS), in 8 F_4 (315 SPS), in 33 F_5 (676 SPS), in 43 F_6 (1822 SPS) were advanced for generation advancement.

5. **Sharing of breeding materials for screening to wilt under sick field:** A total of 1014 advanced generation breeding lines comprising of pre-breeding fixed lines were shared with Dr. RK Mishra, Pigeonpea Pathologist during *Kharif* 2022.

6. **Nucleus seed production:** IPA 203 (60 kg), IPA 206 (40 kg); IPA 15-2 (25 kg)

7. **Seed multiplication of IVT/AVT entries:** 11 AICRP lines (55 kg) and 9 in UP SAT lines (45 kg)

8. **Trait specific donors:** IPAV 16-1: 2 kg, IPAC 79: 2 kg, IPAcliesto 10: 2 kg

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

1. **Promising entries in AICRP and state adoptive trials:** Entry IPAEE 20-5 has been evaluated in AVT-1 (extra early) and IPAE 19-4 & IPAE 19-15 (early) AVT-1 trial. Similarly, IPAE 15-8 & IPAE 15-05 were tested in early AVT-2 of central zone. Four entries (IPAEE 19-12, IPAEE 19-21, IPAEE 19-22 & IPAEE 20-9) were nominated under extra early maturity group and three entries (IPAME 18-06, IPAME 15-06 & IPAME 19-15) under mid early duration under AICRP trials.

2. **Station trials conducted:** Three station trials were conducted with 20 entries each in extra early, early and mid-early maturing pigeonpea along with three checks. In extra early station trial, three entries, IPAEE 21-2 (16.78 q/ha), IPAEE 21-6 (16.75 q/ha) and IPAEE 21-9 (16.27 q/ha) were out yielded over check Pusa Arhar 16 (10.74 q/ha), Pant Arhar 6 (13.68 q/ha). Likewise in early station trial, five entries namely IPAE 21-5 (19.93 q/ha), IPAE 21-6 (20.01 q/ha), IPAE 21-11 (21.17 q/ha), IPAE 21-13 (22.41 q/ha), IPAL 21-17 (20.17 q/ha) were outyielded the check entries *viz.*, UPAS 120 (16.27 q/ha), Pusa Arhar 18-2 (16.21 q/ha) and IPA 15-6 (19.87 q/ha).

3. **Generation advancement:** Total 13 F_1 crosses were advanced to F_2 generations and 21 F_2 populations were advanced to next generation. 18 F_3 generation crosses comprising of 298 SPS, 16 F_4 generation crosses comprising of 654 SPS, 20 F_5 generation crosses comprising of 384 SPS, 5 F_6 generation crosses: AL1992/Dholi dwarf (119 SPS), PAU 881/Dholi dwarf (24 SPS), Pusa 992/Dholi Dwarf (29 SPS), IPA 9F/Dholi dwarf (5 SPS), UPAS 120/(ICPL 20340/ ICP 15739) (64 SPS) and 4 F_7 generation crosses namely UPAS 120/Dholi dwarf (314 SPS), Ranchi Local/D. Dwarf (55 SPS), Ranchi local/Asha (9) were advanced for generation advancement.

4. **Trait specific genotypes maintained:** Extra-large seed (IPAV 16-01), extra bold (IPAV 16-01), water logging tolerance (IPAC 79), closed flower (IPA Cliesto 10, IPA Cliesto 39), extra early(IPAE 19-21, MN5-NDT), early (Pusa Arhar 16), PSB res (IPAC 2, IPAC 3, IPAB 7-2-1-7), PSB res/brown seed (KPBR 80-2-1), PSB res/creamy seed (KPBR 80-2-1), PSB res/dark purple seed (KPBR 80-2-1), wilt res (DPPA 85-01, DPPA 85-03, DPPA 85-05, DPPA 85-07, DPPA 85-08, DPPA 85-12, DPPA 85-13, DPPA 85-14, DPPA 85-16, IPAC 66, IPAC 67, IPAC 68, IPA 10 W 12, IPA 10W1-8, IPA 12W26-01, IPA 8F, IPA 15F, IPA 16F, KPL 43, KPL 44), wilt res/black seed (IPAL 20-05), IPA 37, IPA 37-1, IPA 37-2, dwarf (IPADWARF1, IPADWARF-1-IPS, IPADW ARF 2, IPADWARF3), low chlorophyll (IPA 21-15, IPA 21-13), dark chlorophyll (IPA 21-33).

5. **Maintenance breeding:** Under maintenance breeding, 94 kg of nucleus seed of IPA 15-6 was produced and handed over to seed unit for further multiplication of breeder seed. A set of 105 extra early and early parents were maintained under selfing net to ensure genetic purity.

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

1. **Development of New CMS lines:** Back crosses were attempted using Pant Arhar 6 and Pusa arhar 16 as to generate new A2 and A4 early and extra early maturing CMS lines. Marker assay was done to confirm the A2 and A4 cytoplasms.

S N	Crosses name	No. of seeds	Generation
1	[(ICPL 2047A / Pant Arhar 6) / / Pant Arhar 6]	1017	BC_1F_1
2	[(ICPL 2047A / Pusa arhar 16) / / Pusa Arhar 16]	441	BC_1F_1
3	[(GT 288A / Pant Arhar 6) / / Pant Arhar 6]	459	BC_1F_1
4	[(GT 288A / Pusa arhar 16) / / Pusa Arhar 16]	250	BC_1F_1

C. Lentil

C.1. Genetic improvement for higher yield along with other triats suitable for different lentil growing areas

1. Variety developed

1.1. **IPL 230:** This lentil variety has been developed through hybridization (IPL 522/DPL 62) and released for cultivation in Uttar Pradesh. It has yield superiority of 19.5% over check KLS 218

under normal sown conditions with mean yield 1320 kg/ha. It is early maturing variety (110-115 days maturity) with small seed size (2.4 g/100-seed weight) and red cotyledons. This variety has resistance to rust and tolerance to *Fusarium* wilt disease.

2. **Performance of breeding lines in AICRP trials**: Six entries were evaluated in AVT-1 during 2021-22 and none of them performed well. Among eight IVT entries [IPL 243, IPL 244 (small seeded), IPL 349, IPL 350, IPLRS 703, IPLRS 704 (large seeded) and IPL 607, IPL 608 (rice fallow)], four entries were promoted for evaluation in AVT-1 during 2022-23.

3. **Entries in UP State Adaptive Trials (SAT):** A small seeded (IPLS 241), two large seeded (IPL 348, IPL 701) and two late sown (IPL 605, IPL 606) entries were promoted to AVT-1 for evaluation during 2022-23. Eight entries (IPL 242, IPL 243, IPL 244, IPL 702, IPL 801, IPL 542, IPL 607, IPL 608) are being evaluated in IVT during *Rabi* 2022-23.

4. **Evaluation of breeding lines:** Two station trials with 15 entries each and PYT (60 entries) were evaluated. In ST-I, 2 entries (IPL 1946104, IPL 19-105) with mean yield ranges from 2261 to 2349 kg/ha were identified promising over check IPL 316 (2166 kg/ha). The highest yielding entry IPL 19-105 showed flowering (67 days) and maturity in 127 days, while its harvest index was 0.40. In ST-II, seven small seeded (IPL 19-50, IPL 19-264, IPL 19-181, IPL 131053, IPL 19-258) were identified promising with mean yield ranging from 1984 to 2110 kg/ha over check IPL 220 (1887 kg/ha). In PYT, 10 best entries (IPL 20-248, IPL 20-258, IPL 20-260, IPL 20-247, IPL 20-249, IPL 20-253, IPL 20-257, IPL 20-251, IPL 20-252, IPL 20-259) were identified promising over check IPL 534 having average yield ranging from 2524-2952 kg/ha. The highest yielded entry (IPL 20-259) was small seeded with 2.2 g/100 - seed and yield 2952 kg/ha with maturity of 123 days.

5. **Generation of breeding material:** During 2021-22, 31 crosses including multi-parent crosses [IPL 406/IG 4258, IPL 406/IPL 98/193, IPL 406/L 4710, IPL 406/SLLOPEL, IPL 534/ L 4710, IPL 316/IG 98/193, IPL 316/L 4710, IPL 608/IG 54, IPL 608/IPLPBR-1, Kota M3/IPL 534, Kota M3 / IPL 316, Kota M3/ L 4710, I G54/L 9-12, Kota M3/IPL 406, Kota M1/L4 710, Kota M1/IPL 406, Kota M1/IPL 534, Kota M1/IPL 316, Kota M2/IPL 316, Kota M2/IPL 406, Kota M2/L 4710, Kota M2/IPL 534, IPLPBR-1/L 9-12, IPL 238/IPL 608, IPL 608/L 4710, IPL 220/IPL 98/193, DPL 62/ IPL 98/193, IPL 220/IG 4258, DPL 62/IG 4258, (IPLS 9-23/DPL 62)//BARI-5}//ILWL 131, IPL 406/ ILWL 131] were attempted among elite breeding lines having wider adaptability, heat tolerance, wilt resistance, drought tolerance, seed size, heat, lodging tolerance and new plant types.

F_1s seed were grown derived from 26 crosses including multi-parents [IG 54/IPL 321, IG 54/IPL 329, IPL 220/IPL 98/193, IPL 230/IPL 406, IPL 230/IPL 62, IPL 315/IG 4258, IPL 315/IPL 98/193, 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/MH 36119, IPL 406/SLLOPFL, IPL 220/IG 4258, IPL 220/IPLPBR-1, L 9-12/IPLPBR-1]. Total 186 F_1 plants were generated from these crosses. The SPS were selected from 28 F_2 (334 + 3 bulks), 26F_3 (637 SPS), 29 F_4 (293 SPS), 9F_5 (110 SPS) and 250 progenies of 21 F_6 were bulked for yield evaluation. These breeding materials were advanced to next generation and 60 improved breeding lines have higher yield potential (270-389 g/line) selected from F_6 bulk progenies are being evaluated in PYT during 2022-23. One F_6 line (IPL 21-40) was selected directly for evaluation in ST due to the highest yield 525 g/line (2916 kg/ha).

6. **Development of mapping populations:** Trait specific RIL mapping populations for root traits (IPL 98/193/EC 208362) having 200 RILs has also been maintained and evaluated for yield traits.

7. **Nucleus seed production:** Total 635 kg nucleus seeds of seven released varieties (IPL 526, IPL 220, IPL 321, IPL 315, IPL 534, IPL 225 and IPL 329) were produced and 6800 single plants of above varieties were selected for next year nucleus seed production.

D. Urdbean

D.1. Genetic enhancement of pulses for grain yield, quality and multiple stresses resistance in urdbean

1. Variety developed

1.1. IPU 19-10: This variety has been tested with three checks (IPU 13-1, IPU 10-26, KU 96-3) and yield superiority of 16.61% showed at all locations of MP. It has wider adaptability and suitable for spring cultivation across different agro-climatic regions of MP. It is also tested in IVT & AVT-1 during spring 2020 & 2021 under AICRP and yield varied from 802 to 2130 kg/ha. It is resistant to MYMV, Urdbean Leaf Crinkle Virus (ULCV), Leaf Curl Virus (CLV), Web Blight (WB), Bactrerial Leaf Blight (BLB), Powdery Mildew (PM) and Cercospora Leaf Spot (CLS), white fly, pod borer and pod bug. It is early maturing (74 days), tolerant to pod shattering. IPU 19-10 has black seed colour, medium large seed (4.87 g/100 seeds) with high protein (20.27%).

1.2. IPU 17-2: This variety has been tested with three checks (IPU 13-1, IPU 10-26, KU 96-3) and yield superiority of 18.33% showed at all the locations of MP. It has wider adaptability and suitable for cultivation across different agro-climatic regions of MP. It is also tested in IVT during summer 2021 & 2018-19 under AICRP and yield varied from 692 kg/ha to 1369 kg/ha. Entry IPU 17-2 was exhibited multiple disease resistance under AICRP. It is resistant to MYMV, ULCV, LCV, WB, BLB, PM, CLS, white fly, pod borer and pod bug insects under field conditions. It is early maturing (73 days) and medium large seeds (4.90 g/100 seed) with high protein content (22.14%).

2. Promotion of entries under AICRP and UPSAT: Based on yield performance, entry IPU 13-6 has been promoted to AVT-1 under NEPZ. Eight entries are being tested in IVT under AICRP for their yield performance. Based on yield superiority, entry IPU 18-02 was identified by UP Identification Committee for released in the cultivation during spring in Uttar Pradesh.

3. Hybridization and advancing of segregating generations:

a) Generation of breeding material: Twenty crosses were obtained involving diverse breeding lines or parents, IPU 13-1/VBN-3, IPU 13-1/*V. sylvestris*, IPU 13-1/*V. sublobata* (W107), IPU 13-1/*V. sublobata* (W51), IPU 13-1/IPU 19-27, IPU 13-1/IPU 94-1, IPU 13-1/KUG 479, IPU 11-02/IPU 19-27, IPU 11-02/LBG 752, IPU 11-02/Pratap Urd-1, IPU 11-02/VBN-8, IPU 02-43/LBG 752, IPU 02-43/IPU 19-27, IPU 94-1/*V. sublobata* (W107), IPU 94-1/Shekhar-3, IPU 94-1/KPU 405, IPU 94-1/LBG 787, IPU 94-1/IPU 19-27, IPU 21-11/IPU 19-27, IPU 21-11/IPU 13-1 and harvested pods.

b) Advancement of segregating generations:

✓ F_1's of 22 crosses (IPU 12-5/IPU 13-1, IPU 17-1/IPU 13-1, Shekar-3/IPU 94-1, KUG 96-3/IPU 17-1, ADT-3/IPU 94-1, MASH 114/IPU 17-1, LBG 752/IPU 94-1, TU 94-2/IPU 10-30, KU 96-3/IPU 13-1, NUL 7/IPU 94-1, IPU 19-27/IPU 17-1, 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, IPU 94-1/IPU 17-1, IPU 94-1/IPU 19-27, IPU 02-43/PM 6, BDU 1/*V sylvestris*//IPU 94-1) were harvested.

✓ **F_2's:** Thirty two crosses were raised (wild urd/IPU 19-53, IPU 19-53/*V sylvestris*, IPU 19-53/IPU 19-27, LBG 787/LBG 17, IPU 94-1/IPU 19-53, IPU 94-1/IPU 19-27, DPU 88-31/wild urd, IPU 94-1/small wild urd, IPU 19-27/Mukundra urd-2, IPU 94-1/*V umbellata*, DPU 88-31/*V sublobata* (W51), IPU 02-43/*V sylvestris*, IPU 11-02/*V sylvestris*, small wild urd/IPU 94-1, IPU 94-1/*V sublobata* (W 39), LBG 17/IPU 02-43, LBG 685/LBG 17, IPU 11-02/Lalitpur local, KUG 489/Barabanki local, DPU 88-31/Mukundra urd-2, IPU 11-02/PM 6, PU 19/IPU 99-55, IPU 02-43/LBG 17, T 9/LBG 17, IPU 94-1/Lalitpur local, PKGU 1/IPU 99-95, IPU 94-1/PLU 272, IPU 19-27/IPU 19-53, IPU 94-1/*V trilobata*, IPU 19-53/*V dalziana*, IPU 94-1/*V sublobata* (W-51), IPU 94-1/Jalpaiguri local.

✓ **F_3's:** Eight crosses have been grown in this generation (IPU 19-27/Jalpaiguri Local, IPU 19-27/IPU 11-02, IPU 19-27/IPU 19-53, IPU 94-1/IPU 19-27, IPU 94-1/Jalpaiguri Local, IPU 11-02/IPM 101-102, IPU 13-1/PLU 272, IPU 13-1/IPU 19-27).

✓ **F_4's:** Twelve crosses (NUL 7/DPU 88-31, Lalitpur local/DPU 88-31, KVK-P/DPU 88-31, Lalitpur local/ IPU 94-1, IPU 94-1/PLU 272, Mash-1/PU 11-14, IPU 94-1/Shekhar-2, IPU 94-1/Nodai Urd, IPU 94-1/LBG 752, IPU 11-02/IPU 13-1, IPU 11-02/Jalpaiguri Local, IPU

13-1/ *V sublobata*, IPU 94-1/ PM 6) were raised

- ✓ **F_5's:** Eighteen crosses (MASH 114/PU 11-14, MASH 114/MASH 1008, MASH 114/LBG 623, MASH 114 /TU 103, PLU 59/IPU 02-43, MASH 1008/IPU 94-1, Lalitpur Local/ DPU 88-31, IPU 94-1/PLU 272, Lalitpur Local/ IPU 94-1, Lalitpur Local/IPU 11-02, Lalitpur local/ IPU 02-43, IPU 02-43/PM 6, KVK–P/IPU 02-43, DPU 88-31/LBG 685//*V umbellata*, KVK-P/IPU 02-43, IPU 11-02/PM 6, T 9/IPU 02-43, IPU 11-02/*V umbellata*, were grown.
- ✓ **F_6's:** Fifty four lines from 21 crosses (IPU 02-33/PU 31, DPU 88-31/Barabanki Local, PU 31/LBG 685, IPU 94-1/Barabanki Local, Yakubpur Early/IPU 02-43, Yakubpur early/IPU 99-123, IPU 02-43/UH 4-4, LBG 685/MASH 1008, TU 58/IPU 94-1, IPU 02-43/KPU 11-40, IPU 02-43/KPU 11-46, DPU 88-31/IPU 2000-01, Shekhar-2/KPU 11-4, TU 58/IPU 02-43, Vigna EL/IPU 02-43, KU 99-21/IPU 02-43, PU 31/LBG 17, PU 31/IPU 02-43, PU 31/VBN 6, VBN 6/PU 31, IPU 02-43/PU 31 were grown.
- ✓ **F_7's:** SPS of 7 crosses (Barabanki Local/DPU 88-31, DPU 88-31/Barabanki Local, LBG 752/VBN 7, IPU 94-1/KU 99-21, IPU 02-43/MASH 114, DPU 88-31/RUG 216, Shekhar-2/SPS-5) were tested.
- ✓ **F_8's:** Nineteen fixed lines (Shekhar-2/STY 2289, DPU 88-31/Junagadh Local, IPU 94-1/IPU 02-43, SPS 5/ IPU 02-43, Shekhar-2/VBG 4-008, IPU 11-02/STY 2289, PU 40/PU 31, PU 40/TU 17-4, DPU 88-31/ IPU 11-6, IPU 94-1/IPU 99-123, IPU 02-43/Junagadh Local, PU 31/MASH 114, IPU 7-3/*V sylvestris*, IPU 94-1/*V sylvestris*, IPU 02-43/PGRU 95016, PU 40/KUG 216, IPU 11-02/DPU 88-31, PU 40/ VBG 4-008 IPU 02-43/SPS-5) were evaluated and will be tested in next year in PYTs.

4. **Preliminary Yield Trial:** A set of 79 urdbean entries were tested under preliminary yield trial where yield of four rows of four-meter lengths ranged from 120 to 250 g. The high performing entries will be promo ted to station trials in the next *Kharif* 2023 season.

- ✓ **Station Trial I:** For yield evaluation, a set of 17 urdbean entries along with three checks were tested. Yield ranged from 800 to 1427 kg/ha. Seed will be increased for the best performing entries.
- ✓ **Station Trial II:** For yield evaluation, a set of 10 urdbean entries along with the checks were tested. Yield ranged from 800 kg/ha to 1100 kg/ha. Seed will be increased for the best performing entries.
- ✓ **Station Trial III:** For yield evaluation, a set of 17 urdbean entries with three checks were tested. Yield ranged from 850 to 1300 kg/ha. Seed will be increased for the best performing entries.

5. **Mapping population:** An inter-specific mapping population from IPU 11-02/PM 6 (Urdbean/Mungbean) cross were advanced to F_5 generations. Beside this, five populations advanced to F_4 generations for MYMIV resistance, PM resistance and photothermo sensitivity.

6. **Seed traits and MYMIV reaction (inheritance, linkage, skewness and kurtosis analysis:** Improved seed quality and resistance to MYMIV are important objectives of urdbean breeding. To understand inheritance of seed trait (seed lusture, seed colour, seed surface, MYMIV reaction using intra- and inter-specific bi-parental populations). Seven genotypes (DPU 88-31, LBG 685, Uttara, PLU 272, IPU 11-02, PM 6, Lalitpur Local) were used to generate 5 populations (DPU 88-31/LBG 685, IPU 11-02/PM 6, Uttara/PLU 272, IPU 11-02/Lalitpur local, Uttara/Lalitpur Local). DPU 88-31, ABL had dull seed lustre and brown seed coat with mosaic on seed surface, while LBG 685 had shiny seed lustre and green seed coat with mosaic on seed surface. Another parent IPU 11-02 had dull seed lustre and brown seed surface with mosaic while its contrasting parent PM 6 had shiny seed lustre and green surface without mosaic. F_1 seed were grown along with their parents and advanced to F_2 & F_3 generation. Phenotypic data were recorded and inheritance pattern of seed quality traits was studied in each generation. It revealed that DPU 88-31/LBG 685 population, shining seed registered dominance over dull trait, while green seed color exhibited dominance over brown seed colour. However, inter-specific F_2 population derived from IPU 11-02/PM 6 deviated significantly from Mendelian ratios and supported segregation distortion for seed traits. While mosaic on seed coat or mottling character studied in interspecific population demonstrated a dominant digenic inheritance pattern. In 5 inter and intra-specific F_2 populations, MYMIV resistance demonstrated monogenic dominant inheritance which was

also validated in F_3 generations. Linkage analysis exhibited an association between seed lustre and seed colour while no association was noticed between seed traits and MYMIV resistance. The normality tests revealed that seed width and 100-seed weight were controlled by few major genes while other quantitative traits were governed by many genes with small additive effects. The skewness suggested that complementary gene interactions were present among genes controlling 100 seed weight in intra-specific cross, while duplicate gene interactions were involved in inter-specific cross. The identified monogenic traits and linked morphological marker after further enrichment of linkage group could be used as an important tool in the regular breeding programme.

7. **Genome size of wild *vigna* species (*Vigna marina*):** The flow cytometer based estimation revealed diploid nuclear content (2C DNA content) of *V. marina* to be 1.57 pg. The estimated genome size of *V. marina* was 767.73 Mb. The chromosome spread prepared from root tip of *V. marina* accession revealed 22 chromosomes (*2n=22*). In addition to that, putative genes involved in salt tolerance in *V. Marina* were also identified (NHX gene family 34, HKT gene family 39).

Fig. 1: Chromosome spread of *V. marina* 2n = 22

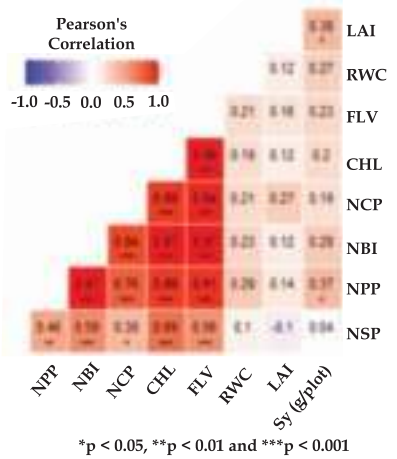
E. Mungbean

E01. Breeding for high yield, wider adaptability, multiple stress resistance and quality in pulses-Mungbean (Drought & heat)

1. **Physiological and yield responses of selected mungbean genotypes in drought stress:** A field trial was conducted to characterize drought response and drought tolerance of 38 mungbean genotypes through evaluation of several physiological parameters and seed yield. The genotypes were subjected to drought stress (1st) at vegetative stage just before flowering (~25 d after planting) and other drought stress (2nd) during pod filling stage (~45 d after planting). It revealed that significant differences were observed between mungbean genotypes for total chlorophyll content (Chl), total flavonoid

Table 1. Identified promising drought tolerant mungbean genotypes

SI	Genotype	NPP	NSP	NBI	CHL	FLV	RWC	LAI	Sy (g/plot)
1	IPM 02-3-2	18.33	12.33	12.44	10.48	9.86	114.62	14.64	128.6
2	BIG 0068-1	22.67	11.67	13.56	10.52	10.14	85.63	13.37	122.3
3	MH 421	22.33	12.00	13.89	11.07	10.77	63.13	7.47	126.3
4	MH 03-18	11.33	11.33	9.33	8.67	7.78	60.80	14.54	115.4
Drought sensitive	IPM 99-125	10.33	9.67	9.22	8.85	8.58	33.56	14.33	85.3
Drought tolerant	IPM 2-14	21.00	11.33	13.33	10.78	10.59	78.67	15.44	120.3



content, relative water content and agronomic traits. It showed the vegetative stage was more sensitive to drought stress, which was further supported by correlation analysis. All things considered, the mungbean genotypes, IPM 02-3-2, BIG 0068-1, MH 421 and MH 03-18 were found to be drought-resistant since they kept their original RWC, chlorophyll content (Chl), total flavonoid content, plant height and yield values despite the drought.

2. **Breeding material:** Large number of crosses were attmpted for development of heat and drought breeding lines during *Kharif* 2021. Total 10 F_1 hybrids were adavanced in summer. Total 6 F_5 seggregating materail such as PM5/EC 398889, HUM 12/EC 398889, SML 668/EC 426841, Pusa Vishal/EC 426841, HUM 12/PM 2 & SML 668/PM 2 adavancing during summer 2022 and produced 11 hybrids for heat & drought tolerance during *Kharif* 2022.

Table 2. Advancement of breeding materials in Mungbean

Stage	Number of crosses	Breeding materials
F_1s	10	10
F_2	8293	SPS
F_3	6152	SPS
F_4	585	SPS

F. Fieldpea

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

1. **Variety developed:**

1.1. **IPFD 16-3:** This variety derived from IPFD 99-13/VRP 3 cross and released/notified (S.O. 8(E).dated 24/12/21) in December 2021 for cultivation of UP state. It has potential yield of 2733 kg/ha with mean yield of 1646 kg/ha. It is resistant to powdery mildew, rust and Ascochyta blight. It has medium, round, smooth and creamish white colour seed with yellow cotyledon.

1.2. **IPFD 19-1 (Shikhar):** It is a dwarf, semi-leafless type, white flower colour and creamish white seed colour fieldpea variety derived from IPF 5-19/MDP 2 cross and identify by VIC for release under NEPZ during 2022. It produced mean yield of 1917 kg/ha and registered 24.72% & 28.83% yield superiority over checks SKNP 04-9 & HFP-4, respectively. It is resistant to PM and moderatly resistance to rust and matures in 120-125 days with medium bold seed size (18.0 g).

1.3. **IPFD 19-3 (Arpan):** Dwarf, leafy type, white flowered and creamy white seed colour fieldpea varieties derived from IPFD 1-10/IPFD 10-13 cross and identify by VIC for release under NEPZ during 2022. It produced mean yield of 1767 kg/ha with registered 14.96% & 18.75% superiority over the checks SKNP 04-09 & HFP 4, respectively. It registered 32.86% yield supremacy over the check HUDP 15. It is resistant to powdery mildew, Ascochyta blight and moderately resistant to rust and least preference by borer, aphid and leaf miner as compared to check and qualified varieties. It takes 103-134 days (122 days) with medium bold seed (18.55 g).

2. **Genetic stock Registered**

2.1 **IPFD 18-14 (INGR 21140):** This is an extra early, dwarf and white seeded genotype of fieldpea developed from DDR 23/VRP 22 cross followed by pedigree method. This genotype flowered and matured in less than 36 and 85 days, respectively. Hence, this extra early type fieldpea genotype has been registered with ICAR-NBPGR, New Delhi.

IPFD 18-14

2.2. **IPFD 18-26 (INGR 22044):** This is an extra early and green seed colour genotypes derived from DDR 23/VRP 22. It flowered and matured in less than 40 and 100 days, respectively. Therefore, it has been registered with ICAR-NBPGR, New Delhi.

IPFD 18-26

2.3. **IPF 2014-13 (INGR 21227):** This genotype is derived from EC 538005/IPFD 1-10 cross followed by pedigree method. Considering multi-location assessment for rust disease showed tolerant reaction. The Institute GIC recommended for registration with ICAR-NBPGR, New Delhi.

2.4. IPF 2014-16 (INGR 22043): This genotype is derived from IPF 99-25/Arkel. Based on multi-location performance, it is tolerant reaction to rust and has been registered with ICAR- NBPGR, New Delhi

3. Genetic stock developed:

3.1. IPF 2022-19 (Acacia type leaf pattern): The fieldpea varieties have mainly two plant types, tall (leafy/tendril type) and dwarf (leafy/tendril type). In leafy type, the leaf includes compound pinnate consist a basal pair of foliaceous stipules, few pairs of proximal leaflets, two pairs of distal tendrils and terminal tendril. In tendril type, all proximal leaflets are substituted by tendril. IPF 2022-19 genotype is tendrilless (*tl*) wherein leaf pattern is deviate from above-mentioned types and comprised of basal pair of stipules, normal proximal leaflets and in distal portion of leaf, leaflets replacing simple tendrils. Such type of leaf pattern is commonly known as *acacia type.* Tall and acacia leaf type genotype possess distinct leaf morphological advantage as compared to available varieties and can be used as unique markers in breeding and seed production programme for identification of variety. This genotype is derived from HFP4/EC1 cross. Based on four years performance (2017-21), it takes 60-65 days to achieve 50% flowering and 125-130 days to achieve physiological maturity. It has tall plant stature and 18.0 g/100-seed weight.

IPF 2022-19 (acacia type)

Normal leafy type

3.2. IPF 2021-21 (Acacia type leaf pattern): The most of the commercial fieldpea varieties have two types of plant types *i.e.* dwarf (leafy and tendril) and tall (leafy & tendril) type. In leafy type, the leaf comprised of compound pinnate consisting of a basal pair of foliaceous stipules, few pairs of proximal leaflets, two pairs of distal tendrils, and a terminal tendril, whereas, in case of tendril type all the proximal leaflets replaced by tendrils. This genotype is tendril-less (*tl*) wherein the leaf pattern is deviate from the above-mentioned plant types and comprised of a basal pair of stipules, normal proximal leaflets and in the distal portion of the leaflets replacing the simple tendrils. Such type of leaf pattern is known as *acacia type.* Therefore, this acacia type fieldpea genotype with high yield potential possess morphological advantage as compared to available varieties which makes it unique and can be used as unique trait in seed production programme for identification of variety. This genotype derived from HFP 4/EC 1 cross followed by pedigree method. The succeeding generations were advanced through SPS. Based on four years performance (2017-21), it takes 60-65 days to achieve 50% flowering and matures in 125-130 days. It has tall plant stature and 24.0 g 100-seed weight. It showed superiority in yield over the best check and yield 2847 kg/ha in station trials conducted during 2020-21 and evaluation in IVTs under in AICRP.

3.3. IPFD 2018-5 (Parsley type leaf pattern): Fieldpea varieties usually have two types of plant *viz.* tall (leafy and tendril type) and dwarf (leafy & tendril type). In leafy type, the leaf includes compound pinnate which consist a basal pair of foliaceous stipules, few pairs of proximal leaflets, two pairs of distal tendrils, and a terminal tendril, while, in tendril type all the proximal leaflets substituted by tendrils. Unlike other field pea varieties, this genotype has a basal pair of stipules and branched tendrils ending in small terminal leaflets which resemble to parsley leaf. Therefore, this parsley leaf type fieldpea genotype with good yield potential have distinct morphological advantage over the available varieties which makes it unique and this can be used as unique morphological marker in breeding programme. It may generate some useful basic/genetic information particularly on low transpiration rate and drought tolerance. This genotype is derived from LFP 212/Azad P-31 cross. Considering four years evaluation in F_5, F_6, PYT and station trials performed during 2014-15, 2015-16, 2016-17 & 2017-18, respectively, this genotype takes 55-60 days to achieve 50% flowering and 100-105 days to achieve physiological maturity. It is a dwarf type genotype with average grain yield potential of 3.0 t/ha and 22.0 gm 100-seed weight.

4. **Generation of breeding material:** Twenty five crosses were successfully synthesized involving various donors possessing specific traits *i.e.* large seed size, no. of seeds per pods, pod length, no. of pods, earliness, powdery mildew resistant and rust tolerant (Table 1) during 2021-22. In addition, crosses also were made to develop MAGIC population and work out genetics of various traits. Similarly, during 2022-23, crosses will be attempted using trait specific donors.

Table 3. Detail of crosses

S. No.	Cross Name	S. No.	Cross Name
1	IPFD 6-3 x HUDP 7	14	IPF 4-26 x HC -2
2	IPFD 6-3 x LFP 240	15	IPFD 13-2 x Pant P 200
3	IPFD 6-3 x HUDP 16	16	IPFD 2014-2 x P 1586
4	IPFD 1-10 x Pant P-243	17	IPF 99-25 x Pant P -14
5	IPFD -1-10 x P-1586	18	IPF 4-26 x HC 1
6	IPF 16-13 x Pant P-200	19	HC 1 x IPFD 21-8
7	IPF 16-13 x pant P-243	20	IPFD 21-8 x HC 1
8	IPF 5-19 x PARA 370	21	IPFD 12-8 x HC 1
9	(IPF 5-19 X IPFD - 18-14) X IPFD 18-14	22	EC 564814 x IPF 16-13
10	(IPF 5-19 X IPFD - 18-14) X IPF 5-19	23	IPFD 9-2 x IPFD 12-2
11	IPF 5-19 x IPFD 18-14	24	EC 564816 x IPFD 12-2
12	IPFD 18-14 x IPF 5-19	25	IPFD 12-2 x Pant P-200
13	IPF 4-26 x HC 3		

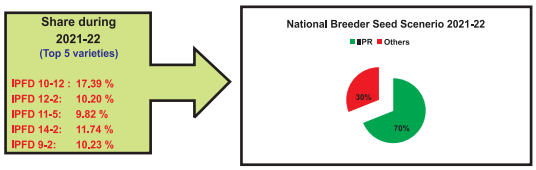
5. **Evaluation of advance breeding lines**: In station trial for dwarf, 13 genotypes were evaluated along with three checks. Among these, IPFD 2022-6 (3986 kg/ha) and IPFD 2022-9 (3811 kg/ha) were out performed the best check IPFD 10-12. In another station trial, 13 tall genotypes were evaluated with three checks of which three genotypes *i.e.* IPF 2022-18 (2697 kg/ha), IPF 2022-22 (2869 kg/ha), IPF 2022-24 (2731 kg/ha) were registered superiority over the best check IPF 5-19. In addition, PYT were conducted in tall category with 39 advanced breeding lines with three checks and of which sixteen entries demonstrated yield superiority over the best check IPF 5-19. Similarly, in dwarf group, total 32 entries were tested and of which 10 entries outperformed the best check IPFD 10-12. In extra early, total 32 entries were tested in PYT with three checks and of them, 7 entries registered yield superiority over the best check IPFD 99-13. Two station trial, 16 entries each in dwarf and tall categories are being evaluated with checks during 2022-23. In PYTs for dwarf (40) and tall (32) entries, respectively are being evaluated.

6. **Selections of promising genotypes from segregating population:** Total 40 crosses were raised in F_1 generation. Segregating generations of 40 F_2, 38 F_3 and 32 F_4 were evaluated and superior SPS were selected considering targeted traits (earliness, seed size, pod length, resistant to powdery mildew, rust, yield/plant). In F_5, F_6 and F_7 generation 638, 742 and 40 single lines were evaluated, respectively. Total 22 F_1 have been raised for further advancement during 2022-23. In case of segregating population in 35 F_2, 40 F_3, 84 F_4, 31 F_5 (306 single lines), F_6 (594 single lines) and F_7 (495 single lines) have been planted for advancement.

7. **Development of mapping population:** RIL population (310) of rust (HFP 4(S) x FC1(R)) harvested and evaluated for rust incidence. During 2022-23, SPS has been raised for evaluation.

8. **Nucleus seed production of fieldpea varieties:** As per DAC indent during 2021-22, nucleus seed production of fieldpea varieties developed by IIPR, IPFD 12-2 (216 kg), IPFD 11-5 (112 kg), IPFD 10-12 (190 kg), IPFD 2014-2 (205 kg), IPFD 13-2 (104 kg), IPFD 12-8 (127 kg), IPFD 6-3 (81 kg), IPFD 9-2 (149 kg), IPF 16-13 (160 kg), IPF 5-19 (52 kg), IPFD 1-10 (22 kg), IPFD 99-13 (25 kg), IPF 4-9 (20 kg), IPF 99-25 (20 kg) and IPFD 16-3 (26 kg**).** Based on DAC indent, nucleus seed production of IIPR released varieties is being taken during 2022-23.

9. **Contribution of IIPR fieldpea varieties in National Breeder Seed chain:** In national breeder seed indent, IIPR varieties total share was about 70%. IPFD 10-12 had the highest share (17.39%) followed by IPFD 12-2 and IPFD 2014-2. The detail of overall scenario is presented below.

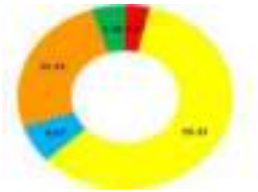


10. **Performance of entries in AICRP & UP SAT:** Two dwarf entries (IPFD 19-1 & IPFD 19-3) were promoted to AVT-2 under NEPZ with 13.83% & 16.78% yield superiority over the best check HFP-4. Similarly, a tall entry (IPF 20-17) and two dwarf entries (IPFD 20-3 & IPFD 20-9) were promoted to AVT-1 trials under NHZ. Two tall entries (IPF 20-17 & IPF 20-21) were promoted to AVT-1 under NWPZ. A tall genotype IPF 20-17 was also promoted to AVT-1 under CZ in addition to NHZ & NWPZ. Two dwarf genotypes IPFD 20-2 & IPFD 20-8 were promoted to AVT-1 under NEPZ & Rice fallow, respectively. Total six fieldpea entries (IPF 21-13, IPF 21-16, IPF 21-21, IPFD 21-5, IPFD 21-7 & IPFD 21-4) were evaluated in IVT trials under tall and dwarf category during 2021-22. Four entries (IPFD 21-2, IPFD 21-6, IPF 21-17 & IPF 21-14) were tested in rice fallow trials under AICRP. In state adaptive trials of UP, total 12 entries were tested including five new entries *i.e.* IPFD 18-1, IPFD 18-9, IPF 19-18, IPF 19-11 & IPF 20-20.

11. **Screening of fieldpea ABLs against leaf miner:** ABLs were screened for their response towards pea leaf miner infestation under field conditions. The per cent leaf infestation showed significant variability among genotypes. The highest leaf infestation was recorded in IPFD 99-13 followed by IPFD 98-7 while the lowest leaf infestation was recorded in IPF 2-19 followed by IPFD 2-6. Three genotypes, IPF 2-19, IPF 2-13, IPFD 2-6 could demonstrate resistance reaction for leaf miner infestation. After validation, they could be used as donor in resistance breeding.

12. **Standardization of colour traps and population trend of pea leaf miner:** To understand the preference of colour by pea leaf miner, a study was conducted using different coloured traps (Fig 1). Among five colour traps, the yellow coloured sticky trap attracted more than 59% of pea leaf miner during the crop growth period than other sticky traps. The population of leaf miner was the highest during the first week of March. 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.

Fig. 2: Different colour traps in fieldpea



Proportion (%) of leaf miner population attracted by different coloured traps

Population trend of pea leaf miner in field pea

13. Phenotyping of mapping population for rust: A RIL population of 310 fieldpea developed for rust has been phenotyped for rust incidence during 2021-22. For phenotyping, standard scale was used and based on that 19 lines demonstrated resistance reaction and 27 lines showed moderately resistance reaction to rust. Overall normal distribution was obtained for rust in RIL population.

Resistant (R)	Moderately Resistant (MR)
FPRILR-1, FPRILR-20, FPRILR-31, FPRILR-45, FPRILR-54, FPRILR-57, FPRILR-103, FPRILR-111, FPRILR-116, FPRILR -121, FPRILR-126, FPRILR-143, FPRILR -156, FPRILR-183, FPRILR-195, FPRILR -199, FPRILR-205 , FPRILR-234, FPRILR-277 (19)	FPRILR-12, FPRILR -25, FPRILR -29, FPRILR -37, FPRILR -49, FPRILR-56, FPRILR -70, FPRILR -78, FPRILR -86, FPRILR-93, FPRILR -101, FPRILR -128, FPRILR -151, FPRILR-162, FPRILR-171, FPRILR-187, FPRILR-193, FPRILR-196, FPRILR-208, FPRILR-225, FPRILR-240, FPRILR-258, FPRILR-271, FPRILR-286, FPRILR-292, FPRILR-301, FPRILR-304 (27)

Rust infected field pea leaves

14. Sharing of breeding materials

Cross	Stage	Receiver
IPFD 12-2 x IPF 5-19	F_3	Tripura,
IPF 5-19 x EC 398597	F_3	Imphal,
IPFD 99-13 x P 995	F_3	Srinagar,
P 995 x IPFD 1-10	F_3	Mohanpur,
IPF 14-16 x IPFD 10-12	F_3	Ranchi,
P-1075 x P 1808	F_3	Raipur
(MDP 2 x G 10) x IPF 5-19	F_4	
IPFD 1-10 x P 1297-84	F_4	
IPFD 12-2 x P 1673	F_4	
IPF 5-19 x P 1297-84	F_4	
IPFD 6-3 x P 1613	F_4	
IPF 5-19 x HUDP 15 x KVW 10-1	F_4	
IPF 5-19 x P 1300-1	F_4	

G. Biofortification in Mungbean and Urdbean

Estimation of Zn content in different plant parts of lentil genotypes under control: Two high Zn uptake lentil genotypes IPL 220 (55.30 ppm), IPL 6002 (63.60 ppm) were grown along with two low uptake genotypes, L 57 (40.10 ppm), T36 (43.10 ppm). Foliar application was applied to treatment and control plants were treated with water spray without any foliar Zn application. The field experiment was carried out during 2019-20 & 2020-21 at Kanpur. The control and treatment plants were analysed for Zn concentration in root, stem, seed coat, leaf, seed and pod. During 2019-20, results for four tested lentil genotypes were as follows:

Table 4. Estimation of Zn content in different plant parts of lentil genotypes under control and foliar spray (values in ppm) in 2019-20

Genotype	Root		Leaf		Stem		Seed		Pod	
	C	T	C	T	C	T	C	T	C	T
IPL 220	48.36	49.23	53.79	63.00	19.81	24.19	57.69	64.60	35.43	40.42
T 36	19.67	33.06	12.50	30.40	32.91	38.80	35.90	78.40	65.60	39.90
L 57	37.15	48.57	34.50	37.20	27.24	32.00	35.55	49.35	23.02	30.77
ILL 6002	33.51	37.29	48.33	56.10	22.80	30.50	67.76	68.50	46.52	50.30
Mean	34.67	42.04	37.28	46.68	25.69	31.37	49.23	65.21	42.64	40.35

#C-control, T-treatment

Table 4: Estimation of Zn content in different plant parts of lentil genotypes under control and foliar spray (values in ppm) in 2020-21

- ✓ High Zn genotypes (IPL 220, ILL 6002) had high seed Zn in both control and treatment.
- ✓ Stem had the lowest zinc content under control and treatment conditions.
- ✓ Low zinc (T 36) genotype had lower pod zinc concentration under treatment condition.
- ✓ High zinc genotypes (IPL 220, ILL 6002) had lower per cent increase in seed zinc in both the years
- ✓ Low zinc (T 36) genotype was the most responsive genotype under the foliar spray.
- ✓ Low zinc genotypes (L 57, T 36) had a higher percent increase in seed zinc in both the years.

Table 5. Per cent increase of Zn content in different plant parts of lentil genotypes after foliar spray (values in ppm) – 2019-20

Genotype	Root		Leaf		Stem		Seed		Pod	
	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase
IPL 220	0.87	1.80	9.21	17.12	4.38	22.11	6.91	11.98	4.99	14.08
T-36	13.39	68.07	17.9	143.20	5.89	17.90	42.50	118.38	-25.70	-39.18
L-57	11.42	30.74	2.70	7.83	4.76	17.47	13.80	38.82	7.75	33.67
ILL-6002	3.78	11.28	7.77	16.08	7.70	33.77	0.74	1.09	3.78	8.13
Mean	7.37	27.97	9.40	46.06	5.68	22.81	15.99	42.57	-2.30	4.18

Table 6. Per cent increase of Zn content in different plant of lentil genotypes after foliar spray

Genotype	Root		Leaf		Stem		Seed		Pod	
	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase	Increase in ppm	Per cent increase
IPL 220	6.03	11.59	4.00	7.41	4.40	17.19	9.76	18.35	0.90	2.78
T-36	31.10	123.41	7.34	56.33	-3.20	-10.53	6.20	20.20	12.82	25.17
L-57	2.52	8.27	9.37	15.35	10.00	30.77	12.07	33.53	3.17	7.75
ILL-6002	3.86	13.31	3.30	5.51	8.59	38.68	4.85	9.63	22.49	47.65
Mean	10.88	39.15	6.00	21.15	4.95	19.03	8.22	20.43	9.85	20.84

2. Estimation of iron and zinc concentration in a panel of 105 mungbean genotypes:

- ✓ Zn concentration ranged from 9-34 ppm in this set of mungbean genotypes with a mean value of 18 ppm and Fe concentration ranged from 11-80 ppm with a mean value of 40 ppm.
- ✓ Two station trials with 20 entries (ABLs) of urdbean each were conducted with 3 replications in RCBD. All test entries will be tested for iron and zinc concentrations.
- ✓ Mapping populations available in biofortification programme for iron and zinc concentration are as following: HPU 120/IC 560408 (F_5), WBU 108/Shekhar-2 (F_5), Azad-3/T-9 (F_5).
- ✓ Marker trait analysis identified SSR markers linked to Fe & Zn concentration in lentil. Based on pooled data, SSR 9-4, SSR 57-5, SSR 135, SSR 59-2 linked to Fe and SSR 57-5 & SSR 167 linked with Zn concentration.

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

A. Chickpea

1. Maintenance of wild *Cicer* species: One hundred thirteen wild germplasm accessions belonging to seven *Cicer* spp. was maintained in wild garden [*C. reticulatum* (42), *C. judaicum* (32), *C. pinnatifidum* (27), *C. echinospermum* (6), *C. cuneatum* (3), *C. yamashitae* (2) and *C. bijugum* (1)].

- ✓ Landraces, isolates & trait specific donors: 151
- ✓ Accessions maintained in cold module: 2,300
- ✓ Accessions could be utilized as donors: 30 (CR, CE, CP, CJ)

- ✓ Two hundred fifty accessions comprising of landraces, trait specific donors, exotic lines etc. were rejuvenated.

2. **Breeding material:** Four wide crosses, ILWC 104/ILWC 105, EC 556270/ICC 17123, ILWC 106 /ILWC 104, ILWC 105/ILWC 106 for cold tolerance and earliness were made with *C reticulatum* accessions ILWC 104, ILWC 105, ILWC 106 as donors. Similarly, eight crosses, ICC 8933/ICC 9001, IPC 17-351/ICC 14447, ICC 5002/ICC 14447, B 22/IPC 05-62, ICC 14334/ICC 14872, ICC 14340/ JAKI 9218, BGD 9971/ILWC 105, ICC 96030/BGD 9971 were developed targeting podding traits (cylindrical pods, flat pod, long pod) utilizing improved donors. Segregating populations derived from wide hybridization and crossing with landraces were advanced.

3. **Generation advancement:** F_1 population derived from six crosses were raised and harvested 55 SPS to advancd F_2 population. Total 236 SPF including 5 F_2: 54 SPS, 11 F_3: 35 SPS, 8 F_4: 30 SPS, 25 F_5: 52 SPS, 14 F_6: 33 SPS and 17 F_7: 32 SPS were harvested based on targeted traits.

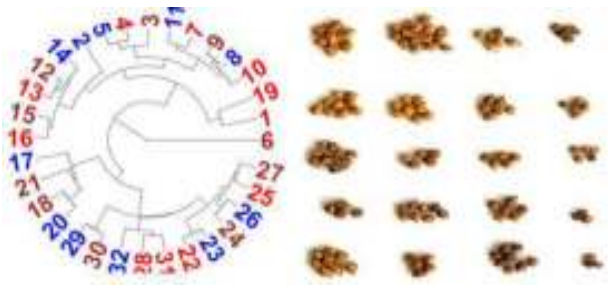
4. **Evaluation of advanced breeding lines:**

4.1. **ST-2 (PB):** Total 23 entries with checks (IPC 11-112, GNG 2207, BG 3043) were evaluated during 2021-22 Entry IPC 19-96 (CA/L, 3939 kg/ha) was found top yielder followed by IPC 20-20 (L/L, 3428 kg/ha), IPC 18-150 (CA/CE, 3378 kg/ha), IPC 20-07 (CA/L, 3344 kg/ha), IPC 20-187 (L/L, 3317 kg/ha), IPC 20-96 (CA/CR//CA/CR, 3306 kg/ha), IPC 20-136 (CA/CR, 3267 kg/ha), IPC 20-60 (CA/L, 3233 kg/ha) and the best check BG 3043 (3156 kg/ha).

4.2. **PYT–2A (PB):** Total 42 entries with checks (GNG 2207, BG 3043, IPC 11-112) were evaluated during 2021-22. Entry IPC 21-107 (CA/CC, 2300 kg/ha) was found top yielder followed by IPC 21-109 (L/L, 2267 kg/ha), IPC 21-99 (CA/CR//CA/CR, 2200 kg/ha), IPC 21-108 (L/L, 2133 kg/ha), IPC 21-72 (CA/CR//CA/CR, 2083 kg/ha) and the best check GNG 2207 (2033 kg/ha).

5. **Pre-breeding for donor improvement for high protein content in chickpea:** Morphologically distinct lines identified through pre-breeding in natural population of high protein chickpea landrace accession ICC 5912 (T 39-1).

- ✓ **T 39-1 isolates (13):** 3) TI 198 (T 39-1 desirable grain type), 4) TI 190 (T 39-1 medium bold angular seed), 5) TI 49A (T 39-1 distinct plant architecture), 8) TI 24A (T 39-1 elite acclimatized), 9) TI 91 (T 39-1 angular small seed), 11) TI 204 (T 39-1 bold round dark seed), 12) TI 202 (T 39-1 angular seed), 13. TI 194 (T 39-1 under acclimatization), 25. TI 195 (T 39-1 under acclimatization), 28) TI 50A (T 39-1 bold angular type), 29) TI 193 (T 39-1 acclimatized), 30) TI 25A (T 39-1 acclimatized with bold angular seed) & 31) TI 47A (T 39-1 advanced acclimatized).
- ✓ **T 39-1(DP) [5]:** 7) TI 205 [T39-1 (DP) angular seed], 10) TI 206 [T39-1 (DP) bold pea type seed], 22) TI 207 [T39-1 (DP) angular seed], 23) TI 192 [T39-1 (DP) nearly angular seed] & 24) TI 208 [T39-1 (DP) medium angular seed].
- ✓ **T 39-1(A) [4]:** 18) TI 200 [T 39-1 (A) medium pea type], 26) TI 201 [T 39-1 (A) nearly angular seed], 14) TI 197 [T39-1(A) under acclimatization], 15) TI 203 (T 39-1 medium pea type seed).
- ✓ **Parental lines [2+4]:** 1) ICC 5912 (Heat sus. check), 2) ICC 8397 (High pro line), 27) T39-1 (base population), 16) T 39-1S (Selection from T 39-1 base population), 6) TI 209 (T 39-1 Stigma exerted) & 17) TI 210 (T 39-1 Stigma exerted).
- ✓ **Test checks (Medium high pro line) [3]:** 19) ICC 9553, 20) ILC 46 & 21) ICC 9914.
- ✓ **Heat/drought tolerant check (1):** 32) SA-1.
- ✓ Euclidean clustering of pre-breeding lines isolated from landrace population of ICC 5912 (T 39-1)
- ✓ Wild accessions identified for resistance to Ascochyta blight, namely ICC 17149 (CJ), ICC 17207 (CJ), ICC 17152 (CP) and ILWC 246 (CE) by cut-twig method.
- ✓ High protein heat susceptible landrace accession T39-1 (ICC 5912) was identified with resistance to *fusarium* wilt race II at wilt sick plot of ICAR-IIPR, Kanpur for the first year.



6. **Herbicides tolerance:** Eighteen ABLs were screened for post-emergence herbicide (Imazethapyr @ 120 g/ha) tolerance. five potential candidate entries were identified on the basis of survival % and lesser yield penalty: IPC 20-73, IPC 20-09, IPC 20-77, IPC 20-40 & IPC 20-158 with respect to checks ICC 12315 and IPC 18-186

B. Pigeonpea

1. **Maintenance of wild species and their accessions at *Cajanus* wild garden:** Ten wild species belongs to Gene Pool-II namely 1) *C. acutifolius*, (1 acc.), 2) *C. albicans*, (12 acc.), 3) *C. cajanifolius*, (4 acc.), 4) *C. lanceolatus*, (1 acc.), 5) *C. latisepalus*, (1 acc.), 6) *C. lineatus*, (4 acc.), 7) *C. sericeus*, (2 acc.), 8) *C. trinervius*, (1 acc.), 9) *C. scarabaeoides* (75 acc.) and 10) *C. reticulates* (1 acc.) are maintained for use in pre-breeding programme. In addition to this, the gene pool-III and other genra wild species are also maintained in pigeonpea wild garden.

Fig. 3: Pigeonpea wild garden maintained at IIPR, Kanpur

Table 7. Fresh Pre-breeding crosses attempted during *Kharif* 2021-22

SN	Crosses	F_1 seed harvested	Trait
1	Pusa 992/*C. scarabaeoides* (ICP 15739)	30	Wilt, SMD, PSB, Nematode resistance
2	Pusa 992/*C cajanifolius* (ICP 15631)	11	Primary branches/plant & pods/plant
3.	Pusa 992/*C cajanifolius* (ICP 15630)	12	Primary branches/plant & pods/plant
4	AC 2881/3811/*C. cajanifolius* (ICP 15632)	28	Primary branches/plant & pods/plant
5	AC 2881/3811/*C. cajanifolius* (ICP 15630)	21	Primary branches/plant & pods/plant

C. Lentil

1. During 2021-22, 206 accessions of active germplasm and 94 diverse accessions were maintained. Two cross [(IPLS 9-23/DPL 62)//BARI-5/ILWL 131] & [IPL 406/ILWL 131] were attempted and and no seed set were observed in both crosses. Twelve SPS were selected in 1 F_4 population derived from wide cross (IPL 316/ILWL 118), while 36 SPS were selected from 3 F_5 populations of wide crosses. Total 47 pre-breeding lines were bulked from $4F_6$ populations with yield ranges from 6 g to 367 g per line. Among these, 5 lines having >27 g/line were selected for PYT. Among 23 pre-breeding entries, 11 entries were found promising with yield ranges of 2063 to 2730 kg/ha in PYT. Based on yield, small seeded entry IPL 19-02 (1991 kg/ha) and early flowering (62 days) were found promising for evaluation in rice fellow trial. 149 pre-breeding lines evaluated for drought tolerance and wilt resistance. Total 121 accessions of 5 wild species (*L. orientalis*: 78, *L. tomentosus*: 10, *L. odemensis*:13, *L ervoides*: 13, *L. nigricans*: 7) were maintained.

D. Fieldpea

1. Genetic stock identified:

1.1. **EC 564816 (INGR 22045):** This is tall & tendril type fieldpea genotype has intact funiculus in matured and harvested seeds. Intact funiculus is not a common trait observed in fieldpea and may serve as a unique morphological marker in seed production programme. Subsequently, this accession was recommended by GIC and registered with ICAR-NBPGR, New Delhi as a genetic stock.

1.2. **EC 0414478 (INGR 21225):** This is a white seeded fieldpea genotype has intact funiculus in matured and harvested seed. Intact funiculus is not a common trait detected in fieldpea and could be served as a unique morphological marker in seed production programme. Consequently, this accession was registered with ICAR-NBPGR, New Delhi.

2. **Germplasm rejuvenation and evaluation:** Total 873 fieldpea accessions were planted for rejuvenation during 2021-22. Out of that, 566 lines were successfully rejuvenated and remaining accessions could not germinate. Besides, a set of 175 accessions was evaluated for different traits like days to 50% flowering, anthocynin, foliage color, leaf axil colour, leaf

size, plant height, Flower colour, branches, FPBN, LPBN, blank node, pod curvature, pods/axil, pod length, total pods/plant, seeds/pod, days to maturity, seed colour and grain yield (g). The results of descriptive statics (Table 2.1) demonstrated substantial variability in evaluated set of germplasm for quantitative traits. Similarly the two way clustering of qualitative and quantitative traits clearly demonstrated that ample amount of variability exist in the studied materials (Fig 2.1). Total 361 germplasm accessions have been planted for rejuvenations and evaluation during 2022-23.

3. **Identification of trait specific donors:** Based on 175 accessions evaluation for different traits and identified of some trait specific donor for important traits. The details are given in Table 3.1.

Table 8. Trait specific donors of fieldpea

Characters	Trait specific genotypes
DF (<56)	EC 598523, EC 598597, EC 598511, EC 583168, EC 598602, EC 598651, EC 598665, IC 311063, EC 598649, IC 279720, IC 469153
Maturity days (<111)	IC 469137, IC 381054, IC 469152, IC 469156, EC 598536, IC 427211, IC 107453, EC 598522, EC 595963, EC 598525, IC 27926
FPBN (<9.0)	IC 396678, EC 598582, IC 469157, EC 598516, EC 595961, IC 372703, EC 598593, EC 598522, EC 598628, IC 109304, IC 469153, EC 598645, IC 296677, EC 598669, IC 107455, IC 27926
LPBN (18)	IC 109306, EC 598639, EC 598526, IC 969148, IC 419145, EC 598646, IC 347387, EC 598637, IC 279720, EC 598583, EC 598514, IC 49682, IC 208327, IC 469158
Blank node (0.33)	EC 595963, EC 598628, EC 598525, EC 598526, EC 598652, IC 107446, IC 427211, IC 399804, IC 296677
Pod length (>6.0 cm)	EC 598646, EC 598511, EC 598646, IC 342026, EC 598670, IC 42489, IC 291541, EC 598598, EC 598519, EC 269507, IC 469147, IC 320964
Seed/Pod (>6)	EC 598528, EC 598519, EC 598670
Yield/plot (>300 g)	IC 320964, IC 109555, EC 507770, EC 32391, EC 269469, IC 334160, EC 568635, IC 342023, IC 107510, IC 469151, EC 598593, EC 959260

4. **Herbicide tolerance in fieldpea against topramezone:** Due to intensive cropping system, weeds have becomes a menace and also being winter season pulses crop, fieldpea is highly affected by weed incidence. During 2021-22, 196 promising lines identified screening were further screened to topramezone @ 20.6 ml a.i./ha (60 ml/ha). Phytotoxicity was recorded on 0-10 scale (0-10 scale: 0=complete tolerance; 10=Susceptible) at 7, 15 and 30 days after herbicide spray. Considering visual phytoxicity following genotypes KSP 23, KSP 11, JP 67, JP 885, P3, ET 5120, ET 5112, ET 5101, IP 2K107 were found promising with minimal phytotoxicity.

5. **Maintenance breeding:** Total 15 varieties of fieldpea developed by ICAR-IIPR were maintained during 2021-22 through single plant selection to maintain the genetic purity of varieties.

E. Genetic resource management and their utilization for genetic enhancement of cowpea

1. **Generation of breeding materials:** During *Kharif* 2022, total 25 crosses were attempted using different donors with traits like determinate to semi-determinate plant type, Yellow mosaic disease, powdery mildew, bruchid tolerance, pod length, number of pods, grain size and color. Of them, 15 crosses were successfully harvested.

Hybridization in cowpea

2. **Selections of promising genotypes from segregating population generation advancement:** In **summer** 2022, a set of 13 genotypes were raised in PYT to assess performance in term of growth habit and disease reaction. Total 10 crosses were raised in F_1 generation for further advancement during 2022. In segregating generations, superior SPS were selected taking into consideration desirable traits (earliness, seed colour, pod length, resistant to YMV, plant type). Total 16 crosses in F_2 (186 SPS), 10 F_3 (328 SPS), 10 F_4 (278 SPS), in F_5 100 single lines and in F_6 (40 lines) were evaluated. Besides, in PYT, 13 genotypes were evaluated for yield with two checks.

3. **Germplasm evaluation and rejuvenation:** During *kharif* 2022, a total of 410 germplasm accessions were planted for maintenance and rejuvenation. Of them, 132 were vitiated due to rains within two days of sowing. Besides, these accessions were evaluated for qualitative and quantitative traits. Abundant amount of variability was noticed for studied traits such as days to maturity, seed size, pod length, seed coat colour etc. In addition, 30 released varieties and 22 wild accessions of cowpea were also maintained.

4. **Evaluation of promising materials**: Total 16 extra early germpalsm accessions including checks were evaluated for earliness and other yield attributing traits. Besides, a set of 11 promising genotypes were evaluated for grain yield with checks.

F. Plant genetic resource management and its utilization through pre-breeding-Rajmash component

1. **Germplasm conservation:** IIPR pulses gene bank unit holds 1946 germplasm accessions in its medium-term cold module. The Institute also kept high-quality trait-specific donors/ accessions and advanced breeding material at different stages. During 2021-22, 30% of available germplasm lines were used for evaluation, characterisation and rejuvenation of common bean line

Table 9. Common bean genetic resource maintained at ICAR-IIPR, Kanpur

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

2. **Germplasm characterization:** Characterised 500 common bean genotypes collected from CIAT, gene bank unit, Colombia with respect to morphological traits, including plant growth (growth habit, growth type, and twinning habit), leaf (colour, size, shape), flower (colour, stripping on outer petal), pod (shape in relation to suture, shape of cross-section, shape of distal part, and stringiness), seed (colour, shape), and quantitative morphological traits (seed weight, length, and breadth). The preliminary trait data analysis revealed substantial diversity across a number of morphological and agronomic characteristics. Result indicated that most genetic variation occurs among exotic accessions, with little genetic variation occurring between geographical regions.

Table 10. Identified trait specific germplasm accessions for breeding programme

SI.	Traits	Promising accession
I	**Days to 50% flowering**	
	a) Early type (<50)	EC 932189, EC 932021, EC 931970, EC 931971
	b) Medium type (50-75)	EC 931111, EC 931112, EC 931107,
	c) Late (>76)	EC 931158, EC 931163, EC 931141, EC 931150,
II	**Days to maturity**	
	a) Early type (<100)	EC 932189, EC 932021 & EC 931971
	b) Medium type (101-120)	EC 931103, EC 931105, EC 931106
	c) Late (>120)	EC 931148, EC 931159 & EC 931161
III	**Pod length (cm)**	
	a) Small (<10 cm)	EC 932461, EC 931812 & EC 931813
	b) Medium (11-15 cm)	EC 931101, EC 931102, EC 931105 & EC 931111
	C) Long (>16 cm)	EC 931347, EC 931924, EC 931925 & EC 932060
IV	**Pods/plant**	
	a) Few (<10)	EC 931104, EC 931107, EC 931111 & EC 931112
	b) Average (15-20)	EC 9 EC 931105, EC 931113 & EC 931114
	c) High (>20)	EC 931109, EC 931111 & EC 931149
V	**Hundred seed weight (gm)**	
	a) Extra small (<15)	EC 932461, EC 931812, EC 931813 & EC 931154
	b) Small (16-25)	EC 931103, EC 931109, EC 931113 & EC 931114
	c) Medium (26-35)	EC 931104, EC 931105, EC 931112 & EC 931118
	d) Large (36-45)	EC 931101, EC 931107, EC 931924 &EC 931925
	e) Extra large (>46)	EC 931924,EC 931925, EC 931119 & EC 931374
VI	**Seeds/pod (>7)**	EC 931121, EC 931237, EC 931385 & EC 931481
VII	**Upright plant canopy**	EC 931895 & EC 932091

3. **Breeding material:** In order to improve agronomic traits (like early maturity, erect and upright plant canopy, high pods/plant, and enhanced grain yield), a new cross was attempted in the common bean breeding programme during 2021-22. These goals also included developing lines with resistance to biotic (BCMV/Anthracnose), abiotic (frost/cold) stresses and enhancing micronutrients (Fe & Zn). In last five years, developed enormous breeding materials for different trait improvement currently breeding lines at various generations (Table 3). The effective crossing programme, evaluation, generation advancement and selection of promising lines were also carried during this season at IIPR, Kanpur. Further, this crop has higher adaptability to diverse ecological environments, therefore during off-season the shuttle breeding approach is being used for advancement of breeding materials, disease screening (BCMV/Anthracnose) & evaluation of Biofortified lines at ICAR-NAISM, Baramati, ICAR-NBPGR, Regional station, Shimla, and ICAR-IIHR, Bangalore.

Table 11. Common bean breeding material developed & maintained for various traits

Stage	No. of crosses	Breeding materials
F_1s	8	8
F_2	11	700 SPS
F_3	6	452 SPS
F_4	7	315 SPS
F_5	4	155 SPS
F_6	4	112 SPS
F_7	4	85 SPS
Mapping population (02)		
MP1 (F_4)	Uday x Amber	BCMV resistance
MP2 (F_4)	Uday x EC931194	*Anthracnose* resistance

4. **Evaluation of promising entries:** A station trail comprises of 12 entries were evaluated with four checks (Uday, Arun, Utkarsh, HUR 15) for agronomic performance and yield traits during 2021-22. Two entries IPR 52-21 (2012 kg/ha) and IPR 264-21 (1820 kg/ha) were demonstrated higher yield over the best check Uday (1543 kg/ha) and Utkarsh (1623 kg/ha) in terms of yield, pods/plant, plant type and BCMV resistance and also being evaluating in IVT trial under AICRP.

5. **Identified an extra early maturing germplasm for common bean:** Total 29 exotic diversified common bean lines were selected from previous germplasm evaluation and characterization study of 1200 common bean accessions based on superior agronomic performance, flowering time, maturity duration (early to medium duration), pods/plant and yield. These accessions were evaluated in RCBD design under diverse production environment for three consecutive years during 2019-20 and 2021-22 at Kanpur and one experiment at ICAR-NBPGR-RS, Shimla during *Kharif* 2021. Based on multi-seasonal field evaluation of 29 exotic diversified lines at two diverse environments, identified two super early maturing lines namely, EC 932021 & EC 932189 (Mature in 90-95 days at Kanpur; Mature in 75-80 days at ICAR-NBPGR-RS, Shimla) in comparison to three checks Arun (120 days (Kanpur); 115 days (Shimla), Uday (118 days (Kanpur); 110 days (Shimla) and Utkarsh (133 days (Kanpur); 122 days (Shimla) and other germplasm lines.

Fig. 4: Extra early maturing germplasm source for common bean improvement

6. **Identified unique germplasm for extra-large pod with high 100 - grain weight:** The experiment study material included a collection of 120 Andean and Mesoamerican germplasm as well as indigenous common bean germplasm and checks (Arun, Uday, Utkarsh, HUR 15) was examined in an augmented design at ICAR-IIPR, Kanpur for three consecutive years from 2019-20 to 2021-22. Agronomical traits, pod morphological attributes, and seed attributes data were gathered. The germplasm EC 931924 & EC 931925 had extra-large pod length (14.4-16.05 cm) in comparison to control varieties such as Utkarsh (12.3 cm), Arun (13.9 cm), and Uday (11.8 cm), as well as the highest 100 seed weight of 54.95 gm, and seed yield of 1656 kg/ha). This germplasm accession was determined to be promising in terms of pod length, and high 100 - seed weight.

7. **Evaluation of biofortified lines for enhanced grain micronutrient:** During 2021-22, a panel of diversity encompassing 101 biofortified lines collected from CIAT gene bank, Colombia, and five Indian elite cultivars was evaluated for agronomic performance and seed micronutrients (iron & zinc) concentration in augmented block design by utilizing three check varieties, Arun, Uday and Amber. It was found that the iron concentration of seed ranges from 62.10 to 185.10 mg/kg, with a mean value of 94.25 mg/kg and zinc concentration of seed having mean value of 38.24 mg/kg, with a range of 24.08 to 84.35 mg/kg. Furthermore, promising 30 genotypes were streamlined out of 109 bean lines were evaluated for seed micronutrients.

Project 3: Seed System Research

A01. Seed Technological Studies in Pulses

1. **Variation of hard seededness in *kharif* and summer grown mungbean and urdbean genotypes:** Hard seededness (physical dormancy) refers to the development of water impermeable seed coat that does not allow the seed to imbibe water. To understand the effect of growing season on occurrence of hard seededness, the freshly harvested seed of 131 urdbean genotypes and 107 mungbean genotypes produced during *kharif* and *summer* 2022 were subjected to germination assay for four days. The hard seeds in *kharif* grown urdbean genotypes ranged between 8 and 78% with a mean of 56%, while in summer grown urdbean, the value ranged from 0-28% with a mean of 3%. Likewise, the hard seeds in *kharif* grown mungbean genotypes ranged between 14 and 76% with a mean of 43%, while in summer grown mungbean genotypes, the value ranged from 0-24%, with mean of 6%.

The occurrence of hard seededness in freshly harvested seeds of mungbean and urdbean was more during *kharif* as compared to summer.

2. **Developmental studies of hard seededness in mungbean and urdbean:** For understanding the development of hard seededness, five genotypes recording more percent of hard seeds in mungbean (ML 935, PDM 262, Soptari, ML 818, EC 396423) and urdbean (IPU 9-112, EH 35-15, GP 28, PLU 302, PKJU 1); five genotypes recording low per cent of hard seeds in mungbean (EC 520029, EC 398894, LM 95, HW 4211, IPM 9901-10) and urdbean (IPU 99-23, IPU 91-22, PLU 144, IPU 99-209, T 9) were selected. The seeds of these genotypes were harvested at three stages immature (60-62% moisture content), half mature (39-45% moisture content) and matured (11-12% moisture content) and were subjected to germination. The immature and half mature seeds of both crop recorded no hard seeds; while seeds harvested after maturing recorded a considerable per cent of hard seeds, more in hard seeded genotypes and low in soft seeded genotypes. The result concluded that seed attains hard seededness at the end of seed filling period.

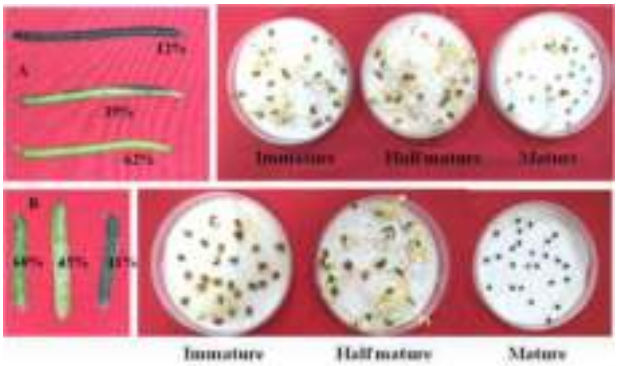
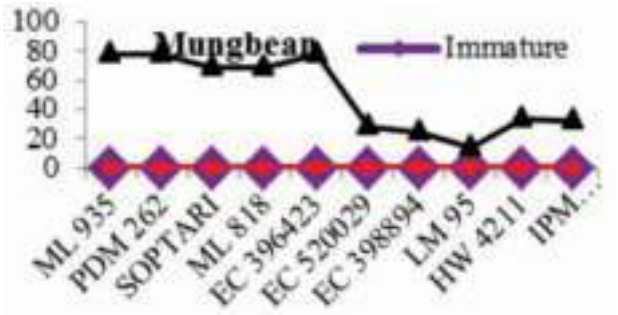


Fig. 5: Stages of seed harvesting and occurrence of hard seed in immature, half mature and matured seed of mungbean (A) and urdbean (B)



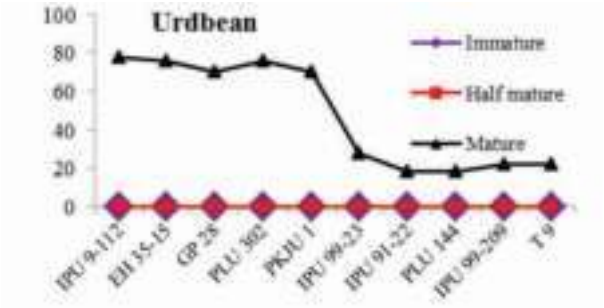


Fig. 6: Occurrence of hard seededness in contrasting genotypes of mungbean and urdbean at different stages of maturity

3. **Breaking dormancy (hard seededness) in wild pigeonpea:** Occurrence of physical dormancy in the form of hard seed coat prevents proper utilisation and conservation of wild pigeonpea species. Hence, an attempt was made to overcome hard seededness in 44 accessions of pigeonpea comprising of 10 species (*C. scaraboides, C crassus*, *C. platycarpus*, *C. cajanifolius, C. lineatus*, *Rynchosia minima*, *R. bracteata*, *R. rothii*, *R rufescens* and *R. aurea*). The treatments included hot air treatment (HAT) for 3, 5, 7 and 14 days, hot water treatment (HWT) for 30 and 60 minutes, concentrated H_2SO_4 treatment (SAT) for 2 and 5 minutes and partial incision in distal end of seed (PSCI). Overall, all the treatments reduced hard seededness and improved germination over control, with PSCI being best treatment for all species recording 70-98% germination, except for *R. aurea* (30%) and *C. cajanifolius* (59%). The HWT for 30 and 60 minutes was the best treatment for *C. cajanifolius* recording germination of 66-70% as compared to 11% in control. The SAT for 2m was the best pre-treatment for overcoming dormancy and improving germination in *R. bracteata* (with PSCI & HAT3D), *R. rothii* and *R. rufescens* (along with PSCI).

4. **Extended funiculus in pea:** The presence of funiculus in harvested seeds has a significant but negative role in rate of water uptake, as the seeds of these accessions imbibed more water when funiculus was removed. Water imbibition by seed is an important step that enables the initiation of metabolic processes for successful germination and intact funiculus mediated reduction in water imbibitions by seed could impact germination. With that in aim, we conducted germination of intact funiculus accession with and without (after removing of funiculus) funiculus. However, there was no significant difference in germination of seed with funiculus and with funiculus removed suggesting that intact funiculus doesnot have any role in germination.

Table 12. Germination of intact funiculus accession with and after removing funiculu

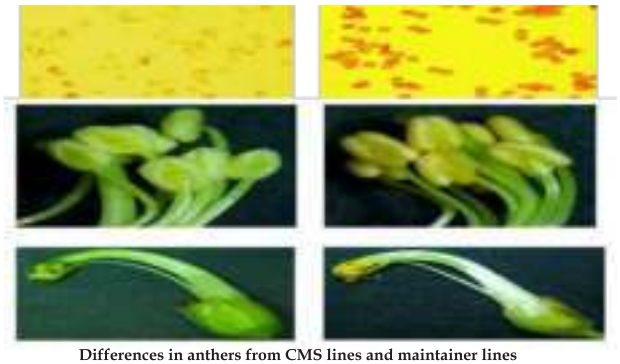
Accession		Germination (%)
EC 564816	with funiculus	94
	without funiculus	100
EC 414479	with funiculus	100
	without funiculus	100
EC 414486	with funiculus	100
	without funiculus	100
EC 328778	with funiculus	98
	without funiculus	100
EC 564814	with funiculus	100
	without funiculus	98

Externally funded projects

1. Consortium research project on hybrid technology (CRPHT) on pigeonpea (ICAR)

1.1. Significant achievements: The Institute GIC identified eight new CMS lines (ICPL 88039A, PAU 881A, ICPL 7148A, ICPL 88034A, AL 201A, Pusa 2002-2A, MN 5A, AL 15A) as unique material for their registration with ICAR-NBPGR. The new lines will boost hybrid pigeonpea breeding.

1.2. Hybrid entries in AICRP trials: Four extra early and early CMS hybrids namely IPH 18-04 (15.6 q/ha), IPH 21-01 (17.5 q/ha), IPH 17-1 (15.9 q/ha) and IPH 18-9 (15.2 q/ha) were evaluated for yield and other traits. Hybrid IPH 21-1 were promoted to AHT-1 under early maturity



Differences in anthers from CMS lines and maintainer lines

1.1. Hybrid entry station trial: Five early maturing hybrid entries namely IPH 21-02, IPH 21-03, IPH 21-04, IPH 21-05 & IPH 20-02 were tested with three check entries IPH 15-3, IPH 09-5 and PAU 881. Hybrid entry IPH 21-5 (18.67 q/ha) out yielded all the check entries.

1.2. Test cross hybrids: A set of 75 test cross hybrids were evaluated for yield, maturity duration and yield attributing traits. The superior hybrid combinations were again reattempted for testing under station trial.

1.5. Maintenance of A, B & R lines of notified hybrids: IPAH 15-3 (A line–10 kg, B line–18 kg, R line–28 kg) and **IPAH 09-5** (A line–00 kg, B line–00 kg, R line–21 kg each)

1.6. Seed multiplication: Four hybrid (4,000 seed each) by hand pollination for ensuring genetic purity

1.7. Seed multiplication of CMS lines: ICPL 88039A, PAU 881A, ICPL 7148A, AL 201A, Pusa 2002-2A, ICPL 88034A, MN 5A, AL 15-A

1.8. An account of A, B & R lines: Total 51 CMS lines including 21 new and their contingent B lines and 82 restorer lines under hybrid breeding.

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

2.1. Digitalization of pigeonpea breeding experimental data: Digitalization of pigeonpea breeding programme in India was started in 2017 by using Breeding Management System (BMS) software through ICAR-ICRISAT collaborative project. BMS is cloud-based server software which assists in completely digitalizing breeding operations and activities. To scale up the implementation of BMS and speed up use of genomics activities in crop breeding, an ICAR-BMGF collaborative grant, application of next-generation breeding, genotyping and digitalization approaches for improving genetic gain in staple crops was initiated in 2019. Through this project advanced bioinformatics and digitalization central support is being provided by Excellence in Breeding Programme (EiB), CIMMYT. Total 146 lines and diverse pigeonpea parents were uploaded on BMS portal to create studies like nurseries and trials. A total of 64 nurseries from 2008-22 and 29 trials from 2013-22 were uploaded. A data from hybrid and station trials of pigeonpea for the period 2013-2022 had been migrated to BMS as part of digitalization. The field layout, experimental design and data sheets of plant breeding trials are being generated through BMS. For more efficient data observation, correct time, date

and weather analysis can be quickly recorded by using Palmtop device. Now, sort, store and retrieve data accordingly will help breeders make data-driven selections of advanced lines for next generation breeding

2.2. Digitalization of chickpea breeding experimental data: Digitalization of breeding data, development and optimization of breeding pipeline following product profiles designed ecology wise were major activities of IIPR component under ICAR-BMGF project. ABLs which were subjected to field trials (station trials) during 2021-22 were digitalized in BMS and trials were laid out. Station trials for different ecologies are being conducted at Kanpur, Bhopal and Dharwad. Eighty ABLs subjected to four station trials viz., mechanical harvesting, rainfed (Kanpur, Bhopal, Dharwad); timely sown, late sown (Kanpur) were uploaded in BMS. Relevant crosses of ABLs were generated in BMS since 2005 and by generation advancement through pedigree breeding scheme, nurseries and germplasm lists were duly documented portraying breeding history of ABL evaluated during 2021-22. Documentation of ABLs by coining preferred entry codes (IPC series) against unique GIDs is under process, following experimental designs will be imported into BMS with field data. In chickpea BMS account till Dec. 2021; 201 germplasm lists and 188 nurseries have been uploaded.

3. Genetic enhancement to Stemphylium blight resistance in lentil through induced mutation (BRNS)

3.1. Generating mutant population by using gamma radiation: Following seed samples of lentil genotypes have been treated with different doses of gamma radiation. These samples will be grown during *Rabi* 2022-23 for generating M_1 generations.

Table 13. Doses of gamma radiation used to eradiate lentil genotypes.

Seed Sample	Dose-1 (Gy)	Dose-2 (Gy)	Dose-2 (Gy)
IPL 220	100	150	250
IPL 406	100	150	250
ILL 6002	100	150	-
IPL 227	100	150	-

3.2. Establishing screening method under controlled conditions: Plant samples affected with stemphylium blight disease were collected from disease infected field. These samples were used for pure culturing of disease inoculum for developing the disease under controlled conditions.

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

4.1. Generation of breeding material: Total 25 crosses were made with different traits (determinate plant type, YMV, powdery mildew, bruchid tolerance, pod length, pod number, seed size and colour and 15 crosses seeds were harvested successfully during *Kharif* 2022.

4.2. Generation advancement: Total 10 F_1's were planted along with parents for further generation advancement. In the segregating generations, superior single plants were selected considering desirable traits *i.e.* earliness, seed colour, pod length, resistant to YMV and plant type to develop superior genotypes. Total 15 F_2 (170 SPS), 10 F_3 (400 SPS), 9 F_4 (300 SPS), 5 F_5 (95 line bulk) and F_6 (40 line bulk) were evaluated. 47 genotypes with two checks were evaluated in PYT for yield

4.3 Material shared: Genetically pure seeds of 96 genotypes were provided to ICAR-NBIPGR, New Delhi for re-sequencing purpose. The same set was also planted for rejuvenation but due poor heavy rains during initial stage only 60 were harvested; however, back-up seeds are available.

5. Pre-Breeding and Genetic Enhancement of Germplasm of Common Bean (CIAT)

5.1 Germplasm collection, evaluation and sharing: Total 106 common bean germplam and 8 wild accessions were supplied to NBPGR for ongoing project activity between Alliance Bioversity International-CIAT, ICAR-IIPR Kanpur and ICAR-NBPGR during 2021. One hundred ten diverse bean germplasm were utilized in germplasm characterization and identification of trait specific germplasm accessions.

Table 14. Trait specific donors identified for breeding programme

Donor Traits	Acc. No	Accessions name
Early flowering (<50 days)	8	EC 932021, EC 931970, EC 932189, EC 931876, EC 931942, EC 932027,EC 932030, EC 932010
Super early maturing(<100 day)	3	EC 932189, EC 932021, EC 931833
High pods/plant	6	EC 931887, EC 931940,EC 931941, EC 931946, EC 931949, EC 931963
Erect & compact canopy	2	EC 931895, EC 932091
Long pod type	1	EC 932060
Extra-large seed (>60 g/100 seed wt)	4	EC 931102, EC 931111, EC 931119 & EC 931374
Extra small seed (<15 g/100 seed wt)	4	EC 931132, EC 931110, EC 931121, EC 931152

5.2 Breeding materials: Few crosses for desired traits (BCMV resistance, Anthracnose resistance, high yield with enhanced micronutrients) were attempted during 2021. The F_1 were evaluated at NBPGR-RS, Shimla. F_1 derived F_2 segregating materials were harvested and same segregating materials were evaluation and generation advancement at ICAR-IIPR, Kanpur during 2022.

Table 15. List of F_1 produced for various traits during *Rabi* 2021

Cross (F × M)	Targeting trait	F_1s seed
EC 1038024 × Amber	High yield & Bush plant type	06
Uday × EC 1038024	High Fe and Zn & yield	04
Uday × EC 932030	Early maturity and high yield	03
Amber × EC 932030	Early maturity and high yield	10
Uday × IC 340947	High yield and BCMV resistant	16
Uday × IC 360831	High yield and BCMV resistant	09

6. Creation of seed hubs for increasing production of pulses in India (DAC)

Quality seed production of high yielding varieties of different pulse crops namely, mungbean (Shikha and Virat) & urdbean (IPU 13-1) and pigeonpea (IPA 203) during *Kharif* 2022 were conducted at farmers' field of Kanpur Dehat and ICAR-IIPR Kanpur with an objective to easy dissemination of quality seed production technology and easy reach of quality seed to the farmers'. While, quality seed production of chickpea, fieldpea and lentil during *Rabi* 2021-22 were taken on farmers' field, BNPG College, Rath, Hamirpur and ICAR-IIPR, Kanpur realized in the month of June 2022, following mandate of the project. The production under the project, a total of 100.15 qtls mungbean (foundation seed with two varieties Shikha and Virat) and urdbean 54.60 qtls were produced. However, during *Rabi* 2021-22, chickpea (IPC 06-77 and yield about 90 qtls), fieldpea (yield 441 qtls as per the assessment of UP Seed Certification), lentil (yield 18 qtls as per the assessment of UP Seed Certification Agency) and pigeonpea (IPA 203 yield 43.00 qtls) were sown on farmers field of Kanpur Dehat and Hamirpur districts. Total quality seed produced under Creation of Seed Hubs for Increasing Indigenous Production of Pulses in India was 746.75 qtls during the year.

7.1. Registration of unique germplasm

A total of 10 germplasm lines were registered as unique germplasm with ICAR-NBPGR during the year 2022, the details are given in the following Table.

Table 16. Germplasm registered with ICAR-NBPAR

S. No.	Name of the species	Acc No.	Reg. No.	Trait for which registered
1	*V. umbellata*	IC 251442	INGR 21226	Photo- and thermo period insensitive
2	*V. vexillata*	IC 0248326	INGR 22039	Resistant against *Callosobruchusmaculatus*
3	*V. umbellata*	IC 0251442	INGR 22041	Resistant against *Callosobruchusmaculatus*
4	*V. radiata*/ IPM 526-11	IC 0641993	INGR 22046	Highly resistant to yellow mosaic disease caused by Mungbean yellow mosaic India virus
5	*V. stipulaceae*	IC 331436	INGR 22040	Early flowering (20DAS) and early maturity (49DAS)
6	*V. mungo* var. *mungo*	IC 251387	INGR 22152	Resistant against bruchid species *Callosobruchuschinensis* L.
7	*Cicer arietinum*	IC 647176	INGR 22153	Highly resistant NIL against Fusarium wilt caused by *Fusariumoxysporum*f.sp. *ciceri*, race 2 (*Foc* 2), developed through MABC approach. High yield and wider adaptability
8	Ricebean/ *Vigna umbellata*	IC 0251439	INGR 22156	Resistant against bruchid species *Callosobruchusmaculatus* (F.)
9	Mungbean/ *Vigna mungo var. mungo*	IC 0251387	INGR 22152	Resistant against bruchid species *Callosobruchuschinensis* L.
10	Wildbean/ *Vigna vexillata*	IC 0248326	INGR 22157	Resistant against bruchid species *Callosobruchuschinensis* L.

7.2. Multilocation evaluation of promising genotypes in AICRP/Adaptive trials:

During 2022, 15 mungbean genotypes were evaluated in multilocation trials under the umbrella of All India Coordinated Research Project (MULLaRP) (Table 2). The genotype IPM 604-16 was retained at AVT-I stage during spring season in NEPZ and will be evaluated again. Likewise, the genotype IPM 1603-3 was promoted to AVT-I in NEPZ and SZ with 6.63 and 13.17 per cent yield superiority over the best check, respectively. The genotype IPM 13-6 (*Kharif*) was promoted to AVT I with 5.69% superiority in SZ. The genotype IPM 1603-7 (*Kharif*) was also promoted to in AVT I in NHZ and SZ with 32.94 and 7.16% yield superiority , respectively over the best check variety. Similarly the genotypes IPM 1103-1, IPM 1610-1, and IPM 1603-1 were also promoted to AVT-I in different zones and seasons with considerable yield superiority over the best checks. In addition to above, 5 new genotypes were also entered in AICRP trials for their multilocation evaluation in different seasons. These included IPM 1205-2 (IPM 02-3 x VBG 04-003), IPM 1704-14 (MH 318 x EC 369223), IPMD 1202-1 (IPM 99-125 x VBG 04-008), IPMD 14-6 (IPM 99-125 X Co5), IPMD 14-10 (PDM 139 X ML 729).

Table 17. Multi-location evaluation of superior fixed lines of mungbean in AICRP trials

S. No.	Entry	Pedigree	Stage/Season	Zone/ State	% Sup. over the best check
1.	IPM 604-16	Sona Mung x IPM 99-125	AVT-I, Spring	NEPZ (retained)	
2.	IPM 1603-3	MH 3-18 x EC 369223	AVT I, *Kharif*	NEPZ SZ	6.63 13.17
3.	IPM 13-6	IPM 6-5 x IPM 409-4	AVT I, *Kharif*	SZ	5.69
4.	IPMD 1603-7	MH 3-18 x EC 369223	AVT I, *Kharif*	NHZ SZ	32.94 7.16
5.	IPM 1103-1	IPM 06-5 x IPM 409-4	AVT-I , Summer	NEPZ	7.40
6.	IPM 1610-1	EC 391178x IPM 99-125	AVT I, Summer AVT-I, Spring	NWPZ NEPZ NHZ	5.13 5.29 5.38

7.	IPM 1603-1	MH 3-18 x EC 369223	AVT-I, Summer AVT-I, Spring	NWPZ NHZ	15.15 25.38
8.	IPM 1205-2	IPM 02 -3 x VBG 04-003	IVT Spring/Summer/Kharif	All zones	
9.	IPM 1704-14	MH 318x EC 369223	IVT Spring/Summer/Kharif	All zones	
10.	IPMD 1202-1	IPM 99-125 x VBG 04-008	IVT Spring/Summer/Kharif	All zones	
11.	IPMD 14-6	IPM 99-125 X Co5	IVT Kharif	Karnataka	
12.	IPMD 14-10	PDM 139X ML729	Kharif	Karnataka	

7.3. Evaluation of elite breeding lines

Two station trials each were conducted during spring and summer2022. During spring season, two station trials were conducted. In Station Trial 1 comprising 24 genotypes including 4 check varieties, the genotypes IPM 1718-1, IPM 1718-3, IPM 1620-6, IPM 312-18, IPM 1604-1, IPM 1704-14, IPM 1711-1, IPM 1722-1, IPM 701-704, IPM 6-5 X IPM 409-4 yielded better than the best check variety IPM 205-7 (1145 kg/ha). In station trial 2, 24 genotypes including 4 check varieties were evaluated and the genotypes IPM 21-15-1, IPM 21-20-3, IPM 21-23-1, IPM 21-23-5, IPM 21-23-13, IPM 1715-1, and IPM 2-14 x DGG 5 were found to be superior to the best check variety IPM 512-1 (1041 kg/ha).

In summer 2022, two station trials were conducted, each trial comprising 24 entries including 4 checks. In ST 1, the genotypes IPM 1604-1, IPM 312-18, IPM 1604-1, and IPM 1603-3 were found be yielding better than the best check IPM 410-3 (1312 kg/ha). Likewise in ST II, the genotypes IPM 21-12-8, and IPM 2-14 x DGG 5 yielded better than the best check IPM 410-3 (Soorya). All the above genotypes were also highly resistant against yellow mosaic disease.

During *kharif* 2022, 2 demonstrations, 3 station trials and 2 preliminary yield trials were conducted at ICAR-IIPR, Kanpur. However, due to excess rainfall during the reproductive phase, the yield data were not recorded and therefore all the station and preliminary yield trials will be repeated during the ensuing spring/summer and *kharif* season in 2023.

7.4. Germplasm resources and wild accessions: During *Kharif* 2022, 1060 germplasm accessions were rejuvenated. This included 308 active germplasm collections, 20 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 supplied under DBT-minor pulses project and 250 wild *Vigna* accessions. The 296 minicore accessions were raised in two replications during *Kharif* season at ICAR-IIPR, Kanpur and during summer season at RS, Dharwad. Data were recorded on 17 morpho-physiological parameters besides disease incidence at IIPR, main campus.

Table 18. *Vigna* germplasm maintenance during *Kharif* 2022

S. No.	Germplasm Set	No. of accessions
1.	Active germplasm collection	308
2.	Landraces and Farmers' materials	20
3.	Minicore set	296
4.	AVMU advanced lines	90
6.	Wild accessions	250
7.	Germplasm set for resequencing work	96
	Total	**1060**

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.

7.5. Generation and advancement of breeding materials: During *Kharif* 2022, 26 fresh intra- and inter-specific crosses were generated using 10 elite 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 and IPM 205-7) as the recipients and 9 donor lines (ML 1808, SPS 5, CoGG 8, LGG 460, ML 1808, PDM 54, Co6, ML 2479, and MH 421). Besides the above crosses, 8 multi-parent crosses were also developed to generate new variability. These crosses were developed for several traits

including yellow mosaic disease resistance, yield related traits, early maturity and bruchid resistance.

7.6 National crossing programme:

Nine promising donor genotypes viz., IPM 409-4 (extra early + synchronous maturity), IPM 410-3 (more cluster/plant + number of pods + YMV), EC 398889 (heat/drought tolerance), IC 2527442 *(V. umbellata)* (photo-thermo insensitivity), RBL 50 (*V. umbellata*, long pod and YMD resistance), and IPM 512-1 (no. of pod per plant and plant type), ML 2479 (YMD resistance),(WGG 42) long pods) and MH 1468 (YMD resistance and mechanical harvesting) were included in National Crossing Programme during *Kharif* season to generate fresh breeding materials. The above donors were crossed with elite mungbean genotypes developed at ICAR-IIPR and 37 F_1 crosses were developed.

7.7 Advancement of breeding materials

The breeding materials in different segregating generations were raised during *Kharif* 2022. A total of 642 superior single plants were raised in different segregating generations in 89 inter- and intra-specific crosses. These included 66SPS in F_2, 106 in F_3, 170 SPS on F_4, 42 SPS in F_5, 28 SPS in F_6, 10 SPS in F_7 and 11 SPS in F_8 generation in mungbean x mungbean intra-specific crosses. In the inter-specific crosses involving urdbean, *V. umbellata, V. unguiculata, V. glabrescens, V. sylvestris*as donors in mungbean background and a total of 267 single plants in different segregating generations were raised including 41 SPS in F_3, 198 SPS in F_4 and 28 SPS in F_5 generations. However, selections could not be made due to excessing rainfall during the reproductive phase and all segregating generations were advanced to the next generation. Selections for isolating superior plants will be taken up in the *Kharif* 2023 season.

7.8 Maintenance breeding

During *Kharif* and Spring/Summer 2022, a total of 492 kg nucleus seed of nine mungbean varieties and 180 kg seed of chickpea variety Samriddhi were produced. The detail of total nucleus seed produced in different varieties is given in the Table 4.Besides the above >3100 single plant selections of the above 9 varieties were also taken during *kharif* 2022 for growing single plant progeny rows for nucleus seed production.

Table 19. Nucleus seed produced in mungbean and chickpea during 2022

S. No.	Name of variety	Quantity Produced (kg.)
1.	Virat	129
2.	Varsha	67
3.	Soorya	106
4.	Shikha	87
5.	Heera	15
6.	IPM 2-14	31
7.	IPM 2-3	30
8.	Kanika	8
9.	Vasudha	19
10.	IPCMB 19-3 (Chickpea)	180
	Total quantity	**672**

8. Establishing International Mungbean Improvement Network-II (IMIN-2)

After the successful completion of International Mungbean Improvement Network-I, the second phase of the project was started, ICAR-IIPR being one of the major partners. This phase will focus mainly on making use of genetic and genomic resources for mungbean research and breeding and testing of improved lines developed and strengthening seed delivery system by fostering partnerships between private sector NGOs, farmer group. The Ist phase of the project was concluded with the following achievements:

1. Germplasm exchange: Received minicore set of 296 acessions, 90 advanced breeding lins and exotic varieties, shared 10 released popular Indian varieties with international partners
2. Developed 22 new intraspecific crosses, advanced interspecific crosses
3. Conducted extensive multi location phenotyping of minicore and advanced liens for 5 years, 2 seasons and two locations (Dharwad and Kanpur), Conducted 11 evaluation trials
4. Developed Mung Advisor, android based bilingual application toolImplementation of online data management system: KDDart
5. Bruchid/YMD screening and development/ identification of resistant donors

6. Organization of 'Mungbean Stakeholders' Workshop'

7. Participatory breeding and product profile development

8. Capacity building: Training of scientists, staff and other stakeholders

9. Development of infrastructural facilities: Solar bubble dryers, insect proof nethouse screening facility During Kharif 202, a replicated trial of mungbean minicore collection (MCC) comprising 296 accessions was conducted to evaluate the MCC at ICAR-IIPR, Main campus. Another trial to evaluate MCC was conducted at ICAR-RS, Dharwad (Karnataka) during *Kharif* season. Another set of 90 superior lines comprising advance breeding line as well released varieties of Australia, Bangladesh and Myanmar was also raised at both the locations and evaluated for morho-physiological characters as well as disease resistance supplied by World Vegetable Centre was evaluated for morpho-physiological traits and 16 promising lines w.r.t yield and quality parameters were identified.

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

This project was undertaken with an objective to introgress multiple race resistance against *Fusarium* wilt caused by races 1, 2 3 and 4 of *Fusarium oxysporum*f.sp. *ciceri* in elite chickpea cultivar JG 16. Two elite chickpea genotypes viz., Vijay and WR 315 are being used as the donors for introgressing the genes of interest in JG 16. The backcross progenies were 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, TA37 for race 2, TR 19, TAA 60, TA 194, GA 16 for race 3, TR 19, GA 16, TA 59 for race 4. The true heterozygotes are further backcrossed to pyramid multiple race resistance against *fusarium* wilt. The nucleus seed production plots of IPCMB19-3 (Samriddhi), the newly released variety of chickpea have been raised during *Rabi* 2021-22. Simultaneously, 12 superior fixed lines in the background of JG 16 developed through MABC were multiplied and evaluatedfor their yield performance.

Project: Detection of genetic loci associated with yield attributed and seed quality traits under high temperature exposure in Field pea (*Pisumsativum* L.)(DST-SERB)

1. **DNA Isolation:** DNA of 150 plant leaf sample were isolated as per manual instruction of NucleoSpin Plant II and subsequently used for GBS analysis

2. **DNA Quantification:** The three major QC methods for DNA sample qualification:

   - Agarose gel electrophoresis analysis for DNA purity and integrity.
   - NanoDrop® 2000 spectrophotometer measurement for DNA purity by assessing the OD260/OD280 ratio.
   - Qubit® 2.0 flurometerquantization for accurate measurement of DNA concentration.

3. **Library Preparation and Sequencing :** Throughout the whole process of sequencing from the DNA sample to the final data, each steps, including sample test, library preparation, and sequencing procedures, influences the quality of data production, while the data quality further impacts on the analysis results directly. The genomic DNA of each sample was digested respectively with proper restriction enzymes based on the in silico evaluation results (EcoRI+MseI), and the obtained fragments were ligated with two barcoded adapters that either with a compatible sticky end with the primary digestion enzyme and the Illumina P5 or P7 universal sequence.

4. **DNA Sequencing:** The qualified DNA libraries were pooled according to their effective concentration as well as the expected data production. Pair-end sequencing was performed on Illumina® HiSeq/MiSeq platform, with the read length of 144 bp at each end. We are generating minimum of 120Mb data from each sample for SNPs analysis. We could generate a data for 96samples, however it get failed for 54 samples. We have re-isolated the DNA from the fresh sample and quantified for further downstream process. The analysis for retrieving SNPs and QTL mapping will be carried out coming year.

5. **Scientific Social Responsibility (SSR):** Organized one day training programme on "True hybrid testing in pulse crops using molecular techniques" Under Scientific Social Responsibility (SSR) of DST-SERB funded project.

Plant Biotechnology

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

SP1: Marker-assisted gene introgression for abiotic stress tolerance and their effect on primary metabolites in chickpea

In the regime of climate change, moisture stress is a major constraint for legume crops including chickpea that affects plant growth and development, ultimately causing yield loss. Marker added gene introgression of "QTL hotspot" was done in genetic background of KWR 108, JAKI 9215 and GNG 1581, respectively. The second, third and fourth round of back crossing was achieved in different genetic backgrounds and materials are at BC_2F_1, BC_3F_2, and BC_4F_1 generations for further study. KASPs assay was designed and demonstrated in chickpea for high throughput foreground marker analysis. However this needs to be further strengthened and standardized.

Recombinant inbreeding lines were also developed using ICC 4958 as donor parent in genetic background of DCP 92-3 and initially screened for QTLs linked flanking markers. They were also phenotyped in pot/tray condition in net house by withholding gradual water moisture depicting real drought situations. The experiment was repeated twice. Relative water content (RWC) of leaf, stem and root along with regeneration capacity after re-watering was documented. More than 10 lines revealed high level of seedling stage moisture tolerance stress and regeneration capacity.

Nucleus seed production of the newly developed drought tolerance MABC variety IPCL 4-14 was done at IIPR, Kanpur as well as RS, Bikaner. Seeds of this variety were also given to NSC, Kanpur for multiplication.

SP 2: 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 in different environments. Six immortal mapping populations (Table 1) involving heat stress susceptible and tolerant genotypes have been developed and were advanced to F_7 stage during *Rabi* season 2021-2022 at ICAR-IIPR main field. Two such F_6 population (BG 256 x EC 556270; and ICC 12155 x ICC 15614) were screened for heat stress under late sown conditions at ICAR-IIPR, Kanpur and RRC, Bikaner. Both the populations exhibited huge variations for number of filled and unfilled pods under heat stress and hence could be used for mapping the traits. 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 map new QTLs as well as to fine map these QTLs, 13,55,754 InDels in 8 chromosomes, 2,88,686 in all contigs, and 31 InDels in chloroplast sequences were mined from re-sequencing data of 294 mini-core lines of chickpea following GATK tools. Of these 13,55,754 InDels, 7,48,068 were of insertion type and rest 8,96,403 were of deletion type. The effect of each Indels was assessed and the majority of InDels were present in inter-genic region, intron, non-coding regions of a gene (UTR), and very few (i.e.458) InDels created stop codon. 200 InDels were chosen randomly based on their functional relevance (*viz.*, exon loss; gene fusion; 3' and 5' UTR truncation; start and stop lost; stop gained and designed InDel flanking primers. These InDel flanking primers will be utilized in mapping new QTLs and fine map the QTLs associated with heat stress tolerance.

Table 1. Chickpea mapping population segregating for heat stress

S. No.	Cross	Population stage	Population size
1	BG 256 x EC556270	F_7	233
2	BG 256 x ICC12155	F_7	155
3	ICCV 2 x ICC9942	F_7	187
4	ICCV 2 x ICC12155	F_7	190
5	ICC 5912 x ILWC141	F_7	170
6	ICC 12155 x ICC 15614	F_7	191

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

Genome-wide effector identification was carried out with predicted proteins from refined genome assembly of *Fusarium udum* developed at ICAR-IIPR, Kanpur. 489 effector proteins were identified in refined *Fusarium udum* genome assembly. Of these four hundred eighty nine effector proteins, 52% were apoplastic and 30% proteins were having cytoplasmic signals. Remaining had both apoplastic and cytoplasmic signals. Besides these, long non-coding RNA (lncRNA) and microRNAs responsive to *Fusarium* wilt were mined in pigeonpea using root transcriptome data of inoculated and non-inoculated plants of ICP 2376 (susceptible) and ICP 8863 (resistant) cultivars at 36 hours post inoculation obtained from NCBI SRA data. A total of 5829 lncRNAs were identified, of these 100, 76, 50 and 90 were differentially expressed in ICP2376-control *vs* ICP 8863-control, CP 2376-treated *vs* ICP 8863-treated, ICP 2376-control *vs* treated, and ICP 8863-control *vs* treated comparisons respectively. Differentially expressed lncRNAs along with their log2 fold value have been represented by heatmap (Figure 1). A total of 124 conserved micro-RNAs belonging to 37 families were identified from the transcriptome data. A total of 3,243, and 15,776 transcripts/genes were identified as microRNA and lncRNA targets, respectively in pigeonpea genome. The integrated study of lncRNAs, miRNAs and their targets provide a regulatory insight for *Fusarium* wilt disease in pigeonpea. Similarly, *Fusarium* wilt responsive lncRNAs and microRNAs in chickpea were mined using shoot transcriptome data of two contrasting genotypes (KWR 108-resistant and GL13001-susceptible to *Fusarium* wilt). A total of 4,169 long-noncoding RNAs and 195 conserved micro-RNAs belonging to 54 families were identified. Of these lncRNA, 102, 45, 80 and 74 were identified as differentially expressed in GL 13001-treated *vs* KWR 108-treated, GL13001-control *vs* treated, GL 13001-control *vs* KWR 108-control and KWR 108-control *vs* treated comparisons. A total of 4063 and 13,339 transcripts/genes were targeted by the identified micro-RNAs and lncRNAs, respectively. These differentially regulated lncRNA and microRNA in chickpea and pigeonpea in response to *Fusarium* infection might determine the interaction of host R genes and fungal effector during pathogenesis.

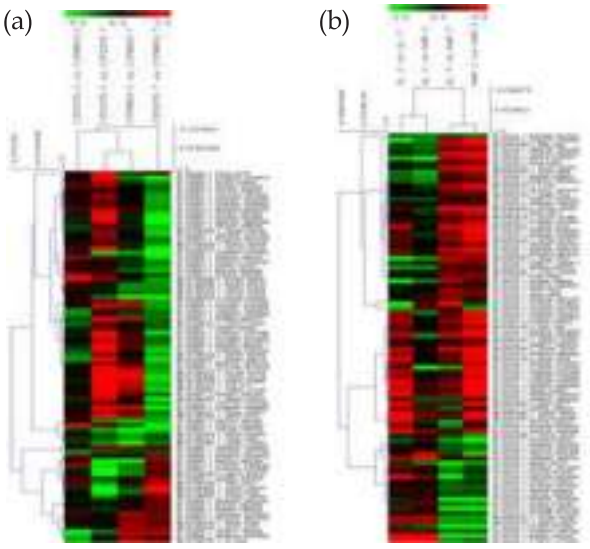


Fig. 1: Differentially expressed lncRNAs in response to *Fusarium* in (a) pigeonpea and (b) chickpea

SP4: Molecular dissection of loci for powdery mildew resistance and photo-thermo-insensitivity in urdbean

Due to its shorter life cycle, great output, and use in different food preparations, urdbean (*Vigna mungo*) crop has a special significance in the Indian farming system. YMD, powdery mildew, photo-thermal sensitivity, and other biotic and abiotic restrictions have prevented the crop from reaching its full yield potential. This effort intends to molecularly identify the loci responsible for resistance and understand the genetics of resistance to different biotic and abiotic stimuli. A panel of 98 genotypes of blackgram was sown at ICAR-IIPR, Kanpur in July, August and September 2021 to record the flowering data in order to identify the photo sensitive and insensitive lines of urdbean. Data on days to first flowering and days to fifty per cent flowering (DFF) was recorded for the individual lines in all three seasons (*Kharif*, late *Kharif*, and *Zaid*). An absolute mean difference for days to flowering in all possible combinations and mean of all absolute mean differences was calculated. The core set of genotypes displayed huge difference in days to flowering, and thus, their differential response to photoperiodism. The set of genotypes were further categorized into early, medium and late flowering according to the mean number of days required for flowering. A total of 32 early, 21 medium, and 2 late flowering lines were identified and were common across both seasons and years. Similarly, 13 photoperiod insensitive and 8 photoperiod sensitive lines were identified for further validation and studies. A panel of 96 genotypes of blackgram was sown at ICAR-IIPR, Kanpur in November 2021, to identify the thermo insensitive lines of urdbean. But none of the genotype was observed to be thermo insensitive.

Powdery mildew screening of blackgram accessions at IIPR RS, Khordha has revealed a graded response against the fungi. Genotypes are being screened using MLO primers, for further association

mapping of blackgram against powdery mildew.

SP5: Precision plant breeding and rapid generation advancement in chickpea

The project aims to develop robust protocols for rapid generation advancement in chickpea to accelerate genome editing pipelines in chickpea, besides development of protocol for routine and targeted modification of locus in chickpea. Based on the pilot experiments conducted with a panel of cultivars and promising genotypes of chickpea, it could be established that LED lights of specific spectra under controlled environmental conditions could significantly shorten seed to seed cycle in chickpea. Also, culture of green chickpea seeds (20-24 days post fertilization) could be established to mature fertile plants. Together the turnaround time estimated was 70-75 days. Detail specifications for Speed Breeding Facility (PBSL-2) were finalized, after several rounds of discussion and submitted to ICAR for establishment of a state-of-art Facility at ICAR-Indian Institute of Pulses Research, Kanpur.

For development of targeted gene-editing (SDN-1) in chickpea, homolog of soybean *Ln* locus controlling NSPP (number of seeds per pod) and leaflet shape were identified in Chromosome 4 of chickpea [NC_021163.1]. Oligos were designed to amplify the genomic regions of the Ln locus in chickpea cultivar, HC5. Oligos for RT-PCR/qRT-PCR were designed based on the predicted coding region of the gene Zinc Finger protein JAGGED (LOC101497400).

SP6: Molecular approaches for improving the nutritional quality of grasspea (*Lathyrus sativus* L.) and field pea (*Pisum sativum* L.)

Aim of the project is to characterize the ODAP biosynthesis pathway related genes in grasspea and RFO metabolism related genes in field pea and to develop and optimise CRISPR/Cas based gene editing system in grasspea. With the construction of four CRISPR/Cas vectors having sgRNAs for oxalyl-CoA synthetase and ODAP synthase genes, genetic transformation of 98 embryonic axis explants of grasspea (cv. Mahateora) using *Agrobacterium* & *tumefaciens* harbouring a CRISPR/Cas construct having dual sgRNAs specific to oxalyl-CoA synthetase gene was done. Six T_0 plants established that produced 60 T_1 seeds and were sown in the nethouse and their molecular analysis is in progress. In order to quickly and inexpensively detect the effectiveness of sgRNA for genome editing, we have developed *Agrobacterium rhizogenes-mediated* hairy root transformation method using cotyledon explants with attached hypocotyl in grasspea that can give transgenic root within a month after transformation (Figure 1).

The expression pattern of ODAP synthase gene was analysed by RT-PCR method using two-days old whole seedlings, seedling shoots, seedling leaf tissues from four genotypes *viz*., Pusa 24, RLK248, EC/9 and Mahatoera having ODAP content 0.17-0.23%, 0.11%, 0.39%, 0.05-0.07%, respectively. RT-PCR revealed expression of ODAP synthase gene in all the genotypes at seedling stage.

The detail *in silico* characterization and identification of SSR motifs in the RFO metabolism-related genes in fieldpea was performed and identified 26 microsatellite loci from the 24 RFO metabolism-related genes. Of these, 17 microsatellite loci were found suitable for primer synthesis and for the development of SSR markers. Primers were synthesized, and their validation for developing SSR markers is in progress.

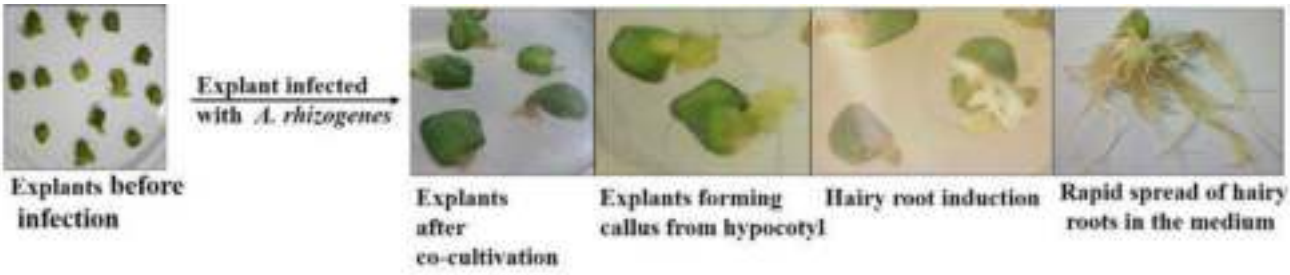


Fig. 2: Process of hairy root induction in grasspea

SP7: Transforming *Vigna* for tolerance to whitefly (*Bemisia tabaci*)

With the objective to develop marker free transgenic greengram tolerant to whitefly, embryonic axis attached to cotyledon of green gram cv. Virat were transformed with *tma12* using biolositics and *Agrobacterium* mediated genetic transformation (Amgt) approach and were directly regenerated in soil to obtain plantlets. Ten plantlets were found PCR positive (Figure 3) of which only four could bear pods under simulated conditions. These were carried forward to next (T_1) generation and confirmed for presence of desired gene(s) by

PCR. T_2 seeds have also been harvested. Enhanced transformation efficiency was observed using the explant with Amgt approach.

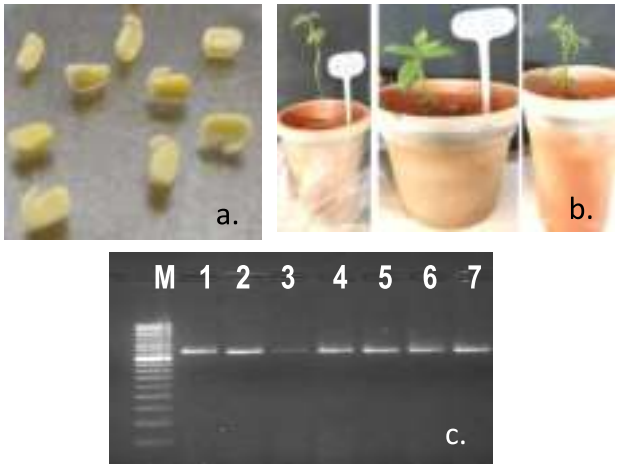


Fig. 3: *Agrobacterium* mediated genetically transformed green gram plants confirmed for presence of *tma12* by PCR a. Explants b. Regenerating hardened transformed plants c. PCR gel of tma12 positive samples

Additional 350 explants were genetically transformed using *Agrobacterium* and 21 plants from four batches have been regenerated and molecular analysis is underway.

Experiments also revealed that an initial mixture of cocopeat and soil was the best for regenerating the transformed plants both under simulated conditions as well in containment. Direct hardening bypassed the issues of rhizogenesis *in vitro* that had led to a major loss of regnerating transformed explants.

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

Objective of the project being development of triple-gene constructs with multiple insecticidal genes, two genes, cryIAc and cry2Aa, were cloned under a pod-specific promoter, and the genomes of five Bt isolates with confirmed insecticidal activity against *Helicoverpa*, AK2.IIPR, F1. IIPR, F5.IIPR, F6.IIPR, and F8.IIPR were sequenced in search of the third gene. The plasmids, however, were not captured due to their low molecular weight. Because plasmids are known to carry cry genes, plasmids were recovered twice at various periods from the five candidate *Bt* isolates, with the exception of the F6 isolate, which did not contain the plasmids, and evaluated for purity using restriction digestion. Further paired-end sequencing of the purified plasmids on the IlluminaNovaseq 6000 platform is in progress.

Further in the quest for the herbivory inducible genes and their promoters, genome-wide identification of the chitinase gene family in chickpea was investigated, which revealed the presence of 27 chitinase genes in chickpea, 21 of which were classified as GH-18 family genes and 6 as GH-19 family genes. Based on the publicly available transcriptome studies, expression profiling of the 11 differentially expressed chitinase genes under simulated herbivory was tested under field conditions by insect feeding experiments, which identified seven genes that were induced in response to *Helicoverpa* herbivory. Additionally, we performed molecular docking and simulation studies of seven herbivory-induced chitinases to examine the chitin-binding capacities, which revealed a varying ability to bind ligands. Overall, based on early or sustained herbivory inducibility and the best chitin binding capacity, Car-Chit-15 was cloned and confirmed. To validate the insecticidal activity *in vitro*, Car-Chit-15 has been subcloned into the pET-28a vector, and the recombinant vector has been confirmed by restriction digestion (Figure 4).

In addition, a Bowman-Birk trypsin inhibitor (BBTi), a pathogen-responsive small secreted cysteine-rich protein (SSCP) with a potential role in plant defense, has also been identified in pigeonpea with the goal of characterizing insecticidal genes with different modes of action. The gene has been cloned into the pET28a vector and confirmed by restriction digestion (Figure 4) and sequencing.

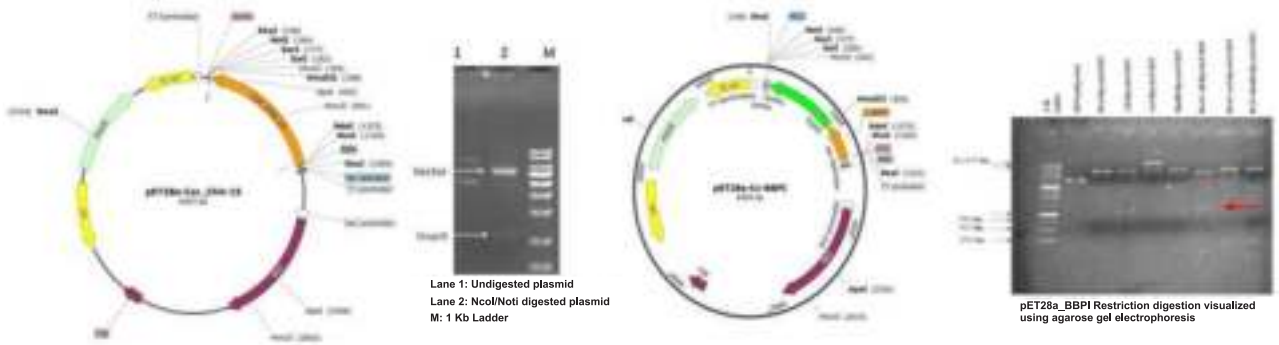


Fig. 4: Vector maps of pET-28a-Car_Chit-15 and pET-28a-Cc-BBTi, and confirmation by restriction digestion.

SP9: Identification of genes/QTLs for salinity tolerance in blackgram and earliness in lentil.

Blackgram is a major pulse crop affected by various biotic and abiotic stresses. Saline soil is one of the major challenges in blackgram cultivation. Accurate phenotyping is required to identify salinity tolerant germplasm for molecular breeding utilising better lines to target these salinity affected regions.

A quick, affordable, and effective hydroponics-based salinity screening facility has been developed and was used to screen 96 blackgram germplasm at 100 mM NaCl as well as under control conditions in order to observe the differential response of various genotypes against salt treatment.

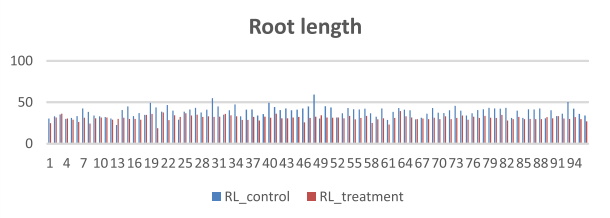


Fig. 5: Distribution graph of root length in control as well treated set after salt treatment

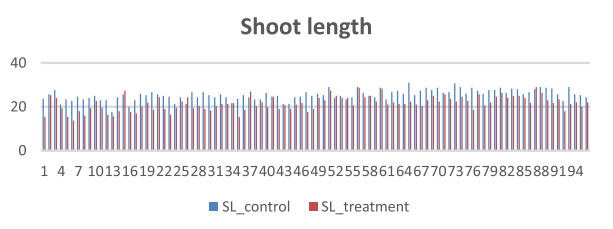


Fig. 6: Distribution graph of shoot length in control as well treated set after salt treatment

Data for various growth attributes like shoot length, root length, fresh and dry root weight has been taken (Figures 5 and 6). Based on these data blackgram lines has been categorized into five categories *viz.* highly tolerant, tolerant, moderately tolerant, susceptible and highly susceptible. SSR markers spanning whole genome were designed and genotyping is under process. 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 for the varietal development.

Externally Funded Projects

DBT- Network project on genetic enhancement of minor pulses

Genotyping of the horsegram variety panel

Horsegram variety panel (21) was genotyped using 50 horsegram specific SSRs and analysis done using DarWin. The variety panel clustered up into two clades (Figure 7) with one variety *viz.* TCR 1746 remaining independent indicating that it possessed high diversity at the loci studied. One clade had 9 members while clade 2 had 10 members.

Fig. 7: Radial Dendogram revealing clustering of horsegram variety panel into two clusters

Whole genome sequencing of bruchid tolerant wild Vigna accession

While a wild *Vigna viz. Vigna vexillata* :IC 248326 (INGR 22039) has been registered in collaboration with other divisions for resistance to the bruchid *C. chinensis,* another wild accession was identified for tolerance to two species of bruchids (*C. chinensis* and *C. maculatus*). A cage test was conducted to document ability of bruchid *(C. chinensis*) to lay eggs on plants growing in pots (field like conditions) in effort to validate the resistant reaction of the germplasm during reproductive stage. It was observed in first year that the species prefers yellowing pods over green and mature pods for laying eggs. The pods collected from plant from cage were found resistant to the bruchid species. And the few larvae that hatched out did not mature over the 1st instar larva, even after storing the pod for ca. one year. This work was done in collaboration with Crop protection Division, IIPR, Kanpur.

The genome of this accession has been sequenced along with bruchid susceptible blackgram cultivars and is currently under analysis using reference based assembly. Preliminary analysis reveals good raw data quality. Post trimming only 0.02 to 0.05 % reads were dropped. AT MapQ>=30, ca. 55% genome was mapped for the accession and 98% for the susceptible cultivar of blackgram. Initial VCF stats indicate good number of stable variants with a het/ hom ratio<1.

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

A set of 96 genotypes were screened for their response against the MYMIV, and grouped into five different YMD disease reaction categories, resistant (R), moderately resistant (MR), moderately susceptible (MS), Susceptible (S), and highly susceptible (HS). Phenotypic analysis of the selected lines depicts huge diversity in term of their response to MYMIV infections. The mean rating severity ranges from 2.22 ± 0.35 to 3.25 ± 0.32. Presence of high standard deviation (27.79-40.11) is an indicative of presence of higher diversity.

Transcripts coding for WRKY33, ROS homeostasis (SOD, POX) were up regulated significantly in the MYMIV affected resistant genotype compared to the susceptible genotype. The level of intracellular superoxide radicals were found lesser in the control as compared to the MYMIV infected plants. Compared to resistant genotype, the susceptible genotype had a higher increase in H_2O_2 accumulation upon interaction with MYMIV. Compared to control, MYMIV infected plants had higher SOD (Super Oxide Dismutase) and POX (Peroxidase) activity, and higher accumulation of phenols. Higher expression of different stress related genes, TFs and enzyme activity in resistant genotype indicates their role in imparting resistance against the MYMIV attack in *Vigna mungo*.

Detection and classification of YMD in Vigna mungo using deep learning Models

Deep learning-based pre-trained models have revolutionized the classification and identification of plant leaf disease in recent times. In the present study yellow mosaic disease of blackgram has been classified using four deep learning models namely; DarkNet-19, SqueezeNet, AlexNet, and GoogLeNet. A total of 1100 images were collected from field experiments for each of three classes namely healthy, moderate and susceptible plants. The results obtained for different deep learning architectures DarkNet-19, SqueezeNet, AlexNet, and GoogLeNet showed validation accuracy and loss scores of 96.09, 60.74, 94.41, and 93.85%, and 0.2319, 0.6923, 0.2429 and 0.1399, respectively. For the YMD disease classification in blackgram, DarkNet-19 showed the highest accuracy and SqueezeNet showed the lowest accuracy (Figure 8).

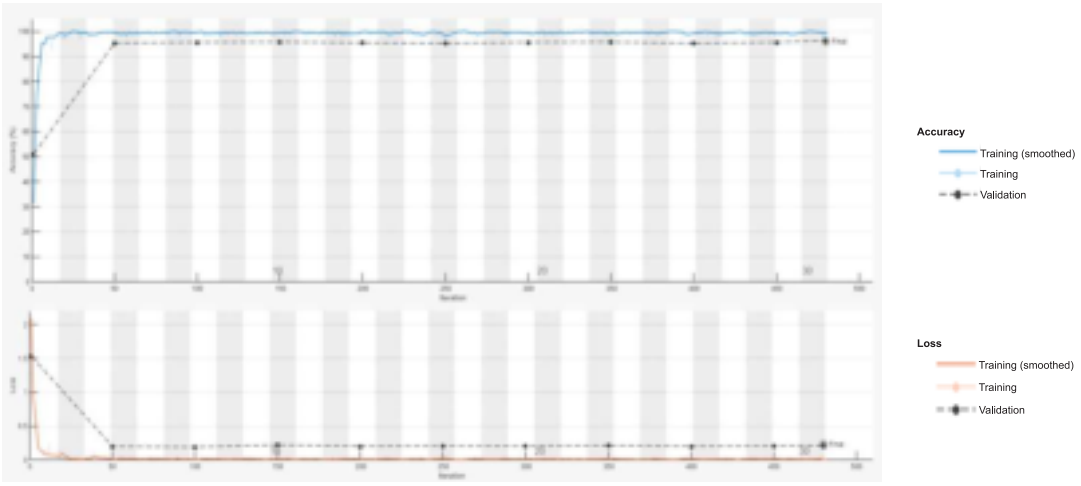


Fig. 8: Performance of DarkNet-19 deep learning model for YMD image classification

NASF Project: CRISPR CROP NETWORK: Targeted Improvement of stress tolerance, nutritional quality and yield of crops by genome editing (*PIGEONPEA COMPONENT*)

The project envisages development of genome editing (CRISPR/Cas9) protocol (SDN-1) in pigeonpea and attempt editing of loci (JAGGED and DEP1) for yield attributing traits in pigeonpea (*Cajanus cajan* L.) using the pigeonpea cultivar, IPA 15-06. Homologs of JAGGED (encoding number of seeds per pod) and DEP1 (Dense and Erect Panicle 1) were identified in the draft genome sequence of pigeonpea (*cv.* Asha/ICPL 87119). Single copy *Cajanus cajan* Zinc Finger Protein JAGGED (LOC109816911) is predicted intron less with CDS of 711 bp.*Cajanuscajan* nucleotide binding protein subunit gamma 3 (three variants XM_20370837/ XM_20370838/XM_20370839) were located in chromosome 11 and predicted intronless with CDS of 681 (X1 variant) and 597 (X2 and X3 variants). Oligos were designed to amplify the genomic regions of the JAGGED and DEP1 in pigeonpea cultivar, IPA15-06. Oligos for RT-PCR/qRT-PCR were designed based on the predicted coding region of the genes JAGGED

and DEP1. Experiments are in progress to assess the regeneration and transformation potential (direct and indirect method) of the pigeonpea cultivar, IPA15-06.

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

The project is a proof-of-concept study for genome editing (SDN-1) in chickpea, based on the hypothesis that mutation in early flowering 1 (*Efl1*) gene (an orthologue of *Arabidopsis* ELF3) in chickpea genome would result in early flowering in chickpea. Variations in *Efl* locus in chickpea genome resulted in identification of high number of bi-allelic SNPs (692), multi-allelic SNPs (36) and multi-allelic InDels (72) were detected in the coding as well upstream region of *Efl1* gene, RNA and mRNA. None of the identified variants could be associated with alteration in initiation codon, mis-sense mutation, variants causing alteration in splice acceptor and splice donor sites or variants causing loss of start and stop codon. Majority of identified variants belonged to modifier category. Of these variants, more number of bi-allelic SNPs (346) functions as a modifier of a protein and followed by multi-allelic InDels (36) and multi-allelic SNPs (18). Besides this, variants also present in upstream and downstream of the gene as well in intronic regions (Table 2). These data will be utilised to identify casual variants linked with flowering trait using phenotypic data of minicore lines phenotyped at ICAR-IIPR, Kanpur and ICRISAT, Hyderabad. Sanger sequencing of 15 genotypes indicated variation across gene and 11 bp deletion in Exon 1 only in two chickpea genotypes *viz*. ICCV96030, ICCV96029.

Table 2. Variations in *Efl1* gene in chickpea minicore collections

	Variants effect in *Efl1*			
	Variants impact as a MODIFIER	Variants effect in downstream of gene	Variants effect in non coding region	Variants effect in upstream of a gene
Multi-allelic SNPs	18	12	0	6
Bi-allelic SNPs Multi-allelic	346	188	70	88
InDels	36	13	3	20

Single gRNA (specific to Exon 1) and dual guide RNA (specific to Exon 1 and Exon 2) were designed and sub-cloned in CRISPR/Cas9 binary vector. Reconstructed vector p201N-Cas9 (Addgene#59175) harboringsgRNA specific to Exon 1 (vicinity of 11 bp deletion), and dual guide (specific to Exon 1 and Exon 2) were confirmed by restriction digestion with SpeI-HF, SwaI-HF and BamHI-HF, PCR amplification with flanking sequences primers (Ubi and ISceR) and Sanger Sequencing. Confirmed clones were mobilized to *Agrobacterium tumefaciens* (LBA4404) for genetic transformation experiments.

Two *desi* 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). Attempts were made for direct genetic transformation of chickpea using single guide (E1) and dual guide (E2) constructs, as reported earlier (Singh et al., 2022). Till date, a total of 10 kanamycin resistant shoots of IPC2011-112 and 25

Table 3. Summary of direct transformation experiments in chickpea

Genotype	**Construct**	**Explant**	**Selection I**	**Selection II**	**Selection III**	**Selection IV**	**Grafted Shoots**
IPC 2011-112	E1	1300	1300	520	185	54	4
	E2	1300	1300	440	130	30	6
GNG 2171	E1	1200	800	470	125	15	11
	E2	1200	800	450	110	18	14

E1: Single guide; E2: Dual Guide

DAC -Incentivizing Research in Agriculture

Development of CaRd22 overexpressing transformed lines in Arabidopsis

The dehydration-responsive RD22-like subfamily belongs to the BURP domain protein family that are unique to plants and has been identified in chickpea (1158bp). This gene was synthesized *in-vitro,* cloned in pBI121 binary vector, confirmed for orientation and sequence and mobilized into *Agrobacterium* stain GVS1301 through electroporation. Genetic transformation of Arabidopsis native plant (col-1) was done by flower dip method and the seeds were harvested.

Molecular characterization of CaRd22 gene

Expression profile of *CaRd22* in various tissues under different stress conditions was confirmed using qRT-PCR. The data predicted an insight towards evolution of the BURP gene family and proposed that numerous such genes may be important for plants to combat stress conditions. The growth process in a plant involves cell wall extension. Previously RD22-like (Response to dehydration 22) gene was found to be notably present in elongating fibre cells, which encodes for a BURP domain protein. Inspired by the same, we have shown that CaRD22 interacts with CaEXPA, a beta-expans in to predictively participate in cell wall loosening. The stress response results in reshuffling of a significant proportion of the transcriptome.

Mapping of a quantitative trait locus for vegetative stage salinity tolerance using QTL-Seq.

To detect genomic segments linked to salinity tolerant in chickpea, QTL-seq approach was used and two extreme phenotypic bulks for tolerant and susceptible lines obtained after cross combination of DCP 92-3 X ICCV 10 were subjected to genome-wide SNP profiling. The study identified a significant genomic region on Chromosome CaLG02 (4 Mb region spanning interval of 30 to 34 Mb) for salinity and drought tolerance. Evaluation of genomic regions SNPs associated with salinity identified various genes associated to different SNPs localized in the distinctive regions. The detected genomic regions in support for salinity were also validated experimentally using various gene expression experiments. 137, 25 and 26 genes in total were retrieved out through QTL mapping at chromosome having SnpEff index greater than the threshold value. Five identified genes supposed to be associated with salinity were picked up on comparative analysis with various Fabaceae genomes and reflected synteny with related genomes and subsequently one gene namely; phosphoinositide phospholipase C 6-like was precede for further study and validation. Further characterization of this gene may decipher the salinity tolerance mechanism which can be utilized for chickpea improvement.

Development of advanced intercross lines (AILs) for fine mapping

Two extreme phenotype of RIL lines RIL 156, 168 (Susceptible) and RIL 169, 169 (Tolerance) derived from DCP 92-3 x ICCV 10 were used in crossing program me to develop advance intercross line (AIL) for fine mapping the genetic loci governing salinity tolerance. The F_1 plants raised during November 2021-April 2022 were screened to obtained heterozygosis plants. The positive heterozygote plants were advance to F_2 generation (Table 4).The phenotyping of the mapping population for r target trait will be done in $F_{2:3}$ populations for QTLs analysis.

Table 4. Status of advanced generations

Sl. No.	Crosses	F_1 Seeds	True F_1	F_2 Popn size
1	RIL156 x RIL169	44	5	228
2	RIL168 x RIL166	27	3	254

Crop Production

A. Institute Funded Projects

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

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). Results showed significantly the highest system productivity in terms of chickpea equivalent yield (CEY) in RWMb (4993 kg/ha) and the least under RW (2984 kg CEY/ha). In case of nutrient management, maximum system productivity was recorded in inorganic fertilizers (4573 kg CEY/ha) which was at par with INM (4458 kg CEY/ha) and significantly higher over control (2098 kg CEY/ha). Similarly, significantly the highest system net return was recorded in RWM (₹.1,31,478/ha) and least under RW (₹.62,480/ha), whereas BCR was maximum in RCRW (2.71) and the least in RW (1.80). In case of nutrient management, maximum system net return was recorded in inorganic (₹.1,28,221/ha) and the least in control (₹.24,022/ha), and BCR was maximum in INM (2.57) and least in control (1.26). The yields of rice and wheat were higher under inorganic fertilizers whereas chickpea under INM and least under control, and 14.8 and 9.8% higher grain yield of rice and wheat recorded under RWMb over RW.

K-fractionations study was done for 0-20 and 0-40 cm soil depths, and the results are depicted here in Fig. 1 for only 0-20 cm soil depth. The major findings of this study are:

- Available-K and total-K (%) were increased under INM.
- Non-exchangeable-K was depleted significantly under INM in rice-wheat system.
- Available K was more in RWRC and RC.

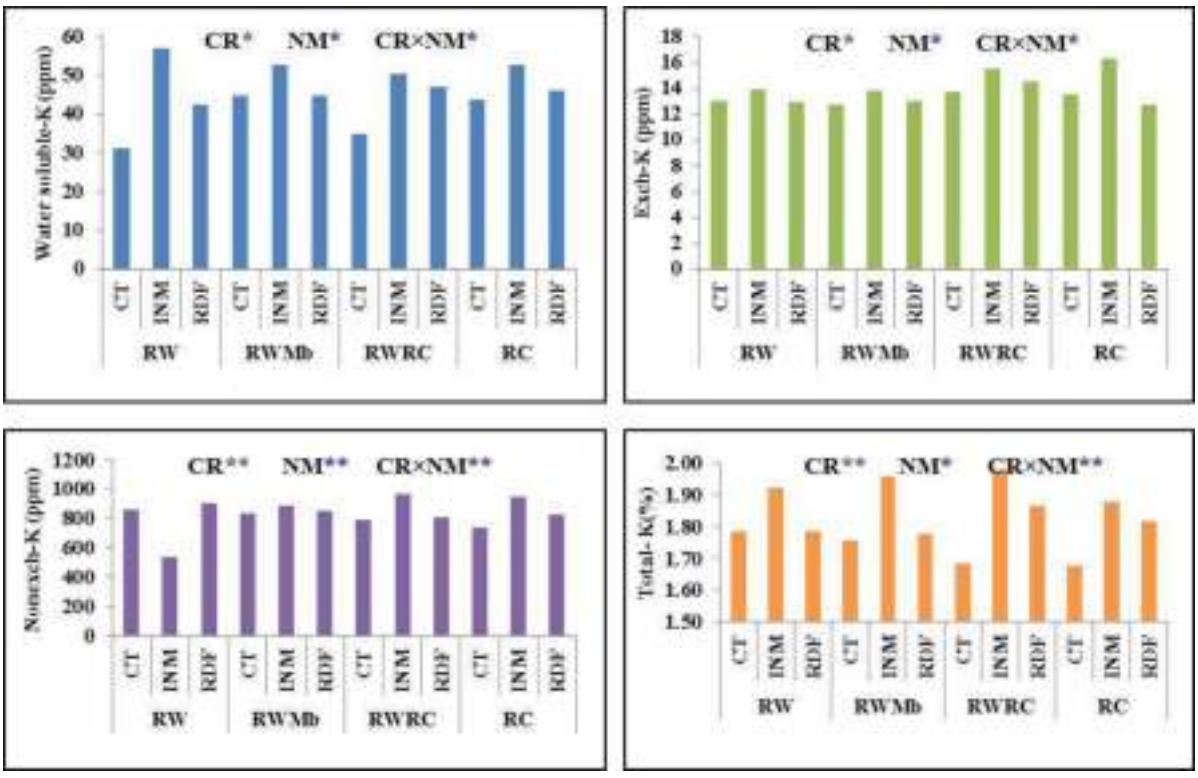


Fig. 1: Different K-fractions (water soluble, exchangeable, non-exchangeable and total) in 0-20 cm soil depth

Maize-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) 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), Azad Urd (urdbean), HD 2967 (wheat), JG 16 (chickpea) and IPM 02-3 (mungbean). Among cropping systems, numerically higher grain yield of maize was recorded in MWMC system. However, in case of nutrient management, maize yield was at par in INM and RDF and both were significantly superior to CT. Similarly, urdbean and mungbean yields were also higher and at par under INM and RDF. Wheat yields were higher in case of MWMb and MWMC, and minimum under MW system. At par wheat yields were recorded under INM and RDF, and these were significantly superior over CT. Significantly higher system productivity was recorded in MWMb. However, in case of nutrient management it was higher under RDF which was at par with INM and significantly superior to CT.

Similar to rice-based systems, K-fractionations study was done under maize-based systems during last year for 0-20 and 0-40 cm soil depths, and the results are depicted here for only 0-20 cm. The major findings of this study are:

- Available-K and total-K (%) were increased under INM.
- Non exchangeable K was depleted significantly under INM in maize-wheat system.
- Available K was more in MWMb and MWMC.

Pearl millet-based cropping systems involving pulses

Four cropping sequences, each 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 2021-22 were MP'7888 (pearl millet hybrid), Azad Urd (urdbean), HD 2967 (wheat), JG 16 (chickpea) and IPM 02-3 (mungbean). Results revealed that cropping systems did not influence *bajra* yields where as significant difference in *bajra* yield was recorded due to nutrient management practices. In case of nutrient management, *bajra* yields were at par in INM and RDF and both were significantly superior to CT. Numerically higher grain yield of urdbean and mungbean was recorded in INM which was at par in RDF and significantly superior over CT. Wheat yields were higher under UW followed by BWBC and the least under BW. At par wheat yields were recorded in INM and RDF, and significantly superior over CT. Significantly higher system productivity was recorded in BWMb. However, in case of nutrient management, it was at par in RDF and INM, and both were significantly superior to CT.

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 3 replications. Rice yield varied between 3624 and 5002 kg/ha, maize between 4992 and 5765 kg/ha and pearl millet 2634 kg/ha. Wheat productivity was ranged from 5072 to 5937 kg/ha and chickpea 1668 kg/ha. The summer mungbean yield ranged from 1164 to 1663 kg/ha. The system productivity in terms of mungbean equivalent yield (MbEY) was significantly the highest in R+Dh-W-Mb (4499 kg/ha) followed by M+*dhaincha*-C-Mb (4344 kg/ha), M-W-Mb (4479 kg/ha), and the least in Pm-L+Ls (1668 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 (INR. 2 35 788/ha) followed by M-W-

Mb (INR. 2 06650/ha) and the least under Pm-L+Ls (INR. 57 019/ha). BCR also followed similar trend with the highest value in M+Dh-C-Mb (3.51) followed by M-W-Mb (2.20) and R+Dh-wheat-mungbean (2.48), and the 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 maize and chickpea, both. The results revelaed significantly lower density of both total weeds (TWD) and narrow leaved (NLWD) weeds in ZT-ZT treatment than CT-CT. However, non-significant difference in broad leaved weed (BLW) density was due to tillage practices. In contrast to maize, significantly higher BLWD and NLWD were recorded under ZT-ZT in chickpea. Whereas, in case of nutrient + weed management treatments under maize, the significantly lowest TWD was recorded in 100% RDF + manual weeding followed by GM+75%N+50%P+post-emergence application of herbicide. Similar results were also recorded in chickpea.

Significant effects of tillage and nutrient+weed mangement practices on crop yield and system productivity were recorded. The significantly higher yields of maize and chickpea, and system productivity were recorded under ZT-ZT over CT-CT. Similar trend was also recorded in net returns and B:C ratio with higher values under ZT-ZT. The significantly highest yield of maize was recorded under GM + 75% N + 50% P + CWM (Post) whereas chickpea under 100% RDF+CWM (Post). System productvity was also higher under 100% RDF+CWM (Post), which was at par with GM + 75% N + 50% P + CWM (Post). Net returns and B:C ratio also followed similar trend.

Integrated nutrient management in maize-wheat-mungbean system under CA

A field experiment was started during *kharif* season of 2021 at Main Farm of Institute to see the effect of tillage and fertilizers and residue management on productivity and sustainability of rice-wheat-mungbean system. The study was conducted with three tillage treatments (CT-CT-CT, CT-ZT-ZT and ZT-ZT-ZT) in main plots and four fertilizers and crop residue management in sub-plots (Full crop residue + 100% RDF, Full crop residue + 75% RDF, 50% crop residue + 100% RDF and Full crop residue + 100% NP with + 50% K in initial two years followed by no K) under split-plot design with three replications. In the first year of results, none of the treatment influenced significantly to the yield of maize, wheat and summer mungbean. The maize crop yields ranged from 5,041 to 5,281 kg/ha, wheat crop yields between 4,800 and 5144 kg/ha and summer mungbean between 1,089 and 1,147 kg/ha. System productivity in terms of mungbean equivalent yield (MbEY) was also non-significant and the values varied between 3,727 and 3,913 kg/ha.

Diversified cropping systems under arid-ecosystem

A field experiment was started during *Kharif* season of 2020-21 at Research Farm of IIPR-RRC, Bikaner to identify the profitable and sustainable cropping system under CA for arid ecosystems. Total 9 cropping systems *viz*., Clusterbean-Chickpea, Clusterbean-Mustard, Mothbean-Chickpea, Mothbean-Mustard, Mothbean- Cumin, Pearl millet-Chickpea, Pearl millet-Mustrad, Mungbean-Chickpea and Mungbean-Mustrad were evaluated in randomized block design with 3 replications. The results revealed that among *Kharif* crops, significantly higher productivity in terms of chickpea equivalent yield (CEY) was recorded in clusterbean-mustard (1,413 kg CEY/ha) and the lowest in pearl millet-chickpea (1,024 kg CEY/ha). Similarly, in *rabi* crops, significantly higher productivity was recorded in clusterbean-chickpea (2,266 kg CEY/ha) and the lowest in pearl millet – cumin (622 kg CEY/ha). System productivity followed similar trend with maximum productivity under clusterbean – chickpea (2789 kg CEY/ha). Net return also followed the similar trend with maximum value in clusterbean-chickpea (₹.1,16,823/ha) followed by clusterbean-mustrad (₹.1,10,458/ha) and mungbean-musatrd (₹.1,02,237/ha), and least in pearlmillet-chickpea (₹.76,490/ha). B:C ratio also showed similar trend.

Resource conservation and agro-technologies

Comparative assessment of different pulse crop cultivars in intercropping systems

Experiments were conducted to select/

characterize the best performing pigeonpea and chickpea cultivar(s) for sorghum + pigeonpea and chickpea + mustard intercropping systems, respectively, for maximizing yield advantage from intercropping systems. Results revealed that among the long-duration cultivars (IPA 16-8, IPA 8-4, IPA 16-8, IPA 203, IPA 206, JKM 189, IPA 15-02), the highest intercrop pigeonpea yield was registered for *cv.* IPA 8-4 (1.85 t ha^{-1}) followed by IPA 15-023 (1.67 t/ha). Likewise, the highest land equivalent ratio, relative crowding coefficient was registered for *cv.* IPA 8-4. The *cv.* IPA 8-4 had significantly higher completion ratio over the remaining cultivars. The duration of early maturing cultivars were increased significantly compared to their sole crops (> 20 days). The architectural changes in pigeonpea cultivars were also prominent (taller plant, reduction in leaf and stem biomass, branching pattern) under intercropping system with reference to their sole crop system.

The experimental results of chickpea + mustard (*cv.* Varuna) intercropping system (5:2) revealed that different chickpea cultivars had variable scale of performance (yield in particular) under intercropping system. The highest chickpea yield under chickpea + mustard intercropping system was observed for *cv.* IPC 2004-134 (1.11 t/ha) closely followed by IPC 2010-72 (1.07 t/ha), where the sole crop yield was the highest for cultivar JG 16 (1.90 t/ha). Yield reduction in the side rows (adjacent to the mustard rows) from that of the middle rows were calculated the reductions ranged from 20.4% (*cv.* IPC 2010-134) to 49.7% (*cv.* JG 16). Therefore, among the selected cultivars, IPC 2010-134, IPC 2010-72 may be recommended as potential cultivars for the chickpea + mustard intercropping system.

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

Field experiments were conducted to evaluate the field efficacy of foliar spray of osmolytes to alleviate terminal stress in urdbean and chickpea crops. The experimental results (2020-21) revealed that among the different osmolyte treatments, KCl (*i.e.*,foliar application of 1% potassium chloride at the post-flowering stage) had higher efficacy to alleviate stress-induced grain yield loss of chickpea and urdbean crops in the tropical environment of Kanpur. Particularly to urdbean crop, an increased response to urea treatment (2% foliar spray) was observed, while the efficacy of $MgSO_4$, Thiourea and $CaCl_2$ was marginal as compared to control treatment in both the crops.

Nutrient management

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

- Plant growth parameters like leaf chlorophyll content, nitrate reductase activity and plant biomass and others growth parameters influenced positively by 20-30% in under poultry manure (1 t/ha) incorporation as compared to control (-P) plots.
- System productivity was higher *i.e* 10% (pigeonpea-wheat) and 9% (pearl millet-chickpea) with crop residue (50%) + PSB application over control (Fig. 2).

Fig. 2: Effect of integrated P-management on productivity of cropping system

- Leaf chlorophyll content (25%-P.Pea), nitrate reductase activity (21%-pigonpea) and plant biomass (22%-P.Pea) and others growth parameters were higher under poultry manure (1 t/ ha) incorporation.
- Soluble P-fraction (40.3%) and labile:non-labile P fraction was higher (0.39::0.23) in the residue + PSB added plot than in control in bulk soils of pigeonpea. In case of chickpea, similar results are obtained.

- P solubilisation study revealed that cumulative P mineralization was maximum with poultry manure @ 1 t/ha by 34% over control; and among residues, pearl millet releases maximum P over others.
- Irrespective of crops overall soluble P-fraction was increased in poultry manure (PM) added plots by almost 30-35% in comparison to control and significantly higher over RDF too. Adsorption study of P showed manure addition reduced adsorption maxima (Xm) because- 1. saturation of the P-adsorbtion site 2. OC covering on oxides and carbonates.

Zinc accounting and enrichment in pulses through integrated crop management practices

A field experiment was conducted at new research farm, ICAR-IIPR, aiming to identify the best zinc management practice in chickpea and to see performance of two chickpea genotypes IPC 11112 and JG 14 during *rabi* season of 2021-22. In this second year of experiments, we have visualized distinct variations among different zinc treatments in both genotypes. The results after this second year of the experiment revealed that foliar spray of 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage) had significant higher yield in both the genotypes. With the 25 kg $ZnSO_4$ (soil application), IPC 112 had shown good response and was at par with 12.5 kg $ZnSO_4$ (soil application) + microbial consortium treatment. Exceptionally, in this two years of study, JG 14 had responded good for pure microbial consortium treatment and the yield obtained was on par with the foliar spray at 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage). Likewise, there was an increase in seed zinc content of 15 to 25% with different zinc management interventions in chickpea. Among all the treatments, foliar spray of 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage) had higher seed zinc content of 65 to 75 ppm and was 20 to 25 % higher when compared to control. While the seed zinc content was found higher in IPC 11112 in comparison to JG 14. The two years experimental results revealed that the performance of two chickpea genotypes markedly differs with yield and zinc content under different zinc management practices.

In the same experiment, plant partitioning analysis *i.e.*, leaf, stem and root for iron and zinc content has been done at different phonological stages of chickpea in both genotypes. The correlation analysis has been done for zinc and iron content in different plant parts and found that Zn concentration was often positively correlated with Fe concentration in different plant parts of chickpea (Table 1).

Table 1. Correlation of zinc and iron content in chickpea

	+Fe Leaf	+Fe Stem	+Fe Root	-Fe Leaf	-Fe Stem	-Fe Root
+Zn Leaf	0.18010	0.22033	-0.04087	-0.20461	0.05171	0.29813
+Zn Stem	0.39835*	0.84495**	0.58585**	-0.05009	-0.32474	0.47493*
+Zn Root	0.66232**	0.21591	0.31878	-0.20008	0.12898	0.07123
-Zn Leaf	0.07611	0.03536	-0.08772	0.40211*	0.07392	-0.20106
-Zn Stem	0.12401	-0.16218	-0.41887*	-0.09929	0.05933	0.22479
-Zn Root	0.20417	0.57884**	0.27443	-0.07295	-0.00361	0.52792**

Screening of chickpea genotypes for zinc uptake, translocation and internal zinc use efficiency

A field experiment was conducted at new research farm of ICAR-IIPR, aiming to identify the best genotype in chickpea for higher internal zinc use efficiency using 25 popular chickpea genotypes during *rabi* season of 2021-22. The experiment was laid out in the same plots of last year experiment and zinc gradient was maintained. Mainly three zinc gradients/management were created one for control *i.e.* No application of zinc, second one is soil application of zinc @ 25 kg/ha and third one was with foliar spray at 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage). GGE Biplot analysis has been done to see the stability of different chickpea genotypes under different zinc regimes. Different indices like grain yield efficiency index and zinc use efficiency index were calculated based on yield and seed zinc content of all the genotypes. Accordingly, these genotypes were classified as Soil Zinc Responsive Genotypes, Foliar Zinc Responsive Genotypes and Soil and Foliar Zinc Responsive Genotypes (Table 2).

Table 2. Categorization of chickpea genotypes for zinc efficiency

Soil Zinc Responsive Genotypes	Foliar Zinc Responsive Genotypes	Soil and Foliar Zinc Responsive Genotypes
JG 16, GNG 2171, IPC 10 62, Vijay, GNG 469, JAKI 9218, Pant G 186, HC 5, RSG 888, IPC 04 01, IPC 10 72 & IPC 10 62	GNG 469, Vijay, GNG 2171, JG 24, JAKI 9218, RSG 888, IPC 11112, IPC 0677	Vijay, GNG 469, JAKI 9218, GNG 2171, RSG 888

The experiment results revealed that higher concentrations of Zn were extracted by Zn-efficient genotypes as these genotypes hoarded significantly higher Zn in the grain at Zn deficient level. High Zn-accumulating chickpea genotypes maintained better growth and yield than low Zn accumulating genotypes under No Zn application treatment. The efficient and responsive genotypes are the most useful ones as they provide higher yield under low Zn supply and also respond to Zn fertilizer application. Zn responsive traits from the identified genotypes of chickpea for developing desired bio-fortified varieties.

Screening Efficacy evaluation of nano zinc oxide as nano-fertilizer in pulses

A field experiment was conducted at new research farm of ICAR-IIPR, to study the effect of nano zinc oxide as nano-fertilizer in pulses. In the first year of experiment, we have taken IPC 11112 genotype and tested with different zinc management practices which included nano zinc oxide treatment which is a soluble powder formulation from ICAR-CIRCOT, Mumbai. In this year of experiment, we visualized distinct variations among different zinc treatments. Higher concentrations of Zn were extracted by Zn-efficient genotypes as these genotypes hoarded significantly higher Zn in the grain at Zn deficient level. Nano zinc oxide spray @ 50 mg/L (At Pre-F and Pod F) has recorded a higher yield of 2,300 kg/ha which is 21% higher than the control. However, among all the tested treatments nano zinc oxide didn't show any significant increase in seed zinc content in chickpeas. However, the experiment will be repeated in this coming *rabi* season to validate the results.

Water management

Precision irrigation scheduling for higher water productivity in pulses-based cropping systems

Pulses are very sensitive to moisture stress especially during spring season. Thus, precision irrigation methods may be helpful for enhancing the water use efficiency in pulses like mungbean during spring/summer season. Keeping these points in view, a fixed plot field experiment was undertaken to find the effect of conservation tillage and irrigation scheduling for higher productivity and water use efficiency of mungbean during spring season. The experiment consisted three tillage practices and six irrigation scheduling in split-plot design and replicated thrice. Results revealed that among the tillage practices significantly higher grain yield of spring mungbean was recorded under ZT compared to RT and CT. Similarly, water productivity had also higher under ZT compared to RT and CT.

Weed management

Weed management strategies in rice-chickpea system under CA developed

Conservation agriculture (CA) is paradigm shift in agriculture for higher productivity and sustainability. Weed management plays a crucial role in CA. Hence, weed management strategies has been developed in CA-based rice-chickpea system. Four tillage methods *viz.*, (i) puddled transplanted rice (PTR) – conventional tilled (CT) chickpea (PTR-CTC), (ii) PTR – zero tilled (ZT) chickpea (residue retention in chickpea) (PTR-ZTC), (iii) ZT dry seeded rice – ZT chickpea (residue retention in both crops) (ZTDSR-ZTC), (iv) CT dry seeded rice – CT chickpea (CTDSR-CTC) and three weed control practices were

undertaken 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). Oxyf. fb Propaquiz. (chickpea) gave significantly higher grain yield of chickpea. The grain yield of rice followed the sequence of ZTDSR-ZTC > CTDSR-CTC > PTR-CTC > PTR-ZTC in, whereas, yield of chickpea followed the sequence of ZTDSR-ZTC = CTDSR-CTC > PTR-CTC = PTR-ZTC. The system productivity in terms of chickpea equivalent yield followed the sequence of ZTDSR-ZTC (4.94 t/ha) > CTDSR-CTC (4.89 t/ha) > PTR-CTC (4.49 t/ha) > PTR-CTC (4.20 t/ha). Sustainable yield index (SYI) of 5 years (2016-17 to 2020-21) revealed ZTDSR-ZTC significantly increased sustainable yield index (SYI) compared with the PTR-CTC. The SYI of rice, chickpea and system followed the order of ZTDSR-ZTC > CTDSR-CTC > PTR-ZTC > PTR-CTC and W3 > W2 > W1. Importantly DSR systems had increasing yield trend over the years (2016-17 to 2020-21). CTDSR-CT and ZTDSR-ZT systems fetched significantly higher net returns and B:C ratio in rice and chickpea over PTR-CTC. Chemical weed management in rice and IWM in chickpea gave higher net returns. DSR based systems (ZTDSR & CTDSR) resulted in higher system profitability over PTR-CTC. Additional benefit of ₹ 35,000-40,000 was achieved under DSR over PTR-CTC. A large plot demonstration of oxyflurofen 150 g a.i./ha (PE) – propaquizafop 100 g a.i./ha at 25 DAS at ICAR-IIPR, Kanpur and is being validated different AICRP centers. The CA practice resulted in higher passive carbon pool (PP) and soil microbial biomass carbon over the conventional tillage. The ZTDSR-ZTC increased soil aggregation and aggregate stability (macro-aggregate, micro-aggregate and MWD) over PTR-CTC. It also increased SOC and its stock and soil enzymes activity (alkaline phosphatse, acid phosphatase, dehydrogenases and β-glucosidases & other) than PTR-CTC.

Table 3. Effect of crop establishment techniques and weed control practices on grain yield of rice and chickpea (5 years mean).

Treatment	Rice (t/ha)	Chickpea (t/ha)
Crop establishment practices		
PTR-CTC	5.30	2.29
PTR-ZTC	5.15	2.27
ZTDSR-ZTC	5.14	2.51
CTDSR-CTC	5.25	2.47
LSD (P=0.05)	0.06	0.08
Weed control practices		
W1: Buta./PMT fb Bis (rice) PMT fb Quizal. (chickpea)	5.35	2.30
W2: Buta./PMT fb almix (rice) Oxyf. fb Propaquiz. (chickpea)	5.13	2.41
W3: Buta./PMT fb HW (rice) PMT fb HW (chickpea)	5.15	2.44
LSD (P=0.05)	0.11	0.06

Management of purple nutsedge (*Cyperus rotundus* L.) in pulse-based system under CA developed

Technology to control purple nutsedge (*Cyperus rotundus* L.) is being evaluated through integrated approach comprising crop rotation, cultural management, stale bed techniques and herbicides. The treatment during summer comprising: (i) mungbean + halosulfuron-methyl 67.5 g *a.i.*/ha at harvest; (ii) summer *Sesbania* (40 kg/ha) + 2,4-D 0.75 kg a.i./ha; (iii) KNO_3 + 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 such as : early pigeonpea (hybrid) - wheat and pearl millet-chickpea in split-

plot design.The result (year 2020-21) revealed that summer *Sesbania* (*dhaincha*) + 2,4-D and irrigation - halosulfuron-methyl 67.5 g a.i./ha reduced *motha* (*Cyperus*) and total weed density over summer fallow situation. The three years field experimentation (2018-2021) revealed that cultural management, stale bed techniques and herbicides could control the purple nutsedge infestation in early pigeonpea (hybrid) - wheat and pearl millet-chickpea cropping systems. Summer *Sesbania* (*dhaincha*) cultivation + knockdown with 2, 4-D 0.5 kg a.i./ha at 30 DAS and summer irrigation + application of halosulfuron-methyl 67.5 g a.i./ha (stale bed) at two leaves stage significantly reduced the motha and total weed density in systems over summer fallow.

- *Varietal screening of chickpea and fieldpea in rice-fallow situation:* The rice fallow areas occupy 11.5 m ha area in India. Therefore, its intensification with suitable crops is of paramount importance. It was assessed that fieldpea can be a candidate crop of rice fallows. It was observed that IPFD 18-35, IPFD 18-34, IPFD 18-36, IPFD 18-40 had the higher grain yield (1155-1238 kg/ha) with early maturity. IPFD 18-14 was the earliest maturity line with a duration of 93 days. Similarly, IPC 05-62, IPC 19-92, IPC 9-50 X BPM, DCP 92-3 X ICC 92944, JG 315 X ICC 1205, IPC 09-50 X IPC 09-35 were found promising in rainfed rice fallow situation. IPC 05-62, IPC 10-72 were found promising in rainfed situation.

- *Root morphology and crop competitiveness of chickpea under zero tillage:* The genotypic variations existed in chickpea crop in terms of root morphology/nodulation pattern *vis-s-vis* crop growth yield. The different genotypes of chickpea were grown in three bed under ZT condition. It was observed that ICC 1582, IPC 2015-52, ICC 1748 had higher root length, nodule number and higher yield under ZT.

Post-emergence herbicides in *Kharif* mungbean and chickpea recommended

(i) Dose and time optimization of Clodinafop-propargyl + Na-acifluorfen (CPNaA) in mungbean

Field experiment was conducted during *Kharif* 2020 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) at four time of application (10, 15, 20, 25 DAS), unweeded control (UWC), and weed free check (WFC) for optimization of dose and time. The experiment was laid on randomized block design with three replications. Dominant weed flora in mungbean was: *Cyperus rotundus, Echinochloa colona, Dactyloctenium aegyptium, Digera arvensis, Trianthema portulacastrum*. Mungbean cultivars/lines : IPM 3, IPM 2K 14-9, IPM 302-2, IPM 205-7, PDM 139, IPM 2-3, IPM 512-2, IPM 312-20, IPM 99-125, IPM 410-3 did not show any phytotoxicity against herbicide upto 245 g/ha. Urdbean was found selective against Clodinafop-propargyl + Na-acifluorfen; however pigeonpea had phytotoxicity (scale >4) for this herbicide. Threfore, needs dose and time optimization in urdbean. CPNaA 183.5 g/ha at 15-20 DAS recorded significantly higher mungbean yield and economic returns. Large plot demonstration of Clodinafop-propargyl + Na-acifluorfen was undertaken at ICAR-IIPR, Kanpur with 723 m^2 area. In mungbean herbicides such as Imazethapyr 100 g a.i./ha, Oxyfluorfen 150 g a.i./ha, Imaz. 100 g a.i./ha – CPNaA 122.5 g a.i./ha, Imaz. 100 g a.i./ha – CPNaA 183.5 g a.i./ha, Oxyf. 150 g a.i./ha – CPNaA 122.5 g a.i./ha, Oxyf. 150 g a.i./ha – CPNaA 183.5 g a.i./ha, Unweeded control and Weed free check were tested. Imaz. 100 g a.i./ha – CPNaA 183.5 g a.i./ha had higher grain yield and weed control efficiency than control.

(ii) Dose and time optimization of imazethapyr in chickpea

In chickpea, Imaz. 125 g ai/ha PE, Imaz. 100 g ai/ha PE, Imaz. 75 g ai/ha PE, Imaz. 50 g ai/ha PE, Propaquizafop+Imaz. 125 g ai/ha 15 DAS, Propaquizafop+Imaz. 93.7 g ai/ha 15 DAS, Propaquizafop+Imaz. 62.5 g ai/ha 15 DAS, Propaquizafop+Imaz. 125 g ai/ha 25 DAS, Propaquizafop+Imaz. 93.7 g ai/ha 25 DAS, Propaquizafop+Imaz. 62.5 g ai/ha 25 DAS, Topramezone 20.6 g ai/ha, Pendi. 1 kg a.i./ha – quizalofop 100 g a.i./ha, Oxyfluorfen 150 g a.i./ha-propaquizafop 100 g a.i./ha, Oxyfluorfen 250 g a.i./ha-propaquizafop 100 g a.i./ha and UWC were tested in randomized block design in chickpea (cv. 'JG 16'). Major weeds in chickpea can be controlled by this herbicide includes: *Chenopodium album, Coronopus didymus, Medica godenticulata, Melilotus indicus, Spergulla arvensis, Fumaria parviflora, Phalaris minor, Cynodon dactylon.* Topramezone 20.6 ml a.i./ha at 14 DAS and imazethapyr 100 g a.i./ha PE resulted in significantly higher grain yield and net returns in chickpea.

Topramezone: a selective post-emergence herbicide in chickpea

- Topramezone 20.6 ml a.i./ha at 14 DAS (2.05 t/ha) and propaquizafop-p-ethyl + imazethapyr 93.7 g a.i./ha (1.98 t/ha) resulted in significantly higher grain yield of chickpea. These also resulted in 75% weed control efficiency in chickpea.
- The selectivity, dose and time optimization has been undertaken for topramezone (33.6 SC: a pigment synthesis inhibitor) in chickpea. Topramezone 20.6 ml a.i./ha at 14 DAS is recommended in chickpea for higher weed control efficiency and yield (2.6 t/ha).

Large plot demonstration of topramezone 20.6 ml a.i./ha at 14 DAS

Large plot demonstration (736 m^2) of topramezone (33.6 SC) was conducted in chickpea (cv. 'JG 16') for 20.6 ml a.i./ha at 14 DAS in comparison with control for validation and recommendation. It resulted in grain yield of 2.11 t/ha. While, control treatment resulted in 0.63 t/ha of yield. The Germplasm & Genotype Identification Committee of the Institute visited the field and evaluated the technology.

Organic farming in pulses

A fixed plot field experiment on green manure-wheat-mungbean 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 in wheat were selected in order to optimize yield under the existing agro-ecosystem defined by existing soil and climatic condition. Under organic packages, nutrients are supplemented with FYM only along with need based organic plant protection measures against pests and diseases. Results indicated that significantly higher yield in wheat (5.73 t/ha) can be realized through organic practice only. Potential productivities in wheat can also be achieved following foliar supply of organic forms of Zinc (Biozinc) and Phosphorus (Biophos) and vermiwash. The higher economic gain in terms of gross returns and B:C ratio (1.83) was recorded under organic cultivation compared to the conventional practices.

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 (04 Dec, 14 Dec and 24 Dec) at Research Farm of ICAR-IIPR Regional Station, Khordha during *Rabi* season of 2021-22. The study revealed that significant effect of varieties and date of sowing were pertinent on grain 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 14 December sowing had recorded significantly higher yield compared to 04 Dec and 24 Dec. IPU 13-1 recorded maximum grain yield at December 14 sowing date compared to others.

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) three different dates of sowing (05 Dec, 15 Dec and 24 Dec) at Research Farm of ICAR-IIPR Regional Station, Khordha during *Rabi* season of 2021-22. Among the varieties significantly higher grain yield was recorded under IPM 2-14 compared to IPM 205-3 and Kamdev. Interaction was significant and IPM 2-14 at Dec 15 had recorded significantly higher seed yield compared to Kamdev.

Effect of rice cultivation practices on performance of chickpea and lentil varieties in rice-fallows

A study was conducted to see the effect of crop establishment methods on productivity, profitability and soil health of rice-pulse cropping system under rice-fallow conditions at ICAR-IIPR, Kanpur in 2021-22. The experiment was laid out in split plot design with keeping three tillage practices in main plot i) conventional tillage direct seeded rice - (CT-DSR), ii) conventional tillage puddled transplanted rice - (CT-PT), and iii) zero tillage direct seeded rice– (ZT-DSR) during *Kharif* season in rice. While eight varieties of (4 low biomass and 4 high biomass varieties) lentil and chickpea were kept in sub-plot during *Rabi* season under zero till conditions. Results revealed that higher growth and yield was observed under CT-PT compared to ZT-DSR and CT-DSR rice.

Lentil

Significantly higher seed yield was recorded under DSR-ZT compared to DSR-CT and PT-CT. Among the varieties, Kota Masoor 1, DPL 62 and IPL 316 had significantly higher yield over others. Kota Masoor 1 under DSR-ZT had significantly higher seed yield compared to others. In rice-lentil system, significantly higher NRPRI (B:C ratio) and EUE noticed under DSR-ZT.

Chickpea

The chickpea has failed to show any significant response of tillage on seed yield, however, significantly higher NRPRI (2.13) was noted under DSR-ZT in system. BG 3043 had significantly higher grain yield amongst the varieties tested. DSR-ZT tillage practices had required 1.18 MJ lesser energy for producing one kg grain yield (CEY) as compared to the PT-CT under rice-chickpea system.

Remote Sensing

Comparative assessment/quantification of soil heavy metals using spectroscopy and multi-spectral remote sensing data from industrial areas of Kanpur

Soil survey and ground truthing was done in Jajmau area, of Kanpur and collected 100 soil samples from different locations in the study area and has been sent to ICAR-IISS, Bhopal. Based on the data of crops grown in the survey area, a Land Use Land Cover map was generated for the study area using ArcGIS software.

Farm Mechanization

Comparative evaluation of IIPR Multipurpose Grinder and Hammer mill (Asian make) for making chickpea powder (*Besan*)

Performance evaluation of IIPR multipurpose grinder and hammer mill (Asian make) was conducted to determine milling capacity for *besan* making from dehusked splits of chickpea (*Dal*). IIPR multipurpose grinder comprises of swinging hammer type beaters whereas the hammer mill (Asian make) has fixed types of beaters. Both the machines operate on 1 hp single phase motors. Total three samples each of 5 kg were taken for testing of the two machines at half opening of the inlet. The sieve at outlet end controls the particle size of the end product, *i.e., besan*. For uniform particle size *dal* was milled putting 0.25 mm (60 mesh) sieve was placed in the mills. Milling capacity of IIPR multipurpose grinder was observed 36.50 kg/h whereas that of was observed to be 21.83 kg/h for Asian make hammer mill for the *besan* making. IIPR multipurpose grinder has shown 67% higher milling capacity compared to Asian make hammer mill. Both the machines are easy to use and can be operated by farm women.

IIPR multipurpose grinder

Hammer mill (Asian Make)

Lab testing of roller-contact-type manual herbicide applicator

An herbicide applicator has been developed at the Workshop of IIPR-Kanpur for the crops at a row spacing of 30 cm. The applicator having dimension l*b*h =105*54*111 cm, consisted of a water tank of 4 litres, a roller of dimension (length=24 cm and diameter(φ)=5.8 cm), a delivery pipe of 1 inch with valve and orifice type of nozzles. The nozzles were placed equidistantly. The discharge rate of the developed applicator was calculated at the different valve openings and results obtained as follows:

Table 4. Lab test results for roller contact type herbicide applicator

Amount of water	Valve openings (%)	Time taken, Seconds	Discharge rate, l/min
4 litres	100%	45.350±0.147	5.29±0.02
	50%	133.72±4.67	1.80±0.06
	25%	197.375.63	1.22±0.03
	12.5%	247.79±4.25	0.97 ±0.02
	6.25%	390.42±6.72	0.61±0.01

The wetting pattern of the roller on plane surface was also studied and it was found that roller could wet a surface of 0.205±0.002 m^2/s. Further, the field evaluation of the developed applicator will be done.

Effect of microwave heating as pre-treatment for milling of pigeonpea

Pigeonpea is mostly consumed in the form of dehusked splits, *i.e.*, *dal*. Due to gum content and strong adhesion between seed coat and cotyledons, milling of pigeonpea is considered as difficult-to-mill kind of pulse. Dehusking operation is performed with the help of emery coated abrasive rollers. Different pre-milling treatments are employed to loosen the husk of pigeonpea. In the present study, microwave heating was explored as pre-treatment of pigeonpea. Pigeonpea grains were heated using microwave oven at the exposure time of 30, 60, 90 seconds at 300, 600 and 900 wattage levels to know the effect of microwave on the milling recoveries of pigeonpea. Cleaned and graded pigeonpea were treated with microwave and milled in a lab scale universal grain testing mill in single pass. Milling was performed with emery disks of different grit sizes, coarse, medium and fine, for the experimentation. The Box-Behnken experimental design (Response Surface Methodology) was used experimentation and data analysis. The results indicated that coarse emery had better dehusking efficiency but resulted into powdering losses, whereas low dehusking was observed with the fine emery grits. Medium grit size gave the higher dal recovery in comparison to coarse and fine emery grits.

Development of sticky belt set-up for the evaluation of metering plate of the planter

A sticky belt setup for the uniformity indices measurement of metering plates of planters has been designed and developed at the Divisional Workshop of the Crop Production Division, ICAR-IIPR, Kanpur. It has dimensions (lxbxh) of 220x40x160 cm. It consisted of two pulleys of dimensions 30 cm each with a rubber belt of width 29 cm mounted on it, an induction motor of 1 hp and a variable frequency drive to control the rpm of the motor. This set-up will help in the evaluation of the uniformity indices of metering mechanism of the planter, which includes missing index, multiple index, quality feed index, and precision.

Modification and calibration of the commercially available seed drill for sowing of mungbean and urdbean

A commercially available seed drill has been calibrated for the row-to-row spacing of 30 cm for the sowing of mungbean and urdbean at a seed rate of 20 kg/ha. Initially, different tynes of seed drill machine was adjusted and fixed at the spacing of 30 cm to suit the requirement of mungbean and urdbean crop. Then, the machine was lifted on a platform and plastic bags were attached to different tynes for the collection of the seeds. The seed drill had total width of 180 cm including 7 tynes placed equidistant at 30 cm. The ground wheel was rotated 39 times and the seed collected was multiplied by 100 to get the seed rate per hectare. This was repeated three times. Then the opening of the fluted roller metering mechanism of the seed drill was fixed at this position and duly marked for the field operation. The seed drill was used for the sowing of mungbean and urbean at NRC, ICAR-IIPR, Kanpur in the approximately 25-hectare area. The machine was operated at 3.2 km/h speed. The field capacity and the field efficiency of the machine were obtained as 0.48 ha/h and 83%, respectively.

Post-harvest management of pulses and value addition

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

IIPR Mini *Dal* Mill has been developed for cottage scale milling of all kind of pulses. Basically, the mill is an integration of four components, *viz*., cleaner-cum-grader, rubber-steel vertical disk *chakki*, abrasive emery roller and cyclone separator. Seed coat in pulses is tightly attached to the cotyledons, specially, in case of difficult-to-mill kind of pulses, like pigeonpea, urdbean and mungbean. Pre-milling

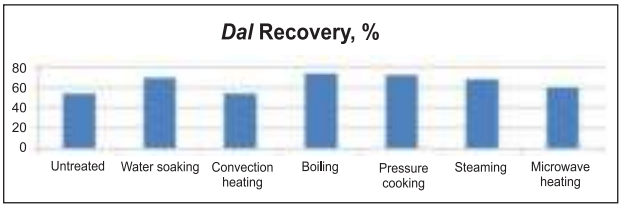
treatments are given in order to loosen the seed coat for ease of dehusking and splitting. The present study targets to evaluate existing commonly adopted pre-milling treatments and develop novel method of pre-treatments. Chickpea, lentil and fieldpea are relatively easy to dehusk due to loose bonding of seed coats. Water soaking and oil treatments are commonly adopted in domestic/cottage and commercial scale pulse milling, respectively. For cottage scale milling of pulses in IIPR Mini *Dal* Mill, water soaking is recommended, however, with multiple passes in emery roller, oil treatment can also be adopted for the mill. Pre-milling treatments were given after pitting or scratching of whole grains in first pass through emery roller. About 25-30% of grains get dehusked in the process of pitting. Abrasive dehusking of grains through emery roller unit in multiple passes, results into high powdering losses and lower dal recovery, though it gives better dehusking. Therefore, in IIPR Mini *Dal* Mill, it is recommended to treat grains to be milled in rubber-steel disk *chakki* mechanism for dehusking and splitting. Pre-milling treatments like water soaking and oil applications were evaluated and *dal* recovery was compared with that of untreated grains. The results of traditional pulse milling in IIPR Mini *Dal* Mill are shown in Table.

Table 5. *Dal* recovery in IIPR *Dal* Mill using traditional pre-milling treatments

S. No.	Crop	Treatment	Method	Dal Recovery, (%)
1.	Pigeonpea	Untreated	Emery roller	76.90
			Rubber disk	78.71
		Water treated	Emery roller	79.97
			Rubber disk	82.48
		Oil treated	Emery roller	76.98
			Rubber disk	80.76
2.	Chickpea	Water soaking (2h)	Emery roller	68.03
			Rubber disk	81.98
		Water soaking (4h)	Emery roller	76.05
			Rubber disk	82.48
3.	Urd	Untreated	Emery roller	69.21
			Rubber disk	91.75
		Water treated	Emery roller	81.86
			Rubber disk	83.59
		Oil treated	Emery roller	80.35
			Rubber disk	82.84

Novel pre-milling treatments evaluated

Novel pre-milling treatments such as convection heating, boiling, pressure cooking, steaming and microwave heating were explored and *dal* recoveries were compared with the untreated and water soaking treated grains for pigeonpea. Milling was performed in abrasive dehusking unit (Universal Grain Testing Mill) using 26 mesh emery grit disks. Milled products were fractionated into whole grains, dehusked whole, *dal* with husk, *dal* without husk, broken and byproduct generated. Boiling, pressure cooking, water-soaking and steaming pretreatments gave the *dal* recovery of 73.20, 72.03, 69.24 and 67.24%, respectively. Thermal treatments, *viz.*, microwave and convection heating, and untreated grains, where no water activity was involved, gave lower *dal* recoveries of 59.75, 5.71 and 53.90%, respectively. It has been observed that in case of pigeonpea, presence of water enables loosening of gums, in comparison to thermal treatment. The results are shown in following graph.



Enhancing processing of pulse seeds and development of methods for their long-term storage

Preliminary studies were conducted on lentil

grains stored in jute bags, PP Woven bags, Metal Bins, LDPE, HDPE and laminated bags for period of six months. Maximum change in moisture content was observed in jute bag and the least in the laminated plastic bags, followed by HDPE bags. Bulk density was maintained in laminated bags. No insect activity was observed in in all the type of packaging materials during six months of storage.

Considering mungbean as one of the difficult crops from storage point of view, mungbean seeds (*Shikha* variety) was procured from ICAR-IIPR, Kanpur seed unit. The seeds were sun dried and fumigated using AlP (Aluminium Phosphide) in air tight drums to control initial field level infestation before packaging. Viability of seeds were determined prior to storage in different packaging materials, *viz*., Jute bag, Cotton bags, Metal bin, Plastic container, PP woven, LDPE, HDPE and laminated bags. In plastic flexible packaging materials like LDPE, HDPE and Laminated films, seeds were packed under normal and vacuum conditions. Samples were drawn after interval of four months. Observations on seed viability, root and shoot lengths, physical properties and milling parameters are being recorded at an interval of four months.

Externally funded project (UPCST)

Integrated management of field peas through conservation tillage and sprinkler irrigation under limited resources

Pulses requires less water (compared to other field crops of same duration) and are constrained to produce/perform optimally especially in presence of excessive soil moisture customarily retained in the soil through surface-flood irrigation. This could happen both in rainy months (June-Sept) and rain-scarce winter/fall months (Nov-Feb) supplemented with flood irrigation. Therefore, appropriate precision irrigation scheduling decision through micro irrigation (sprinkler/trickle drip) is the key for optimal crop productivity. Fieldpea, being a winter pulses/vegetables, is not the exception. When soil fertility and crop productivity are the issues, amalgamating suitable tillage (Zero or reduced tillage under conservation agriculture) decisions with appropriate irrigation scheduling could reinforce our efforts in enhancing the higher (water/nutrient) use-efficiency in the crop in question besides conserving natural resources. Keeping this in view, a permanent field experiment was undertaken to find the effect of conservation tillage and sprinkler irrigation for higher productivity and resource use efficiency of fieldpea. The experiment consisted of three tillage practices *viz.* zero tillage (ZT), reduced tillage (RT) and conventional tillage (CT) in main plot and six irrigation scheduling (*viz*. 3 sprinkler irrigation at branching (Ibr-Sprinkler), pod development (Ipd-Sprinkler), at both branch + pod development stages (Ibr+pd-Sprinkler); and 3 flood irrigation at branching (Ibr-Flood), pod development(Ipd-Flood) and at both branch + pod development stages (Ibr+pd-Flood) laid out in thrice replicated split-plot. The results indicated that tillage options, with their inherent differences in terms of time and frequency of its application (tilling), significantly influenced both grain and straw yield of fieldpea. Higher crop yield was realized (with an average yield of 2418 kg grain yield/ha) under zero tillage condition. To the contrary, precision irrigation scheduling could not influence crop productivity of fieldpea although the maximum grain yield was realized with irrigation at pod development stage (being the most critical stage so far water-need of the crop is concerned) followed by that applied at branching stage of the crop. Since sprinkler irrigation could save some water over normal irrigation (following its staggered delivery without run off losses), it could be advantageous, if it could be automated in its application at appropriate stages of the crop depending upon weather status in the agro-ecoregion (as here also the yield contributing attributes and yields were similar due to adequate winter rains received at least in four occasions during crop growth and development stages elapsing through ~4 months). Similar higher values/observations were also recorded in respect of stover yield, harvest index and total biomass of fieldpea. Contrary to irrigation effects, conservation tillage-effect was evident as ZT had significantly higher WUE (119.5 kg/ha-cm) and water productivity (1.37 kg/M^3) over those in RT and CT. As a result, the net return and B:C ratio were also significantly higher in ZT over those in RT and CT. The effect of RT on water productivity and WUE was also evident compared to that in CT in this experiment.

Organised ICAR-sponsored short course on 'Pulses as the climate smart crops for resource conservation and economic intensification / diversification of cropping systems'

An ICAR-sponsored Short Course on 'Pulses as the climate smart crops for resource conservation and economic intensification/diversification of cropping systems' was organized at ICAR-IIPR during March 2-11, 2022. Total 19 participants in the rank of Assistant Professor or equivalent from six states participated in the short course. The short course was a centre of vivid activities involving

lectures (45 no. periods of lectures & practical) from eminent agriculture scientists, learning practical skills in laboratories, visits to the farms and also at the end interaction and feedback. The short course broadly *deals* with scenario of pulses production in country, pulses role in resource conservation and ecosystem services, conservation agriculture, pulses for intensification of different cereal based production systems including rice fallow, RCTs & physiological approaches for abiotic stress (soil moisture deficit/excess and temperature), biotic stress (diseases & insect-pests) management, varieties suitable for different production systems & ecologies, post-harvest management & value addition in pulses, mechanization for pulses production system, role of biofertilizers/bio-pesticides, climate resilient agro-techniques, pulses in dryland farming, participatory technology

development & delivery systems, *etc*. Dr. Shiv Sewak, Director ICAR-IIPR inaugurated the programme and Dr. Masood Ali, Former Director, ICAR-IIPR was the Chief-guest in valedictory session. Dr. Narendra Kumar, Head & PS, Division of Crop Production was the Course Director of the short course.

Crop Protection

Plant Pathology

Pigeonpea: Resistance against wilt

A total 1,286 pigeonpea lines were screened in the wilt sick field at IIPR Research Farm for identification of new sources of resistance against *Fusarium udum* (Race-2) causing wilt disease of pigeonpea. Pigeonpea variety, Bahar used as susceptible check. Observations on wilt disease incidence have been recorded at fortnightly intervals. Out of 234 advance breeding materials, some lines (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, 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, 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) were identified as resistant against *Fusarium udum*.

Out of 30 IIPR promising pigeonpea lines, entries, 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. Some genotypes were identified as donors (IPAC 66, IPAC 67, IPAC 68, IPA 10w12, IPA 20-2, IPA 10w1-8, and IPA 12w26-1) for *Fusarium* wilt (*Fusarium udum*, race-2) resistance. Out of 42 genotypes received from ICRISAT, 4 genotypes (ICPWS 1913, ICPWS 1905, ICPWS 1924, ICPWS 1908) were performed resistant reaction. A total of 123 genotypes of AICRP centres along with check variety Bahar were planted for evaluation.

Pigeonapea: Resistance against *Phytophthora* stem blight

A total of 303 early and medium duration pigeonpea lines were planted for evaluation against *Phytophthora* stem blight (PSB) resistance in sick field during *Kharif* season. UPAS-120 and ICP 7119 was sown as check after every two rows of test entry. PSB incidence was recorded fortnightly intervals in different genotypes. Based on the mean disease incidence of the three replications, pigeonpea lines *viz.*, KPBR 80-2-1, DPPA 85-7, DPPA 85-12, DPPA 85-8, IPAC-3, IPAPB 7-2-1-7, IPAPB-7-2-1, IPAC-3, IPA 15-01, IPA 15-07, IPH 9-05, IPH 18-02, IPH18-01, IPH 18-09, IPAE 15-05, IPAB-2019-1-6, IPAB 10-67 and IPA 16E-7) were identified as promising entries with disease incidence up to 15-20 per cent.

A total of 123 genotypes of AICRP were planted for evaluation against *Phytophthora* stem blight resistance. A set of 25 accessions of wild derivatives belonging 2 different genera (*Cajanus, Rhynchosia*) were screened for identifying the resistant sources for further use in PSB resistant breeding programme.

Chickpea: Resistance against wilt

A total of 1,131 chickpea lines were screened in the wilt sick plot (Figure 1) at Main Farm, ICAR-IIPR during *rabi*, 2021-22 for identification of new resistance source against *F. oxysporum* f. sp. *ciceri*. WR-315 genotype was used as resistant check and JG 62 & C 104 were used as susceptible check for early and late wilting respectively. Out of 277 AICRP entries, two entries (NBeG 1428 and NBeG 1430) were found resistant and 20 lines were found moderately resistant (RKG 21-1, NBeG924, RSGD-1155, BRC-8, Phule G1314-3-27, RSGD116, IPC 2016-231, PBC 501, DBGC 3, BGD166, NBeG1267, GJG 1916, PBC 509, RKG13-125, KCMH20-15, DCP-92-3, GNG 2299, NBeG 1427, GL17033, Pant G 186 and IPCK 02-29). Rest entries were found susceptible and highly susceptible.

Fig. 1: Field view of chickpea genotypes screening plot

Similarly, screening of 106 entries of elite breeding materials, no one found resistant, only 9 were found moderately resistant (GNG 16081, IPC (L22-33-2), H 16-05, GJG 1912, Phule G 1221-1, GNG 2510, IGK 2021-116, RSGD 1071 and H 17-16).

Lentil: Resistance against wilt

Exploiting host plant resistance against wilt disease is accepted as the most economical and eco-friendly way of limiting yield losses this disease causes to the lentil crop. Identification of resistance against wilt is required for the development of disease resistant varieties of any crop. Lentil wilt is known to be widely occurring soil borne disease inflicting substantial yield losses in lentil growing

areas particularly in areas where it is grown under rain-fed condition. One hundred genotypes of lentil were screened against wilt in a wilt sick plot using infector row technique (Figure 2). Lentil genotype, L9-12 used as susceptible check was sown after every ten rows of test genotypes. None of the 100-lentil genotype was found resistant. However, 24 genotypes (IPL 203, IPL218, IPLS-9-23, IPLS-9-27, L 147, IPL 220, PL02, DPL 58, IPL 406, Pant L 406, VL 1, VL 4, IPL 326, IPL-10820, IPL 222, L4603, ILS9-22, IPL 181565, IG 3801, IPL141570, IPL121802, IPL 141595, IG 3869, IG 70191) showed moderately resistant disease reaction (wilting 10.1-30.0%) against wilt. Eleven genotypes were susceptible and 65 genotypes were highly susceptible.

Fig. 2: Field view of lentil genotypes screening plot

Out of 160 pre breeding lines, two (IPL 406 x IG 136667-1 and Wild F4 1594-3) were recorded as resistant with 9.23 and 10.00% wilt incidence, respectively. Eighteen genotypes were moderately resistant with wilt incidence ranging between 15.95 and 30.00%. Rest of the pre-breeding lines was either susceptible or highly susceptible. Two wild accessions, ILWL 168 and ILWL 92 showed resistant reaction against wilt.

Monitoring of wilt development in sick plot at Kanpur

Wilt incidence in sick plot was recorded in three wilt susceptible lentil genotypes viz., L9-12, K75 and Sehore 75-3. Plant mortality in wilt susceptible check ranged between 80 and 100%. Also, the isolations made from wilting plants indicated involvement of wilt pathogen *F. oxysporum* f. sp. lentis in 92% samples.

Diagnostic of chickpea wilt pathogen

A LAMP based detection protocol was developed and optimized for the detection of *F. oxysporum* f. sp. *ciceris*, which can give clear cut difference based on colorimetric methods. Pink colour represented the Negative control, while yellow colour development in case of DNA of F. oxysporum f. sp. ciceris as template as positive reaction. The LAMP products when checked on the 2% agarose gel, multiple bands were present in case of Foc (yellow) while no bands in case of Negative control (Pink).

Monitoring of viruses causing YMD in pulse crops

Thirty seven leaves samples of mungbean (n=8), urdbean (n=8), cowpea (n=15) and Rajmash (n=6) and 18 leaves samples of different weed plants were processed to detect the YMD causing viruses (MYMIV, MYMV, HgYMV and DoYMV) using species specific primers in PCR. Two mungbean samples were found infected with MYMIV and DoYMV and six with MYMIV. One cowpea sample were found infected with two viruses (MYMIV and MYMV), two samples were found infected with three viruses (MYMIV, MYMV and DoYMV) and three samples having the infection of two viruses (MYMIV and DoYMV) among the 15 samples of cowpea tested. Among 18 weed plants tested, only seven samples showed the positive reactions. Six were found infected with MYMIV and one was found infected with (MYMIV or DoYMV and MYMV).

The phylogentic tree was constructed using the CP gene sequences (n=58) obtained from different hosts during 2020-22 along with nine references sequences of the viruses causing YMD in pulse crops. All the virus isolates obtained in the study clustered with the respective reference virus species i.e MYMIV, MYMV and DoYMV. The analysis of the samples from crops and weed plants showing viral symptoms indicated that the viruses causing yellow mosaic in pulse crops are present as single or mixed and also survive on weed plants.

Secondary metabolites of *Trichoderma* sp. and their efficacy against chickpea wilt

The present study was aimed to investigate the effects of secondary metabolites produced by five *Trichoderma* spp. for the management of *Fusarium* wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceri* (*Foc*). *In vitro* biocontrol potentialities of *Trichoderma* spp. against *Foc* was tested. Potential *Trichoderma* isolate IIPRTh-31 was selected for secondary metabolite isolation solvent extraction methods and evaluated against *Foc*. *In vitro* tests showed very good inhibitory effect by IIPRTH-31 against *Foc* along with an inhibitory rate up to 65.8% (Figure 4). Plants treated with secondary metabolites of *Trichoderma* isolate IIPRTh-31 showed 56.94% of reduction in disease severity.

Development of Bio-consortia against wilt pathogens

Trichoderma sp. are important agricultural biocontrol microorganisms that are often used as effective components of microbial fungicides and microbial biofertilizers. However, most of these products are prepared by a single strain in monoculture, which significantly limits the biocontrol efficiency of *Trichoderma* products. Therefore, the establishment of a design and screening approach for consortia with multi-*Trichoderma* strains for co-culture is of great importance to overcome the shortage of traditional *Trichoderma* biocontrol products. Consortium of compatible *Trichoderma* species was prepared (Mycelial mats of compatible *Trichoderma* isolates (IIPRTH-23+IIPRTh-33+IIPRTh-4+IIPRTg-3) grown in PDB medium +Bacterial (*Bacillus subtilis*-IIPRSHEP-6) cell growth in nutrient broth+ Sunflower oil+Tween-80+CMC+Peptone+Glycerol) and checked for the efficacy against wilt pathogens and growth promoting effects. Biocnsortia treated seeds showed increased disease resistance by 42.06%, germination 50.26% and plant height by 22.99% (Figure 3 and 4).

Fig. 3: A-Compatible *Trichoderma* isolates B-*In vitro* efficacy of developed consortia on Pigeonpea, Chickpea and lentil germination

Fig. 4: *In vivo* efficacy of Developed consortia on A-Lentil B-Chickpea C-Pigeonpea

Nineteen isolates of different species of *Trichoderma*, and 5 isolates of *Bacillus* sp. and 1 isolate of *Pseudomonas* were deposited to ICAR-NBAIM, Mau (Table 1).

Table 1. Detail of Biocontrol agents (*Trichoderma* spp + PGPRs)

Sl No	Culture ID	Trichoderma spp/PGPRs	NAIMCC No
1.	IIPRTaf-64	*T.afroharzianum*	NAIMCC-F-04299
2.	IIPRTas-12	*T.asperellum*	NAIMCC- F-04300
3.	IIPRTas-9	*T.asperellum*	NAIMCC- F-04301
4.	IIPRTas-13	*T.asperellum*	NAIMCC- F-04302
5.	IIPRTas-74	*T.asperellum*	NAIMCC- F-04303
6.	IIPRTh-10	*T.harzianum*	NAIMCC- F-04304
7.	IIPRTh-3	*T.harzianum*	NAIMCC- F-04305
8.	IIPRTh-38	*T.harzianum*	NAIMCC- F-04306
9.	IIPRTh-32	*T.harzianum*	NAIMCC- F-04307
10.	IIPRTlg-72	*T.longibrachiatum*	NAIMCC- F-04308
11.	IIPRTlg-59	*T.longibrachiatum*	NAIMCC-F-04309
12.	IIPRTg-3	*T.longibrachiatum*	NAIMCC- F-04310
13.	IIPRT-103	*T.virens*	NAIMCC- F-04311
14.	IIPRSBa89	*B.altudinis*	NAIMCC-B-03172
15.	IIPRMKCP-9	*P.guariconsis*	NAIMCC-B-03173
16.	IIPRAJCP-6	*B.amyloliquefaciens*	NAIMCC-B-03174
17.	IIPRANPP-3	*B.amyloliquefaciens*	NAIMCC-B-03175
18.	IIPRMKCP-10	*B.haynesiei*	NAIMCC-B-03176
19.	IIPRDSCP-9	*B. valegensis*	NAIMCC-B-03177
20.	IIPRTh-1	*T.harzianum*	NAIMCC-F-04395
21.	IIPRTh-2	*T.harzianum*	NAIMCC- F-04396
22.	IIPRTh-13	*T.harzianum*	NAIMCC- F-04397
23.	IIPRTh-17	*T.harzianum*	NAIMCC- F-04398
24.	IIPRTh-20	*T.harzianum*	NAIMCC- F-04399
25.	IIPRTh-39	*T.harzianum*	NAIMCC- F-04400

Management of *Ascochyta* blight, *Botrytis* gray mold and rust disease

Defence inducers such as Jasmonic acid (1,000 ppm) and Isotianil (1,000 ppm) had 31.98% and 28.49% inhibition capacity against *A. rabiei* but none of them inhibited the mycelial growth of *Botrytis cinerea*. Identified six chickpea lines *viz.*, IPCK 2013-209, PBG 7, IPC 2016-31, IPCK 2012-310, IPC 2015-273, PBG-7 was found moderately resistant to AB disease. Seven wild chickpea lines *viz.*, ILWC 263, ILWC 246 (1), ICC 17152, ILWC 188, ICC 17149, ICC 17151 and ICC 17207 identified as resistant to AB disease. Four chickpea lines *viz.*, HC-5, IPC 2005-41B, IPC 2013-248, IPC 2016-31, H 12-22 were found moderately resistant to Botrytis grey mold.

Entomology

Screening of germplasms for resistance against major bruchid species

Two germplasms, *Vigna vexillata* (IC 0248326) and *Vigna umbellata* (IC 0251442) found highly resistant against *Callosobruchus maculatus* F. and registered at ICAR-NBPGR, New Delhi. One each accessions of *V. umbellata* (IC 251439), *V. vexillata* (IC 248326), and *V. mungo mungo* (IC 251387) were submitted at NBPGR for their resistance against two bruchid species. A set of 30 pigeonpea wild accessions were screened for bruchid resistance against two bruchid species following free-choice and no-choice assays. Among 30 accessions, three accessions (ICP-15799, ICP-15886, ICP-156888) were found consistently resistant against *C. maculatus*.

Screening of pigeonpea derivatives of *Cajanus scarabaeoides* against pod borer

Field screening: Among the 41 wild pigeonpea derivatives screened along with 5 checks three genotypes WDBCE6-3-4-7, WDBCE3-1-1-6 and WDBCE6-3-4-3 belonging to pest scoring category 3 followed by 7 genotypes including WDBCE6-3-4-6 falling under category 4 during *kharif* 2021. The percent pod damage varied from 8.67% (WDBCE3-1-1-6) to 28% (WDN2 136-2-1-5). Only the yield was recorded for the 45 pigeonpea genotypes ranged from 0.015 to 0.532 kg/1.5 m row.

Laboratory screening: Forty two wild pigeonpea derivatives were screened using no-choice assay (NCA). The pod consumption varied from 0.026 g (ICP 15685) to 0.208 g (Asha) while the larval weight gain varied from 0.0036g (ICP 15685) to 0.0447 g (IPAWD28-1). The Relative Pest Resistance Percentage under NCA ranged from 3.37 to 87.5. Out of 42 pigeonpea genotypes, 12 had scored Pest Resistance Rating of 3. The phenol content and total glucose content in pod wall were estimated for 7 promising genotypes along with 4 parents cum check genotypes and it ranged from 6.53 to 13.15 GAE/g and 13.32 to 35.43mg/g, respectively.

Only genotypes WDBCE6-3-4-7 and WDBCE6-3-4-6 were identified as pod borer resistant based on pest resistant rating, phenol and glucose content estimation.

Monitoring of whitefly, *Bemisia tabaci* (Gennadius) in greengram and blackgram

A major peak was observed during summer at 23, 24 and 25 SMW while another small peak was observed during 34, 35 and 36 Standard Meteorological Peak (SMW). The blackgram crop ecosystem recorded higher number of whiteflies as compared to greengram (Figure 5).

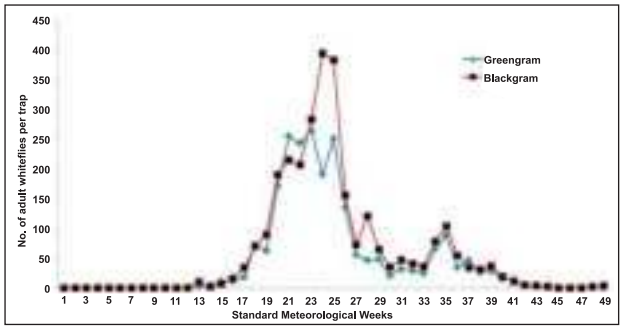


Fig. 5: Number of adult whitefly per trap in greengram and blackgram

Monitoring of *H. armigera* (Hubner) and *Spodoptera litura* (Fabricius)

Maximum number of *H. armigera* adults caught in a trap was 39 and 37 at 21 and 22 SMWs respectively (Figure 6a). The population was also observed higher during 34 to 41 SMWs. As high as 142 adults of *S. litura* were caught in a single trap during the 21 SMW (Figure 6b).

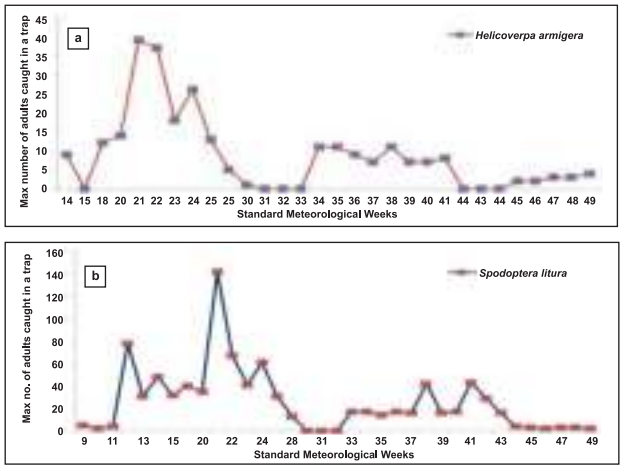


Fig. 6: Maximum number of adults caught in a trap; (a) *H. armigera*, (b) *S. litura*

Infestation, distribution and diversity of bruchids

Five different bruchid species (*C. chinensis*, *C. maculatus*, *C. analis*, *A. obtectus*, and *C. serratus*) were identified infesting collected grain samples (Figure 7) and among them, three species belonging to *Callosobruchus* genera are common across the samples. Though *C. analis* was cosmopolitan across half of the surveyed locations, the species *C. maculatus* was equally abundant and dominant as far as the density of insects in the collected samples was concerned. The diversity index for recorded bruchid species was 1.1 and the effective number of species was only three. *C. maculatus* was found as the most abundant and dominant species than other two species, collectively under small-scale storage conditions, whereas, under large-scale storage conditions, it was *C. analis*. The species diversity and richness were found higher under small-scale, whereas, the evenness index was found higher under large-scale, storage conditions. Across different states, *C. analis* was recorded from ~80 (%) of the states covered, whereas, *C. maculatus* was recorded from ~50 (%), and *C. chinensis* from ~38 (%) of the states (Figure 8). Among pulse crops, the maximum diversity indices were recorded on chickpea (*desi* and *Kabuli*) and field pea.

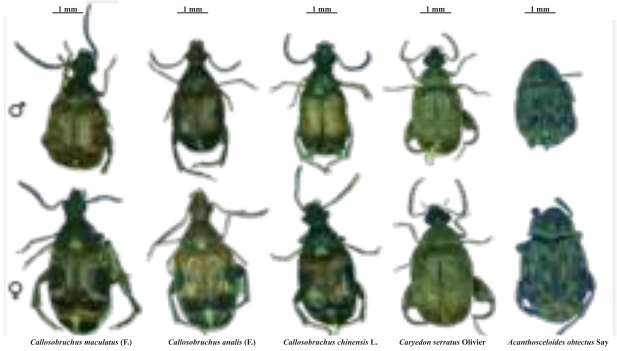


Fig. 7: Bruchid species collected from stored grain legumes

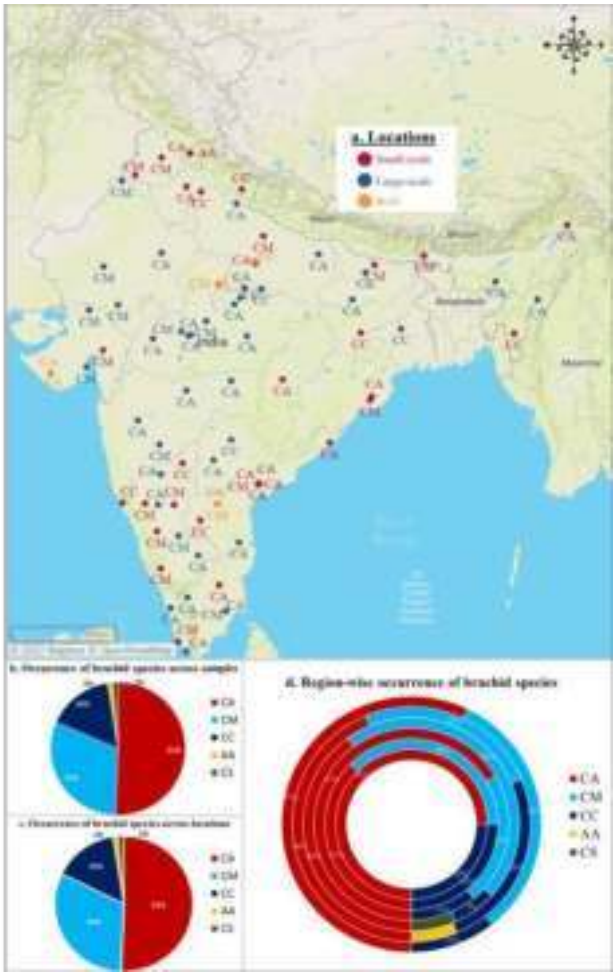


Fig. 8: Occurrence and distribution of bruchid species on stored grain samples (Note: CA- C. *analis*; CM- C. *maculatus*; CC- C. *chinensis*; AA- A. *obtectus*; CS- C. *serratus*)

Pest diversity in long duration pigeonpea: Insect pest diversity of pigeonpea included 24 insect pests belonging to five orders *viz*., hemiptera, lepidoptera, coleoptera, thysanoptera and diptera. The pests belonged to ten families of hemiptera, six families of lepidoptera, six from coleopteran families and one each family from thysanoptera and diptera.

Pod and seed damage due to pod borer complex: In long duration pigeonpea, the pod damage due to pod borer (*H. armigera*) and pod fly was ranged from 2–18% and 4–22% in IPA- 203, while it was 4–16 and 6–34% in Bahar variety. The seed damage due to pod bug complex was 0.70 and 1.94% in IPA-203 and Bahar.

Avoidable yield losses and economic threshold level: Avoidable yield losses were ranged between 33-52% and 12-47% in IPA 203 and Bahar. The Economic Threshold Level (ETL) for IPA 203 and Bahar was estimated to be 0.50 and 0.34 larvae per plant. For, every unit increase in larval population, the reduction in yield was calculated to be 4.56 and 4.35 kg / ha for IPA 203 and Bahar.

Effect of sowing dates on whitefly population in blackgram

Field experiment was conducted to see the effect of sowing time on incidence of whitefly. Sowing of blackgram (IPU 94-1) was done on four different dates *i.e.* 10, 20, 30 July and 10 Aug 2022. It was observed that at 30 DAS and 45 DAS, whitefly population was significantly low in the crop sown on 10 July 2022 as compared to other dates of sowing (Figure 9). The mean population throughout the crop period was also the lowest in case of first date of sowing. Contrastingly, the highest population, both at 30 and 45 DAS, was recorded in the case of third sowing.

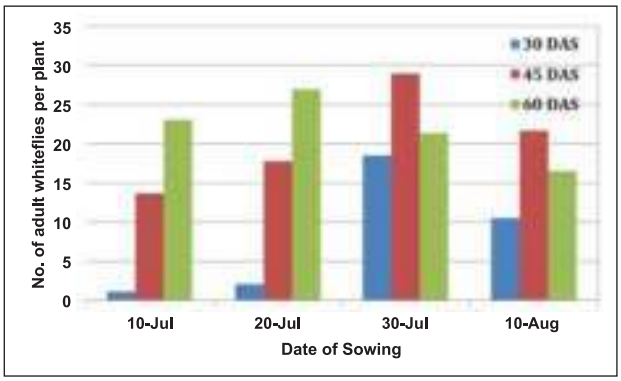


Fig. 9: Whitefly incidence at different plant ages

Development of liquid bio-formulation of indigenous *Bacillus thuringiensis* against pod borer

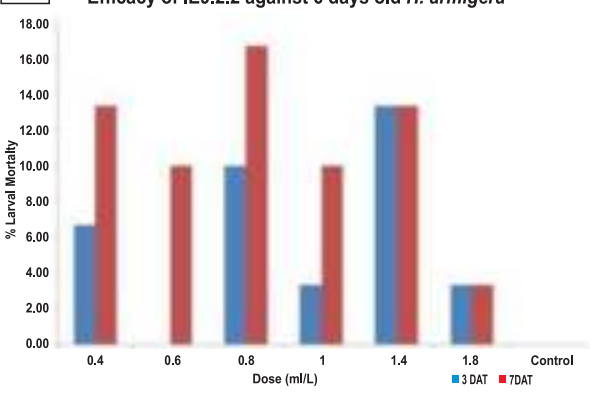
Invert emulsion formulations efficacy against pod borer: The spore crystal mixture (SCM) of indigenous *Bt* strain F8. IIPR (NAIMCC-SB-065) was used for developing 13 invert emulsion (IE) formulations with a single surfactant. The formulation, IE 9.2.2 was tested against 7 days old *H. armigera* in 6 different doses 0.4ml/L to 1.8ml/L. The mean per cent mortality on 3rd DAT ranged from 0 to 13.33 in different doses while during 7th DAT varied from 3.33 to 16.67% (Figure 10a). The physical stability of 13 IE formulations (Figure 10b) at 25°C ranged from 1 to 70 days.

Bio-efficacy of VIP3 against pod borer: The SDS-PAGE analysis of secretory proteins from F8.IIPR revealed the presence of VIP3 and chitinase protein by having prominent bands at 89kDa and 66kDa (Figure 12). The bacterial growth in GSM & SSM was measured at λ= 600nm [OD] at different time intervals which indicates that GSM having more absorbance than SSM (Figure 12a). The bio-efficacy of VIP3 from 2 different indigenous media indicated that VIP3 from GSM had resulted in the highest mean per cent insect mortality (100%) in pod borer (Figure 12b) followed by SSM (86.67%) and control (73.33%). The probit analysis for LT_{50} showed that VIP3 from GSM is having lower than SSM. Further the proteins were quantified by Lowrys' method and found as 18.315 and 20.654µg/µl in case of GSM and SSM, respectively. The probit analysis for different doses of F8.IIPR SCM and VIP3 showed that 2.46 µg/µl & 5.14 µg/µl as LC_{50} doses for respective proteins.

Stability and efficacy of improved IE formulations against pod borer: The stability analysis of 14 improved invert emulsions (IExM) ranged from 12 to 72% stability (Figure 13a). The percent insect mortality of 14 different improved invert emulsions varied from 20-60%, 40-65% and 15-65% respectively for IE9Mii, IE10Mi and IE12Mi (Figure 13b). The lowest LC_{50} was recorded from IE10mi (1.75 ml/L) followed by IE9mii (3.92 ml/L) and IE12mi (2.96ml/L).

Compatibility of VIP3 and SCM against BHC: In order to test the compatibility of VIP3 & SCM of F8 & Ak2.IIPR against BHC larva they were tested alone and in combination by diet contamination method wherein the results showed that VIP3 and SCM exhibited synergistic in 1:10 ratio against BHC larvae by recording the highest mean percent mortality (100%) in T2 and T4 at 7 DAT (Figure 13ab).

a



b

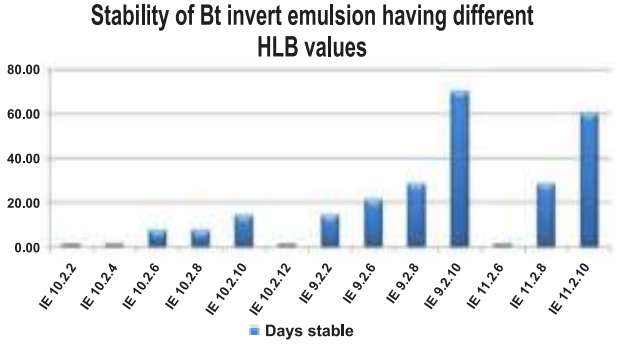


Fig. 10: Efficacy and physical stability of 13 IE formulations

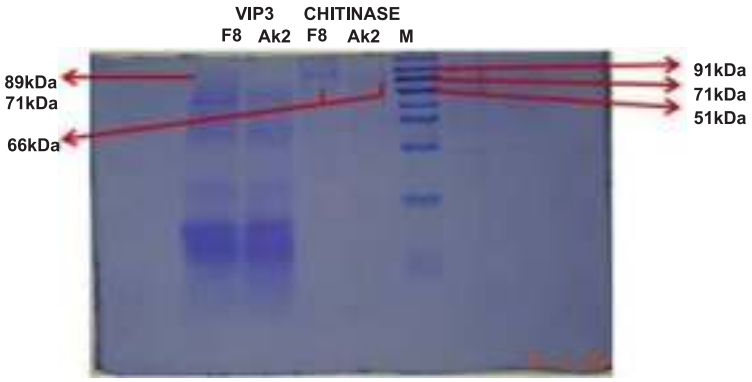


Fig. 11: SDS page of VIP3 & Chitinase from indigenous *Bt* strains

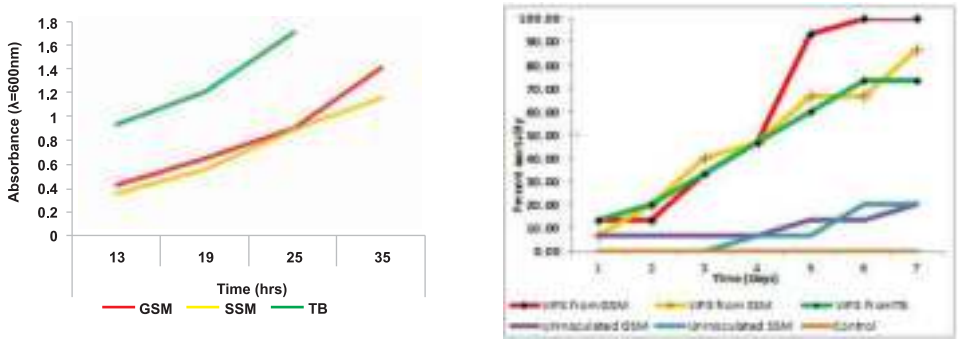


Fig. 12: Suitability of different media for VIP3 production from *Bt* strain F8.IIPR and its bio-efficacy against *H. armigera*

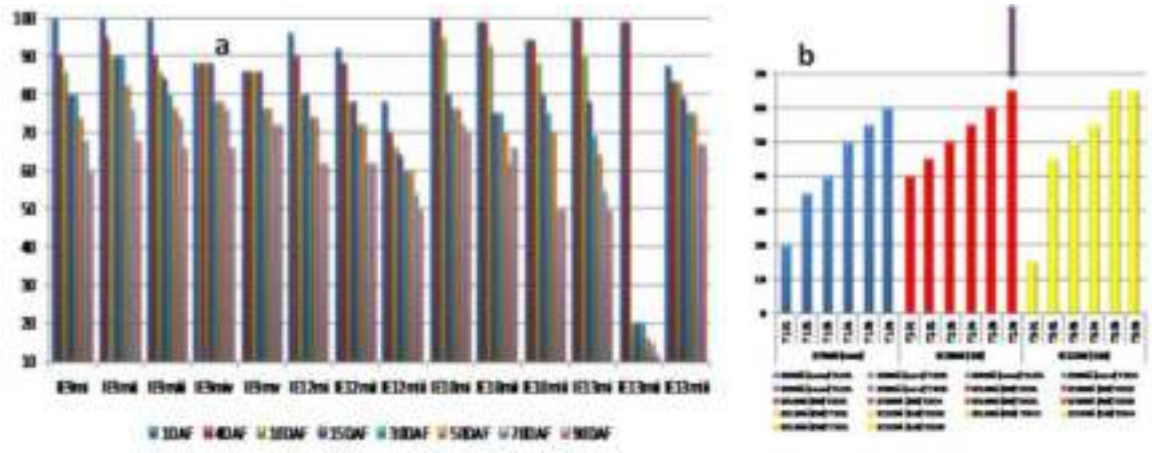


Fig. 13: Physical stability and bio-efficacy of improved IE formulations against tobacco caterpillar

Determination of LC_{50} of DOR Bt-127) formulation developed by ICAR-IIOR against larvae of *H. armigera* (Hübner)

The LC_{50} of DOR Bt-127 (Technical) belonging to *Bacillus thuringiensis* var. *Kurstaki* (Btk) was 0.39 g/L and 0.22 g/L against *H. armigera* at 48 h and 72 h after treatment, respectively. The LC_{50} of DOR Bt-127 Suspension Concentrate (SC) formulation against *H. armigera* was 1.18 ml/L and 1.01 ml/L at 48 h and 72 h after treatment, respectively.

Identification of effective insecticides to prevent field-carry-over infestation of bruchids during storage

The second season experiments confirmed that the field infestation, similar to previous season, was commenced from 8 weeks after field infestation (WAFI) and was found increasing along the crop maturity. The mean pod infestation per cent reached up to 6.5 per cent, however, pod damage reached only up to 1.9 per cent, at field level (Figure 14). Among seven insecticides tested; two spray schedules each for cowpea (during 4th and 5th WAFI)

and mungbean (3rd and 4th WAFI), and five spray schedules for pigeonpea (8th to 12th WAFI) were given. The treatments sprayed with Azadirachtin 0.03% WSP recorded < 1 per cent oviposition and <0.4 per cent pod damage which was on par with Deltamethrin 2.8 EC, Malathion 50 EC and Lamda Cyahalothrin 5 SC followed by Chlorantriniliprole 18.5 EC and Spinosad 45 EC. The initial and post spraying observations indicated the insecticide Azadirachtin 0.03% WSP was found equally effective with other conventional insecticides tested, in preventing field-carry-over infestation to storage.

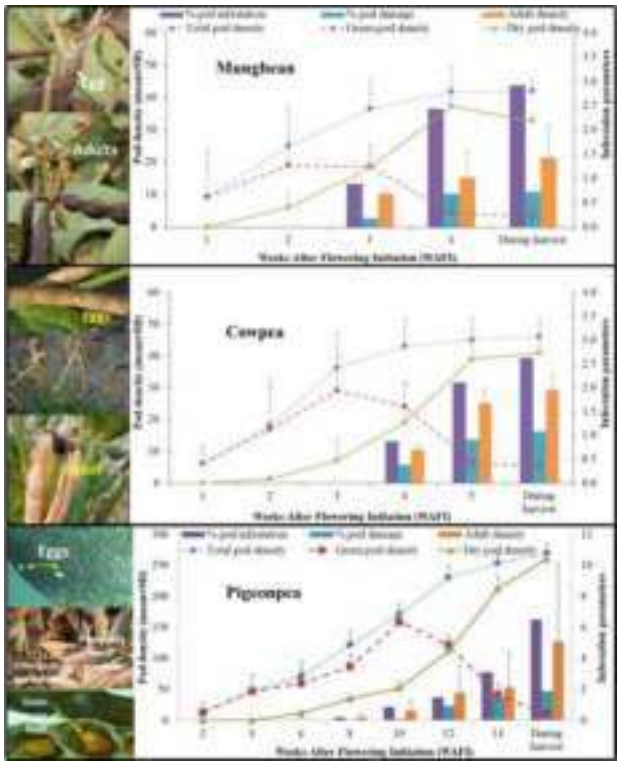


Fig. 14: Field-carry-over-infestation of bruchids in mungbean, cowpea, and pigeonpea

Status of phosphine resistance in major bruchid

The populations of three bruchid species collected from various locations demonstrated a varied response to phosphine toxicity within and between species (Figure 15). The phosphine resistance order for species was *C. maculatus* > *C. analis* > *C. chinensis*. The populations of each species collected from NE hilly areas and foothills of the Himalayas were found the least resistant to phosphine, whereas, the populations from plain areas where pulses are cultivated and stored demonstrated higher phosphine resistance. Overall, the bruchid populations collected from different locations demonstrated the resistance ratio against phosphine ranging from 1.1 to 4.5 folds. This is the first of its kind report ever from India.

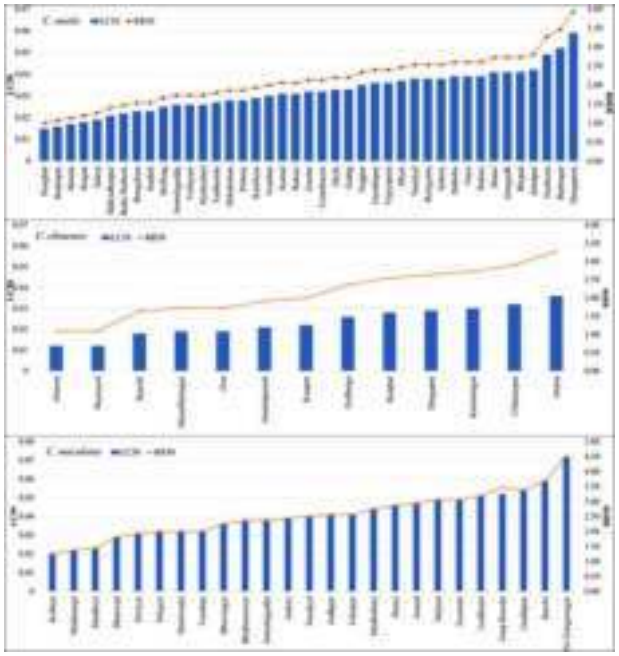


Fig. 15: Phosphine resistance status in bruchid species across different states of India

Insecticidal activity of plant volatile oil extracts against stored grain pests

The plant essential oils (EOs) reduced the egg laying and adult emergence of pulse beetle (*Callosobruchus analis*) in a dose-dependent manner. EOs of *Tagetes minuta* and *Cymbopogon martini* demonstrated complete deterrence to oviposition wherein no egg laying was observed on treated seeds. EOs of *Acorus calamus*, *C. martini*, *T. minuta*, *Mentha citrata*, *Trachyspermum ammi* demonstrated complete deterrence to adult emergence. The insecticidal Eos inhibited the activity of acetyl choline esterase (AChE) in treated insects and AChE inhibition was ranged from 6.12 (*O. basilicum*) to 37.94 (*C. winterianus*) per cent. The *Acoruscalamus* and *Mentha arvensis* EOs demonstrated high residual toxicity and treated seeds were found free from bruchid infestation for 70 days post-treatment.

Nematology

Screening for resistance against root-knot nematode

***Kharif* Pulses (Pigeonpea, Mungbean and Urdbean):** Thirteen pigeonpea, 32 mungbean and 15 urdbean lines were evaluated for their resistance against root-knot nematode, *Meloidogyne javanica*. In pigeonpea, out of 13 lines, 2 lines (GJP 1915 and BDN 2013-2) were resistant and eight lines (BDN 711, PA 291, UPAS 120, PT 10-1-1-2, RVKT 333, PT 11-4-4-1, IPA 15-21 and CRG 16-12) were found moderately resistant. In mungbean, out of 32 lines, two lines IIPM

20-2 and SML 2015) were found resistant and 7 lines (Varsha, MI 750-1, RVSM 18-1, SKNM 1705, OBGG 109, OUM 11-5 and IPMD 1603-7) were moderately resistant. In urdbean, out of 15 lines, 2 lines (IPU 2-43 and LBG 752) were found moderately resistant against *Meloidogyne javanica*.

***Rabi* pulses (Chickpea, lentil and fieldpea):** Twenty-five lines of chickpea, 43 of lentil, 42 of field pea and 10 of rajmash were evaluated against root knot nematode, *Meloidogyne javanica*. Out of 42 lines of fieldpea, 2 lines (Pant P 498 and TRCP 9) were moderately resistant. In chickpea, lentil and rajmash, none of the lines was neither resistant nor moderately resistant.

Screening for resistance against *Heterodera cajani*

Pigeonpea: Thirteen 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. One line BDN 716 was observed resistant, five lines namely, BDN 711, PA 291, UPAS 120, PT 10-1-1-2 and PT 11-4-4-1 were moderately resistant and remaining were either susceptible or highly susceptible.

Urdbean: Fifteen lines of urdbean were evaluated against *H. cajani*. Three lines namely, LBG 787, PU 31 and Shekhar 3 were observed as moderately resistant. Rest all lines were either susceptible or highly susceptible.

Evaluation of mustard crops as bio-fumigant for the management of root-knot nematode

A field trial was repeated at New Research Centre, IIPR, Kanpur. Seven treatments *viz.*, four varieties of bio-fumigant mustard crop, GSL-1, Neelam, Sheetal and Karan Tara, Neem cake @ 1000 kg/ha, nematicide carbofuran 3G @ 1.5 kg a.i./ha and control were taken (Figure 16). 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. One set of treatments with four replications was covered with polyethylene and other set was kept as such. Twelve days after covering that is on 16th Nov. 2021, the covers were removed and soil samples were collected to record the juvenile population. Same day sowing of chickpea variety ICC 2005-62 was sown. Three months after sowing, plant growth parameters were recorded.

Fig. 16: Lay out of the experiment

The per cent decrease in population over initial population after 12 days was calculated. The decrease in population was more in all the treatments compared to control (Figure 16). With covering of plots after treatment, maximum decrease (63.8%) was recorded in Karan Tara treated plots followed by 53.0% in neem cake. In uncovered plots maximum decrease (71.7%) was recorded in neem cake treatment followed by 60.7% in Karan Tara treatment.

There was improvement in the plant growth parameters such as plant height, fresh and dry shoot weights, number of pods etc. in all the treatments compared to control in both (covered and uncovered) plots. However, the improvement was more in covered plots compared to uncovered. The grain yield was also improved in treated plots compared to control. Grain yield was maximum 2725 and 2206 kg/ha in Karan Tara and neem cake treatments compared to 1650 and 1234 kg/ha in control. respectivley. Covering of plots after incorporatioon of biofumigant crop into soil improved the yield.

Influence of temperature on *Pasteuria* endospore attachment on *M. incognita*

In-vitro assay was carried out as described by Hewlett and Dickson, 1993. Endospore attachment assay with pre-treated endospores at 20, 30, 40, 50, 60 and 70°C revealed that maximum number of endospore attachment of all isolates was observed at 30°C followed by 40°C and least number of endospore attachment was observed at 60°C and above. The isolate Pp3 exhibited maximum number of spore attachments among all isolates at 30°C treatment (14) and 40°C treatment (10.67). Endospore attachment assay with Pre-treated J2 at 20, 25, 30, 35, 40 and 45°C revealed that maximum number of endospore attachment of all isolates was observed at 30°C treatment and no attachment was observed at 40°C and above. The experiment results concludes

that favourable temperature for endospore is 30 to 40°C and for J2 is 30°C for Pasteuria endospore-nematode cuticle attachment

Development of consortium for nematode and soil borne pathogens

Identification of biocontrol agents for development of consortium: The strains Actinobacteria (IIPR:KR01:03 *Streptomyces ginkgonis* (accession no: MN966860), Purpureocilliu mlilacinum (IIPR-Pl-11), *T. harzianum* (IIPR-Th-64), *T. asperellum* (IIPR-Ta-31) and *Bacillus cereus* (IIPR-Bc¬-14) are identified as effective against root knot nematode, *Meloidogyne incognita*, soil borne pathogens *viz.*, *F. oxysporum* f sp *ciceri*, *R. bataticola* and mutually inclusive among themselves and beneficial rhizobium.

Identification of liquid media for co-cultivation: Out of six media evaluated, TSB medium supported growth of all the potential strains, so this is identified as a liquid growth media for co-culturing of identified best strains

***In-vitro* bioassay and green house experiment on *M. incognita*:** Based on LC50 value on Juvenile mortality, nematode biocontrol consortium (2.5x103) is very effective compared to individual strains. Green house experiment revealed that biocontrol consortium was suppressed *M. incognita* population on chickpea significantly than individual strains.

Externally Funded Project

Project: CRP on Agro-biodiversity: PGR management and use of lentil (Component II: Evaluation of trait specific germplasm)

Evaluation of lentil germplasm against wilt: Five hundred genotypes of lentil received from ICAR-NBPGR, New Delhi were tested for wilt disease phenotyping in wilt sick plot. Three wilt susceptible lentil genotypes-L9-12, K 75 and Sehore74-3 used as check recorded 75-100% wilt incidence. Of the 500 genotypes, thirteen genotypes viz., EC 0267596, EC 0267536, L-4717, IC 0060375, EC 0267595-D, IC 0093392, EC 0223199-B, EC 0225460, EC 0078526-B, IC 361467, EC 0213197-B, EC 0267541 and IC 0078552 were found resistant with wilt incidence being 8.2-10.00%. Fourteen genotypes viz., EC 0267539, EC 0267577-D, EC 0267577, EC 0199459, EC 0267575-A, IC 316132, EC 0267544-A, EC 0223237-A, IC 0073120, EC 0267619, IC 22666, EC 0241434, EC 0267573-A and EC 0267597 were moderately resistant with wilt incidence being 11.48-20.00%; whereas wilt incidence in fifty seven other moderately resistant genotypes (EC 0267544-B, EC 0267570, EC 955432, EC 0223226, EC 0225995, EC 0223209-B, EC 0223236, EC 0267614, EC 267362, EC 0267588, IC 73121, IC 241475, IC 544563, EC 0267528, IC 0014214, EC 27659, EC 0223224, EC 0223237-C, EC 0267576-B, EC 955431, EC 0255502-A, EC 0267694, EC 0078541-A, IC 346268, EC 0225456, EC 0241442, EC 0267572-A, EC 0267693-B, EC 267554, IC 78406, IC 0014224, EC 0267569-B, EC 0267647, IC 0073122, IC 0014167, EC 0078526-F, IC 0078526-A, EC 0300191, IC 267668, EC 0267574, IC 0014225, IC 447768, EC 0267652, EC 0267601, EC 0267562, EC 0223197-C, IC 241531, IC 241543, EC 0213199-A, IC 0014250, IC 201776, EC 0267614-B, IC 0014215, EC 0267651-C, EC 0267641, EC 0267619-B and EC 0267619-A) ranged between >20.00-30.00%. Rest of the genotypes was either susceptible or highly susceptible.

Project: Management of wilt disease in pulse crops using bioformulation (UPCAR funded)

Isolation of bacterial and fungal isolates with biocontrol potential: forty three bacterial isolates and 11 *Trichoderma* isolates were purified from pulse rhizospheric soil and their antagonistic and other biochemical characterization has been completed. *Trichoderma* isolates HMPT-2 and IIPRt-5 and rhizobacterial isolates Ltp-1 and Bnd-4 showed maximum antagonistic activity against *F. oxysporum* f. sp. *lentis* with around 60% growth reduction.

Field evaluation of a talc-based formulation of *Trichoderma*: Seed treatment with *Dalhanderma*, a talc based Trichoderma formulation for management of wilt disease in lentil was evaluated at farmers' fields in Hamirpur and Banda districts using lentil variety IPL 220. Two trials each in Hamirpur and Banda district were conducted. Efficacy of the *Dalhanderma* against wilt disease in farmers' fields and its impact on yield were recorded. Data indicated that seed treatment with *Dalhanderma* reduced wilt incidence by 24.60-35.50% in Hamirpur and 17.15-30.83% in Banda district. Yield increase in trials at Hamirpur and Banda was 16-20% (Table 2 & 3).

Table 2. Wilt management in lentil through seed treatment with Dalhanderma at Kusmura village, Hamirpur district

Hamirpur Kusmara Villages	Wilt incidence %		% reduction over control	Yield q/ha		% increase over control
	Treated	Control		Treated	Control	
Trial 1	14.26	22.11	35.50	10.78	8.65	19.76
Trial 2	16.53	21.92	24.60	9.56	8.03	16.00

Table 3. Wilt management in lentil through seed treatment with Dalhanderma at Khurhand village, Banda district.

Hamirpur Kusmara Villages	Wilt incidence %		% reduction over control	Yield q/ha		% increase over control
	Treated	Control		Treated	Control	
Trial 1	12.20	17.64	30.83	11.05	9.32	15.66
Trial 2	21.64	26.12	17.15	9.21	7.44	19.21

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

Correlating the inter-linkages between environmental factors on epidemiology of wilt, dry root rot and pod borer in chickpea

Analysis of the last ten-year (2009-10 to 2019-20) data of major chickpea growing state across the country, revealed that wilt and pod borer incidence was positively correlate with maximum temperature (Tmax) and minimum temperature (Tmin) with average value of (+) ve 0.27- 0.21., 0.38- 0.18 respectively, however, RH and Rainfall interlinked negatively with average value of (-) ve 0.68- 0.61., 0.40- 0.15. The correlation between dry root rot, RH and rainfall was found positively correlated with average value of (+) ve 0.21, 0.11, respectively. However, temperature (Tmax, Tmin) was found negatively correlate with average value of (-) ve 0.20- 0.14.

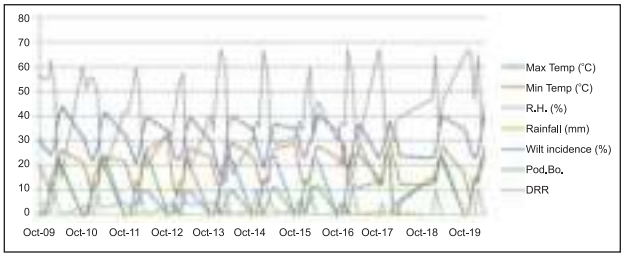


Fig. 17: Relationship between weather parameters, Wilt, Pod borer and dry root rot incidence in chickpea (2009-2019-20)

Table 4. Correlation between diseases, pod borer and weather variability

	Max Temp (°C)	*Min Temp (°C)*	*R.H. (%)*	*Rainfall (mm)*	*Wilt incidence (%)*	*Pod Borer*	*DRR*
Max Temp (°C)	1						
Min Temp (°C)	0.7937283	1					
R.H. (%)	-0.682769	-0.61186	1				
Rainfall (mm)	-0.401173	-0.15753	0.291499813	1			
Wilt incidence (%)	0.2751011	0.218519	-0.174837392	-0.021858967	1		
Pod borer	0.3897632	0.182451	-0.342471978	-0.186725077	0.693263	1	
DRR	-0.207726	-0.14498	0.216099046	0.119134172	0.033887	-0.11329	1

Basic Science

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

Project: Deciphering the physiological mechanisms of heat tolerance in lentil (*Lens culinaris* Medik.)

Heat tolerance in lentil

In a field experiment conducted during *Rabi* season (2021-22), 22 contrasting genotypes of lentil were evaluated/ validated for heat tolerance under normal and late sown condition based on non-destructive physiological parameters (NDVI, Chlorophyll Index and Thermal Imaging), yield and yield attributes. Sowing of the crop was done under timely (normal, 9th November 2021) and late sown (3rd January 2022) conditions in three 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 attribute 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 were measured using chlorophyll SPAD meter. Canopy temperature was measured using Thermal Imager (FLIR-E64502). Five plants from each genotype under late sown condition were tagged at flowering 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 vigour, produced pods in terminal branches and grain filling was also recorded at higher temperature (>30^{0}C). It was observed that higher crop vigour, MSI, canopy temperature, high 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. Twelve promising contrasting lines (IG 2507, IG 2543, IG 2598, IG 2821, IG 2559, IG 2960, IG3522, IG 4112, IG 4253, IG5128, WBL 58 and IG 4258) were identified based on Heat Susceptibility Index (HSI) and physiological parameters for further study (Fig. 1).

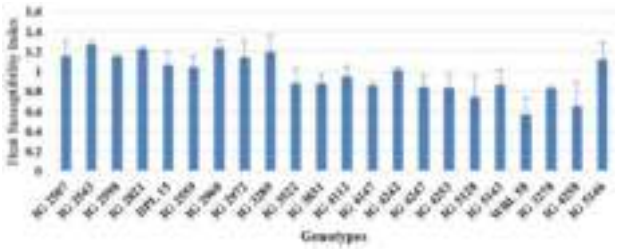


Fig. 1: Heat Susceptibility Index of lentil genotypes

Drought tolerance in lentil

A mapping population comprising 198 recombinant inbred lines (RILs), derived from a cross IPL 98/193 (long root) x EC 208362 (short root) developed for root traits (root length and root dry weight), was phenotyped for agro-physiological traits under drought conditions in dug-out microplot of main research farm, IIPR, Kanpur. Among these RILs, a RIL named as RILRT-200 was identified for early growth vigour based on plant height (25.0 cm) and NDVI (0.47) and early flowering (44 -52 days) and early maturity (95-100 days) compared to parental genotypes. This resulted in identification of a unique RIL for early growth vigour, early flowering and early maturity, which can be further utilized in lentil breeding program for developing the early maturing genotypes in lentil (Table 1).

Table 1. Comparative growth vigour (55 DAS) and days to 50% flowering and maturity

Parents/RIL	Plant height (cm)	NDVI	Days to 50% flowering	Days to maturity
EC 208362	18.0	0.430	64-66	112-113
IPL 98/193	16.5	0.435	69-72	114-119
RILRT-200	25.0	0.465	44-52	95-100

Another 160 pre-breeding lines of lentil was also screened for drought stress tolerance under dugout micro plot and rainout shelter.

Screening of wild genotypes of lentil for drought tolerance under rainout shelter

Twenty-six wild accessions of lentil belonging to four different species including *L. orientalis* (14), *L. nigricans* (3), *L. odemensis* (3) *L. ervoides* (3) and *tomentosus* (3) were screened for drought tolerance under rainout shelter during *Rabi* season (2020-21 & 2021-22). Out of 26 wild germplasm lines screened, 4 accessions (ILWL 432, ILWL 236, ILWL 425 and ILWL 398) belonging to *L. orientalis* performed well in terms of crop establishment, crop vigour (NDVI), MSI, biomass/plant, pods/plant and seed yield/plant (Fig. 2 and Fig. 3). These accessions can be used further in physiological characterization and genetic studies.

Fig. 2: Wild genotype ILWL 432

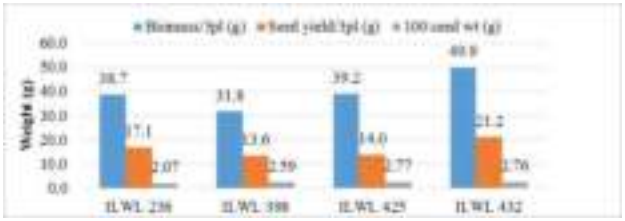


Fig. 3: Biomass, seed yield & test wt. in wild genotypes under rainout shelter

Project: Physiological characterization of pigeonpea genotypes for water logging tolerance

The experiment was conducted with 21 pigeonpea genotypes including checks. These were 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. Waterlogging stress was imposed for 24 h-48 h-72 h having minimum depth of water 12 inches at 30 DAS with three replications and a set of all genotypes sown under normal 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. Based on morphological characters' pigeonpea genotypes like ICPL 20241, ICPL 87091, ICP 5028, MA 6, NDA 1, Bahar, IPA 203 and IPAC 211 showed tolerance against water logging stress whereas IPAC 202, RCM/DD 17, WB 2019/25, WB 2019/26, WB 2019/27 and IPAC 212 showed susceptibility against water logging stress. Tolerant group showed the formation of adventitious roots but susceptible group showed no adventitious roots. Physio-biochemical parameters including NBI, chlorophyll, NDVI and photosynthetic efficiency were markedly reduced under water logging conditions over normal 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 pigeonpea genotypes against water logging stress.

Fig. 4: Morphological performance of pigeonpea genotypes

Fig. 5: Adventitious roots of pigeonpea genotypes

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

The experiment was conducted in field and laboratory condition during *kharif* 2021-2022. In field under irrigated condition, 51 urdbean genotypes were sown in augmented design on August 2, 2022 to find out heat tolerant genotypes. These genotypes were selected on the basis of their performance from large number of genotypes and various phenological parameters, growth parameters and yield observations were recorded, another set of experiment were under laboratory condition in growth chamber in which selected six genotypes (PGRU 16, PGRU 14, LBG 20, LBG 99-79, IPU 99-123, PU -19) were used for the study and screened for thermo tolerance.

Seedling growth: Urdbean seedling was selected to standardize protocol for temperature induction response (TIR) technique. This technique required standardization of age of seedlings, lethal temperature and induction temperature. Urdbean seeds (about 15-20) were soaked in water for 2 h and then allowed to germinate in moist petriplates at room temperature. Three-day old seedlings or 1.5 cm length of seedlings were selected for the experiment. The uniform seedlings from each genotype were transferred to three different sets of Petriplates for further studies.

Identification of lethal temperature: The minimum temperature which causes more than 100 per cent mortality when the seedlings exposed without induction cycle is the lethal temperature. To determine the lethal temperature, urdbean seedlings were subjected to different lethal temperatures *viz.*, 48, 50, 52°C followed by recovery at 30 °C for 72 h. The control seedlings were maintained at 30°C throughout the experiment period. The survival per cent was recorded after the recovery period. Among the three lethal temperatures tried, the highest mortality rate was recorded in 52°C for 3 h (98%). As the temperature increases from 48°C to 50°C with increment of 2°C, the mortality increased from 25 to 98 per cent (Table 2). Even when the temperature was increased above 52° C, the mortality was found to be 100 per cent since the lethal temperature is decided based on the lowest temperature with the highest mortality, the 52°C is optimized as lethal temperature in urdbean (Fig. 6).

Table 2. Mortality per cent of urdbean seedlings exposed to high temperature stress

Treatment	Mortality per cent
Control	0
48°C	25
50°C	38
52°C	98
Mean	40.2

Identification of optimum induction temperature: Induction cycle is the sequence of temperature treatments during which the urdbean seedlings are exposed to an optimum sub lethal to lethal temperature followed by recovery at 30°C for three days. In the present study, induction temperature was optimized by exposing the urdbean seedlings to different induction cycles *viz.*, 32-40°C for 3h, 34-42°C for 3 h and 36-44°C for 3 h with increase of 2 °C per hr. After this treatment, the seedlings were exposed to a standardised lethal temperature. Later the seedlings were kept at 30°C for recovery. Root and shoot length of induced and non-induced were recorded after recovery period.

Table 3. Impact of Temperature Induction Response on growth of seedling (Shoot length and root length in cm) and per cent reduction over control

Treatment	Growth of seedling (Shoot length and root length in cm)		Per cent reduction over control
	Growth at the end of recovery	Growth during recovery	
Control	14.4	9.77	NA
32–42 °C	8.4	3.90	60.1
36–46 °C	9.92	5.24	46.4
38–48 °C	9.61	4.97	49.2

Table 4. Measurement of cellular level tolerance using TIR

Genotypes	Root length (cm)		Shoot length (cm)		Seedling growth (RL-SL)		Survival percentage	
	C	I	C	I	C	I	C	I
PGRU 16	3.2	2.7	8.2	7.2	11.4	9.9	100	100
PGRU 14	5.1	3.9	12.2	9.3	17.3	13.2	100	100
LBG 20	3.7	2.0	9.3	4.2	13.0	6.2	100	88
LBG 99-79	3.0	2.1	12.4	5.1	15.4.	7.2	100	88
IPU 99-123	5.5	3.4	13.5	5.6	19.5	9.0	96	92
PU 19	3.8	3.2	10.2	8.4	14.4	11.4	95	92
Mean	4.05	2.88	10.96	6.63	15.16	9.48	95.0	93.33

Genotype PGRU 16 and PGRU 14 observed heat tolerant genotype shows 100% survival percentage, root length, shoot length and seedling growth followed by IPU 99-123, PU 19 whereas genotype LBG 20 and LBG 99-79 are heat sensitive genotypes. (Table 4)

Estimation of proline content. After lethal temperature treatment, proline was estimated in seedlings observations shows that proline content was higher in PGRU 16, PGRU 14 followed by LBG 20 and IPU 99-123 genotypes shows PGRU 16 and PGRU 14 were more heat tolerant than LBG 20 and IPU 99-123 genotypes (Table 5)

Table 5. Effect of Temperature Induction Response on proline content (µg g-1) of urdbean seedlings

Sl. No.	Genotypes	Control	Induced
1.	PGRU 95014	0.96	1.82
2.	PGRU 95016	0.94	1.70
3.	LBG 20	0.77	1.10
4.	IPU 99-123	0.88	1.24
Mean		0.9	1.5

Chlorophyll a, b and carotenoid was recorded in different genotypes and it was observed that in PGRU 14,PGRU 16 carotene, chlorophyll a, chlorophyll b were more than LBG 20, PU19, IPU 99-79, IPU 99-123.

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

Under this project, the total phenolic content (TPC), total flavonoid content (TFC), condensed tannin content (CTC) and total antioxidant potential of fifty commonbean genotypes was estimated using standard spectrophotometric methods. The TPC varied from 0.4 to 3.27 mg GAE/g seed, the TFC ranged from 0.1 to 1.8 mg CE/g seed, the CTC varied from 0.57 to 2.99 mg TAE/g seed and the total antioxidant potential varied from 0.39 to 5.12 mg TROLOX Eq/g seed (Table 6).

The phenolic profile of all fifty cultivars was explored using reversed-phase HPLC. The retention time of fifteen phenolic standards was determined. The free and bound phenolics from each commonbean genotype were extracted separately. Chromatographic analysis was done on an Agilent model (1260 infinity) equipped with a diode array detector. Gallic acid, proto-catechuic acid, p-coumaric acid, ferulic acid, sinapic acid, ellagic acid, catechin hydrate, myricetin, quercetin and kaempferol were detected in common bean genotypes. Among the phenolics detected in commonbean gallic acid, catechin hydrate, p-hydroxy benzoic acid, and ferulic acid were predominant. The polyphenol ellagic acid, and the flavonols myricetin, quercetin and kaempferol were detected in only a few genotypes. The black cultivar EC 931743 was found to have the most diverse phenolic profile among all the genotypes.

In addition, the RFO profile of 20 commonbean genotypes was explored using HPLC-RI and the data generated was consolidated with the RFO data of 30 common bean genotypes that were analyzed last year. Stachyose was found to be the major galacto-oligosaccharides in common bean followed by raffinose. Verbascose was not detected in any of the 50 genotypes that were analyzed. Out of 50 genotypes, three (Uday, EC 932147and EC 931772) were found to have low stachyose content (<3%) (Table 7) and four (EC 932197, EC 931772, EC 100098, and EC 931866) were found to have low raffinose content (< 0.5 %) (Table 7). Overall, six commonbean genotypes (Uday, EC 932147, IC 360831, EC 931844, EC 931874 and EC 931772) were found to have low total RFO content (3.2%) (Table 7).

Table 6. Total phenolic content (TPC), total flavonoid content (TFC), condensed tannin content (CTC) and total antioxidant potential of commonbean genotypes

S.No	Genotype	Total phenolic content (mg GAE/g seed)	Total Flavonoid Content (mg CE/g seed)	Condensed tannin content (mg TAE/g seed)	Total antioxidant potential (mg TE/g seed)
1	Arun	1.32	0.80	1.63	2.86
2	Uday	1.52	1.01	1.89	3.23
3	Utkarsh	2.04	1.34	2.49	4.54
4	HUR 15	0.54	0.30	0.77	1.08
5	HUR 137	1.13	0.58	1.26	2.09
6	Gujrat Rajmash	1.53	0.93	1.71	2.98
7	Baspa	2.23	1.19	2.58	4.31
8	IC 360831	1.40	0.84	1.69	3.14
9	IC 340947	2.22	1.41	2.37	4.81
10	EC 931873	0.41	0.28	0.72	1.08
11	EC 1038024	1.16	0.76	1.34	2.22
12	EC 931102	0.83	0.56	1.14	1.65
13	EC 931413	1.24	0.90	1.62	2.63
14	EC 931495	1.14	0.72	1.46	2.18
15	EC 931364	2.10	1.38	2.41	3.97
16	EC 931417	0.89	0.54	1.17	1.57
17	EC 931319	1.41	0.87	1.63	2.45
18	EC 931119	1.46	0.77	1.63	2.29
19	EC 931366	1.74	1.57	2.02	3.71
20	EC14920	1.06	0.79	1.35	2.29
21	IC 419887	1.06	0.77	1.34	2.04
22	EC 931948	1.15	0.85	1.54	2.31
23	EC 932092	0.88	0.99	1.25	1.70
24	EC 932028	1.58	0.79	1.80	2.82
25	EC 931996	0.93	0.56	1.37	1.81
26	EC 932071	1.25	0.91	1.77	2.40
27	EC 932047	1.77	0.91	2.08	2.01
28	EC 932197	1.23	0.53	1.33	1.80
29	EC 932147	3.27	1.80	2.99	5.12
30	EC 931874	1.16	0.41	1.15	1.48
31	GC 672	1.29	0.59	1.35	2.00
32	GC 785	1.05	0.43	1.09	1.40
33	GC 761	0.80	0.25	1.08	1.61
34	GC 847	0.65	0.11	0.74	0.75
35	GC 643	1.89	0.72	1.89	2.29
36	GC 683	1.15	0.38	1.08	1.36
37	GC 760	2.26	0.96	2.38	3.49
38	GC 797	2.14	0.87	2.12	2.40
39	GC 921	2.26	1.03	2.39	3.66
40	GC 806	1.58	0.75	1.69	2.28
41	GC 656	1.73	0.85	1.88	2.72
42	GP 15	1.19	0.48	1.33	1.86
43	GC 845	0.86	0.21	1.02	1.08
44	GC 744	0.80	0.24	0.81	0.82
45	GC 771	0.40	0.10	0.57	0.39
46	GC 41B	1.20	0.34	1.16	1.55
47	GC 690	1.15	0.37	1.30	1.71
48	GC 682	1.96	0.84	2.09	3.08
49	GC 766	1.35	0.62	1.41	2.02
50	GC 681	1.81	0.79	1.85	2.83

Table 7. Stachyose content, raffinose content, sucrose + maltose content, and total RFO content of commonbean genotypes

Sl No.	Cultivar	Stachyose content (mg/g seed)	Raffinose content (mg/g seed)	Sucrose + Maltose content (mg/g seed)	Total RFO (mg/g seed)
1	Arun	35.47	7.79	25.15	43.26
2	Uday	28.38	8.46	24.79	36.83
3	Utkarsh	38.15	8.35	17.18	46.5
4	HUR 15	38.18	9.48	19.24	47.67
5	HUR 137	40.61	10.01	21.75	50.62
6	Gujrat Rajmash	42.52	8.92	17.94	51.44
7	Baspa	38.77	10.76	24.22	49.53
8	IC 360831	33.07	7.3	21.27	40.37
9	IC 340947	41.3	10.45	21.39	51.76
10	IC 419887	40.83	11.48	25.9	52.31
11	EC 931948	33.56	11.9	30.63	45.46
12	EC 931873	33.64	11.1	22.88	44.74
13	EC 1038024	36.14	9.68	23.73	45.82
14	EC 931102	37.55	8.21	22.52	45.76
15	EC 931413	40	10.37	15.34	50.37
16	EC 931495	33.71	11.51	19.25	45.23
17	EC 931364	40.94	9.53	16.49	50.47
18	EC 931417	35.83	8.19	21.62	44.02
19	EC 931319	41	8.1	24.19	49.1
20	EC 931119	40.61	12.7	21.26	53.3
21	EC 931366	36.82	18.87	39.78	55.69
22	EC 14920	47.73	17.08	30.35	64.8
23	EC 932092	34.86	11.24	39.55	46.1
24	EC 932028	40.08	9.89	20.04	49.97
25	EC 931996	36.24	8.37	23.94	44.61
26	EC 932071	37.8	12.16	25.6	49.96
27	EC 932047	39.03	10.54	29.75	49.57
28	EC 932197	41.97	4.89	25.71	46.86
29	EC 932147	29.84	7.33	33.84	37.17
30	EC 931874	32.44	6.52	28.22	38.96
31	EC 931772	27.64	4.8	33.6	32.44
32	EC 931885	39.12	10.32	22.33	49.44
33	EC 931861	56.95	9.06	13.75	66.01
34	EC 931947	44.22	13.72	28.21	57.93
35	EC 931743	39.45	7.64	29.58	47.09
36	EC 931783	50.53	10.72	25.95	61.25
37	EC 931860	46.78	7.21	20.21	53.99
38	EC 931897	42.22	7.32	27.49	49.53
39	EC 932021	45.13	7.58	26.76	52.71
40	EC 931906	41.16	5.29	29.97	46.44
41	EC 931756	40.72	10.49	49.9	51.2
42	EC 100098	38.83	4.41	28.91	43.25
43	EC 931945	41.34	8.9	40.57	50.24
44	EC 931844	34.17	5.58	34.68	39.75
45	EC 931871	40.68	6.53	25.07	47.21
46	EC 931141	37.05	5.83	29.99	42.88
47	EC 931790	44.34	6.69	23.57	51.02
48	EC 931782	36.28	6.61	38.89	42.89
49	EC 931866	43.38	4.34	16.86	47.71
50	EC 931781	38.93	5.13	22.7	44.06

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

Under this project, the method for the estimation of phytohormones (such as Gibberellic acid (GA_3), Auxin (IAA) and ABA) were standardized in chickpea using HPLC (High-Performance Liquid Chromatography). Auxin and ABA were estimated in leaves and roots using HPLC in heat-tolerant and susceptible genotypes of chickpea under normal as well as high-temperature condition.

Method standardization for Gibberellic acid (GA_3) estimation:

A slightly modified method of Bhalla *et al.*, 2009 was used for the estimation of GA3 in chickpea flowers. GA_3 (Purchased from Sigma Aldrich) was used as standard. 100% acetonitrile and 0.01 % phosphoric acid (H_3PO_4) in HPLC grade water in a 60:40 ratio was used as the mobile phase. C-18 (Zorbax SB-C18; 4.6 X 250 mm, 5 µ) column was used for the separation. The column temperature, flow rate, injection volume and total run time were 35^{0}C, 0.6 ml/minute, 20 µl and 20 minutes, respectively. The Photo Diode Array detector was used to detect the GA3 at a wavelength of 206 nm. 0.1 to 100 ppm standard GA3 was used for standard curve preparation.

Method standardization for estimation of Auxin (IAA) and ABA simultaneously

A slightly modified method of Bosco *et al.*, 2013 was used for the estimation of Auxin and ABA simultaneously in the leaves and roots of chickpea. IAA (Indole 3 acetic acid) and ABA (± 2-Cis-4 trans abscisic acid) (Purchased from Sigma Aldrich) were used as standard. 100% acetonitrile and aqueous Phosphoric acid (H3PO4) solution (pH 3.2) in gradient mode was used as the mobile phase. C-18 (Zorbax SB-C18; 4.6 X 250 mm, 5 µ) column was used for the separation of compounds. The column temperature, flow rate, injection volume and total run time were 40□C, 0.5 ml/minute, 20 µl and 111 minutes, respectively. The Photo Diode Array detector (at wavelength 265 nm) and fluorescence detector (at 281 nm excitation wavelength and 265 nm emission wavelength) were used to detect ABA and IAA, respectively. 1 to 100 ppm standard ABA and 0.1 to 25 ppm IAA were used for standard curve preparation.

ABA content of leaves, roots and flowers

Higher abscisic acid (ABA) content was observed in roots as compared to the leaves and flowers of chickpea. ABA content of leaves and roots was found to be higher in heat-tolerant genotypes than heat susceptible genotypes. Further, its content increased under high temperature in leaves, roots and flowers of all the genotypes. The percentage increase under high temperature was higher in tolerant genotypes than in susceptible genotypes of leaves and roots (Fig. 6).

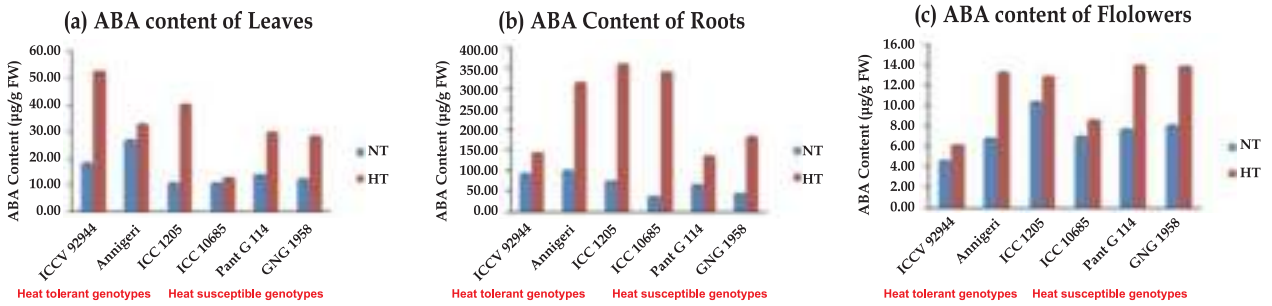


Fig. 6: ABA content of (a) Leaves, (b) Roots, and (c) Flowers of heat tolerant and susceptible genotypes of chickpea grown under normal as well as high-temperature condition

Auxin (IAA) content of leaves, roots and flowers

Under the high-temperature condition, the auxin (IAA) content decreased in chickpea leaves, roots and flowers of heat tolerant as well as susceptible genotypes. In the case of leaves and roots, a decrease in IAA content was higher in susceptible genotypes than in tolerant genotypes (Fig. 7).

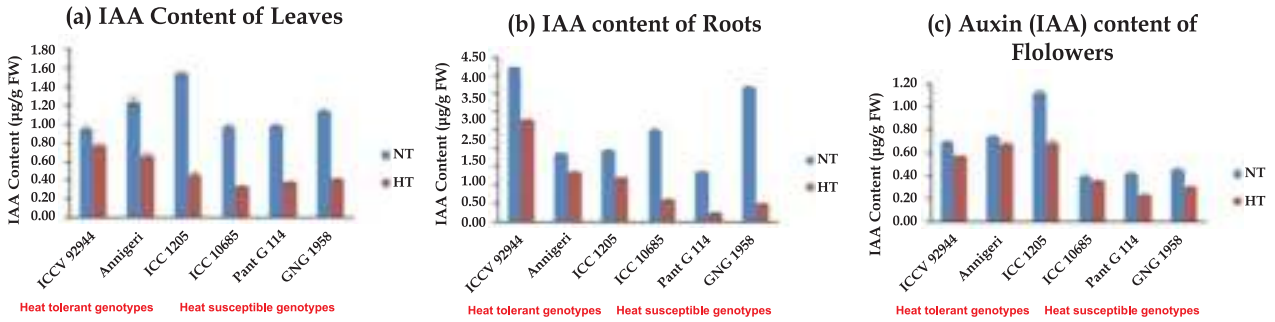


Fig. 7: Auxin (IAA) content of (a) Leaves, (b) Roots, and (c) Flowers of heat tolerant and susceptible genotypes of chickpea grown under normal as well as high-temperature condition

Gibberellic acid (GA_3) content of flowers

GA_3 was found to decrease under high temperature in tolerant as well as susceptible genotypes of chickpea flowers. The percentage decrease in GA_3 content due to high temperature was relatively higher in the heat susceptible genotypes compared to the tolerant genotypes.

RWC (Relative water Content) and MSI (Membrane stability index) of chickpea leaves

RWC and MSI were estimated in the leaves (at flower initiation stage) of heat tolerant and heat susceptible genotypes of chickpea under normal as well as high-temperature condition to know whether plants are under stress or not in stress due to high temperature. Results demonstrated that MSI and RWC content of leaves decreased under high temperature in all the genotypes and the decrease in MSI and RWC content were slightly higher in heat susceptible genotypes than heat tolerant genotypes (Fig. 8).

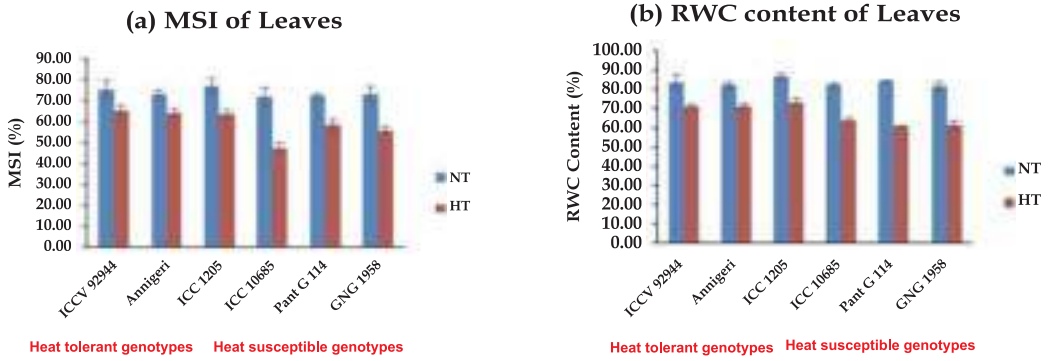


Fig. 8: MSI and RWC of leaves (at flower initiation stage) of heat tolerant as well as heat susceptible genotypes of chickpea grown under normal as well as high-temperature condition.

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

An analytical method was standardized for analysis of imazethapyr by using HPLC system coupled with photo diode array (PDA) detector, which involves acetonitrile-0.1% ortho phosphoric acid (70:30, v/v), as mobile phase with flow rate of 1 mL/min (Fig. 12a). Calibration curve (Fig. 12b) was prepared by plotting areas *vs.* concentrations of active substances, which confirmed linearity of the proposed method in between concentration range of 0.005 and 10 µg m/L. Acetate buffered quick, easy, cheap, effective, rugged and safe (QuEChERS) technique was utilized for sample preparation. Solvent-matched and matrix (soil and plant)-matched calibration curves (10, 5, 2.5, 1, 0.5, 0.1, 0.05, 0.01 and 0.005 µg m/L or/g) confirm matrix effect in analysis of imazethapyr (Fig. 12c and 12d). To nullify this effect, matrix-matched standards were used for residue quantification in soil samples. Recovery studies revealed 83.2 ± 1.41 to 92.6 ± 1.02% recoveries of imazethapyr from spiked soil samples (0.005 to 10 µg/g) (Fig. 12e). LOD and LOQ were found to be 0.005 and 0.01 µg/g, respectively.

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, along with control. Soil samples were collected at periodic interval at 0 (2 hr after app.), 1, 3, 5, 7, 10, 15, 20, 30, 45, 60, 75 DAA and analyzed for residues of imazethapyr. It was observed that residues dissipated with time and persisted beyond 75 days after application (Table 8). The half live values were ranged in between 53.75 to 59.02 days.

Table 8. Dissipation kinetics of imazethapyr in soil at different treatment levels

Dosage of imazethapyr (g a.i./ha)		Residues (µg/g) ± SD						T ½ (Days)
		0 days	5 days	15 days	30 days	45 days	75 days	
Pre-emergence	100	0.701 ± 0.007	0.630 ± 0.019	0.547 ± 0.016	0.468 ± 0.021	0.403 ± 0.022	0.243 ± 0.012	55.74
	150	0.930 ± 0.014	0.851 ± 0.009	0.725 ± 0.022	0.611 ± 0.019	0.560 ± 0.012	0.346 ± 0.010	59.01
Post-emergence	100	0.721 ± 0.011	0.637 ± 0.008	0.565 ± 0.020	0.478 ± 0.013	0.390 ± 0.015	0.254 ± 0.20	53.75
	150	0.962 ± 0.017	0.871 ± 0.009	0.752 ± 0.013	0.657 ± 0.021	0.552 ± 0.018	0.365 ± 0.120	55.74

Another analytical method was standardized by using HPLC system coupled with fluorescence detector (FD) for determination glyphosate and its major microbial degradation product, amino methyl phosphonic acid (AMPA), which has toxicity comparable to glyphosate. The mobile phase comprised of acetonitrile (solvent A) and 0.05% ortho phosphoric acid (solvent B), with flow rate of 1 m/l min. The gradient system adopted was: 0 min 5% of A, 23 min 45% of A, 28 min 95% of A, 33 min 5% of A, re-equalizing the initial conditions by 5% until 36 min of runtime. The fluorescence emission at 317 nm was detected after excitation at 260 nm. The retention time was 19.19 min and 21.7 min for Glyphosate and AMPA, respectively (Fig. 13a). Calibration curve (Fig. 13b) confirmed linearity of the proposed method in between concentration range of 0.05 and 10 µg m/l. Recovery studies were conducted on spiked soil samples by following alkali extraction technique, which showed 92.4 to 95.8% recovery of Glyphosate and 87.7 to 96.3% recovery of AMPA at different spiking level (0.01, 0.05, 0.1, 0.5, 1 and 2.5 µg/g) (Fig. 14a). LOD for glyphosate and AMPA was 0.01 µg mL^{-1}. LOQ for glyphosate and AMPA was 0.05 µg/g for soil samples. In pot experiment, glyphosate was applied at the rate of 1.5 kg a.i./ha and 2.25 kg a.i/ha on weeds, which was followed by sowing of urdbean after 10, 15, 20 days of waiting time. Soil samples were collected at different time interval and analysed for residue status of glyphosate and AMPA, which showed glyphosate persisted beyond 45 days after application (Fig. 14b). AMPA persisted longer than glyphosate in soil.

Programme 2: Establishment of effective symbiotic nitrogen fixation in pulses

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

SNPs and InDels in genes determining nodulation and symbiotic efficiency in chickpea were mined from 285 chickpea minicore genotypes following GATK tool and identified 29,15,827 bi-allelic SNPs and 66,76,215 InDels. Of these SNPs, 22,935 biallelic SNPs were present in 21 nodule organogenesis related genes especially those are present in various parts of genes such as UTRs, upstream of a gene, splice junction etc. The variants are grouped as downstream gene variant (6,125), intergenic region (5,130), non-coding transcript variant (2,722), intron variant (1,593), 3 prime UTR variant (277), 5 prime UTR variant (160) and splice region variant (65) non coding transcript exon variant (29), intragenics variant (19) stop gained (4), stop lost (1) and splice donor variants (1) (Fig. 9).

Locus LOC101490264 is an ortholog of *Medicago truncatula* cytokinin response regulator 9 and has SNP in exonic region which causes creation of stop codon in ICC1230 and ICC1710 genotypes and produces non-functional protein product. It's well corresponding with nodule phenotypic data where these genotypes are low nodulator. Of these 6676215 InDels, 5251 InDels are present in 21 nodule

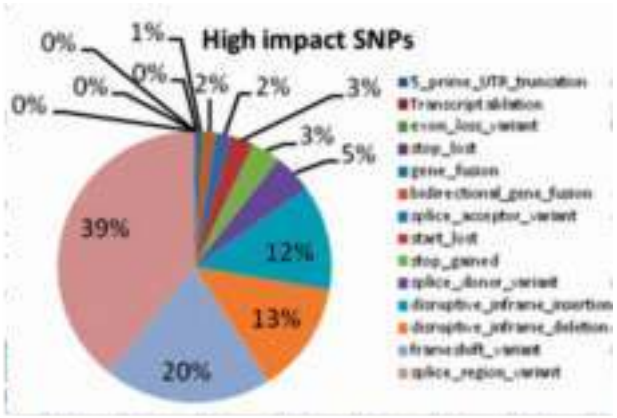


Fig. 9: High impact SNPs

organogenesis related genic region. The most of these InDels are upstream (1556) and downstream (1365) gene variants. Some genetic variants are causing effects such as Splice acceptor (1) and donor (1) variants, disruptive inframe insertion (4) and deletion (6), and loss of start site (3). Start lost variant caused by InDel is observed in the locus LOC101500280 of ICC20183 genotype which encodes *Medicago truncatula* ortholog VAPYRIN. This genotype is also a poor nodulator (Table 9).

Table 9. List of BNF related genes with high impact SNPs

DMI1	*DOES NOT MAKE INFECTION 1*	EMS; Tnt1	Membrane depolarizing pump, needed for the generation of the self-sustaining Ca2+ spiking
NIN	*NODULE INCEPTION*	FNB,Tnt1	RWP-RK domain containing transcription factor activate downstream gene expression
NSP2	*NODULATION SIGNALING PATHWAY 2*	EMS; Tnt1	GRAS domain containing transcription factor activating downstream gene expression
VPY	*VAPYRIN*	FNB,Tnt1	Major sperm protein domain and a multiple of ankyrin repeats containing protein required for IT formation
CBS1	*Cystathionine-β-Synthase-like1*	Tnt1	Cystathionine-β-Synthase and DUF21 domain containing protein, probable role in IT wall formation
RPG	*RHIZOBIUM-DIRECTED POLAR GROWTH*	EMS	Nuclear localized coiled-coil protein

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

A total of 10 selected rajmash genotypes contrasting in nodulation potential along with three varieties were reevaluated for confirmation of their nodulation potential under field condition with different level of nitrogen fertilization. Rajmash genotypes IC 417352, EC 150250, IC 356018 and IC 356072 were found to be high nodulators. Nodule number varied from 3-15/plant. Nodule specific weight varied from 2-16 mg/nodule (Fig. 10).

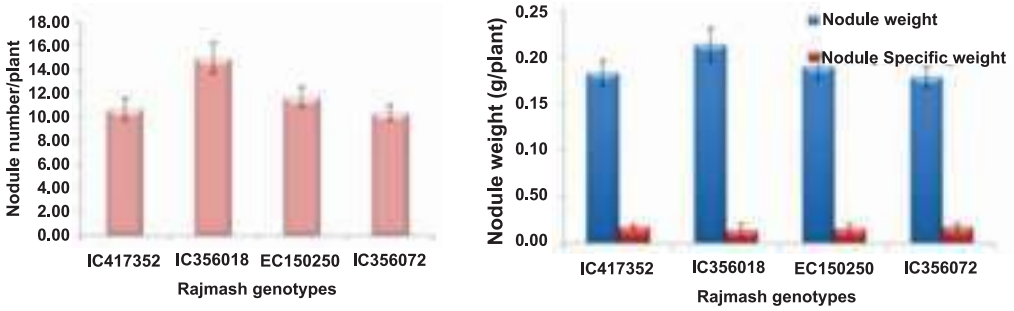


Fig. 10: Nodulation potential of *rajmash* genotypes under field condition

Two best *Rajmash* genotype-*Rhizobium* combinations (Rajmash genotype IC 356018, EC 150250, and Rhizobial isolate IIPR-RR17, IIPR-RR40) were revaluated for their nodulation potential under sand and hydroponics system. Both the combinations were found positive for nodulation with genotype IC 356018 being the highest nodulator. Better root proliferation was observed in sand medium compared to hydroponics system. Since the presence of humus in soil organic matter may interfere with extraction of signal molecules, hydroponics system was chosen for further optimization of nodule induction (Fig. 17). Both the combinations were found positive for nodulation with genotype IC 356018 showing better growth response. A series of experiments were conducted to optimize sampling time and interval for maximum extraction of root exudates under hydroponics system and Gibson tube. Root growth was comparatively better in conical flasks with aeration than in Gibson tubes. Based on the data, 6 to 12 days after inoculation is the suitable time for extraction of root exudates for trapping the signaling molecules. Further standardization of the protocol is needed to improve the nodule induction process.

Social Science

Programme 1: Innovative extension approaches for enhanced farm income, nutritional security and impact assessment through pulses 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 purpose of dissemination of pulse production technologies among potential stakeholders. A total of 80 videos have been prepared on improved pulse production technologies and success cases of partner farmers have been prepared and uploaded on Institute You Tube channel "ICAR-IIPR Pulse farmer corner". The channel has reached 136,228 views with about 2,500 subscribers.

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

A total of 125 demonstrations on chickpea (71), lentil (16), Mothbean (10), clusterbean (20), horsegram (2), cowpea (3) and mungbean (3) were conducted collectively in Marundasuchit village of Unnao, Badrasar & Nagasar villages of Bikaner and Narendra from Dharwad district, Padli village of Sehore, Madhya Pradesh state. The farmers received yield advantage of 12.31%, 19.17%, 16% and 20% in chickpea, lentil, cowpea and horsegram from demonstration plots, respectively. In addition, three farmers-scientist interaction program was conducted wherein about 210 farmers from the model villages interacted. One farmers training programme was also conducted, wherein 20 farmers participated. One field day was also conducted to support the farmers.

Project: Impact Assessment of pulses varieties developed by ICAR-IIPR, Kanpur

The project was initiated with major objective to analyze the impact of the adopted pulses varieties developed by ICAR-IIPR, Kanpur. Fieldpea varieties *viz*; IPFD 1-10 (Prakash), IPF 5-19 (Aman) and IPFD 10-12 and mungbean varieties *viz*; IPM 205-7 (Virat), IPM 410-3 (Shikha) and IPM 02-03 were selected for the study. Considering the recommended zone of the varieties and on the basis of area and production under the crop, Uttar Pradesh and Madhya Pradesh were selected for fieldpea whereas Rajasthan and Madhya Pradesh were selected for the mungbean. Further, Nagaur, Jodhpur (Rajasthan), Hoshangabad and Sehore (Madhya Pradesh) districts were selected for mungbean whereas, Jalaun, Jhansi (Uttar Pradesh), Datiya and Jabalpur (Madhya Pradesh) districts were selected for fieldpea. The time series data on area, production and productivity of mungbean and fieldpea were collected from Directorate of Economics and Statistics for sampled area. The collected data were analyzed and compound annual growth rate (CAGR) and Cuddy Della Valle instability index (CDVI) was calculated for both mungbean and fieldpea.

During the entire period of twenty years (2000-01 to 2019-20), there was positive growth rate in area, production and productivity of mungbean in Rajasthan while, the period witnessed the high instability in all area, production and productivity as the instability index was greater than 30. Madhya Pradesh also showed the similar results for the period 2009-10 to 2019-20 i.e. positive growth rate and high instability in area and production of Mungbean.

Further, the growth rate in sampled districts of Rajasthan and Madhya Pradesh found to be positive which but also accompanied with high instability.

The growth performance of fieldpea in Uttar Pradesh and Madhya Pradesh shows the positive growth rate but very high instability in all the area, production and productivity of fieldpea in both the states.

Further, the growth rate and instability index in sampled districts of Uttar Pradesh and Madhya Pradesh *viz*; Jalaun, Jabalpur and Datia revealed the similar results with positive growth rate and high instability in all area, production and productivity of fieldpea during the study period.

The primary data collection was started with the help of structured survey schedule and focus group discussion. A total of 80 farmers cultivating peas from Maheva block of Jalaun district were interviewed. The adoption pattern of different fieldpea varieties was examined. It was found that IIPR fieldpea varieties *viz*; IPFD 1-10 (Prakash), IPFD 10-12, IPFD 99-13 (Vikas) and IPFD 12-2, developed by ICAR-IIPR, Kanpur were together adopted by almost 50 % of the sampled farmers.

Programme 2: IT enabled data management in pulses for policy support system

Project: Digitalization of quality seed production and germplasm database for pulses

Different characteristics of germplasm data for major pulse crops maintained/stored in IIPR Gene Bank were collected and processed using digital format. A Germplasm Resources Information System for Pulses (IIPR-Gene Bank) has been developed. An user-friendly interface for data entry has been designed for entry of data related to different locations & characters of germplasm accessions allows users to store, modify & update information and perform search operation efficiently. Presently, the system contains information on available germplasm accessions (Chickpea: 2300, Pigeonpea: 1200, Mungbean: 700, Urdbean: 523, Lentil: 1532, Rajmash: 1950, Fieldpea: 950 and Cowpea: 600) maintained in gene bank and evaluated for different valuable descriptors (qualitative traits and quantitative traits). System has two components one for data management and other for generating queries and reports. Queries & reports have been designed for retrieval of information *viz.*, Location-wise report, Character-wise report, Query-based report, Detail report. System has developed using WAMP (Windows, Apache, Mysql and PHP) technology. System provides the information need of researchers, exporters and policy makers and also serve as an information highway for sharing pulses germplasm information through digital platform.

Fig. 1: Query/Report section: Character-wise germplasm accessions

Project: Development of a procedure for promotion of AICRP crop performance trials

Genotype-Environment Interaction (GEI) occurs in both short-term and long-term crop performance trials. It is a challenge for plant breeders, geneticist, and production agronomists who conduct crop performance trial across diverse environments. GEI can reduce progress because researchers usually ignore GE interaction encountered. In this regard, Eberhartand Russell model has been used to developed an index to rank the genotypes in crop performance trials using average yield and stability component of genotypes. Yield index has been computed by taking ratio of each genotypes to the average of all the genotypes and stability information has been computed by taking reciprocal of sd2 that represents genotype and the combined index is linear combination of yield and stability index.

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

Data collection, submission, analysis and retrieval in smoother and easier way are the major aspects of All India Coordinated Research Project of Pulse crops. There were delay in processing of data collection, analysis and report generation in the manual system of data collection and retrieval of the coordinated trials. To address this issue, a system has been developed to submit, analyze and retrieve the AICRP plant breeding trial data for pulse crops. The client side interface layer has been developed using HTML and PHP that contains forms and reports for accepting information from user. Server side application layer is implemented using PHP and these PHP page generate HTML pages according to the user's action and request. Database layer for which the relational and normalized database structure was used with its implementation using SQL server. The system has four online functional module viz. Centre information, Trial information, Upload data and Retrieval of submitted data with primary key.

Externally Funded Project

Project: Establishment of Agri-Business Incubation Unit at ICAR-IIPR, Kanpur under NAIF scheme ICAR, New Delhi

- Mahodhya Agriworks, Kanpur signed MoU for incubation support for preparing "High fiber and protein rich biscuits from pulse

byproducts" on 29th July, 2022. Delemeo brand of high fiber and protein rich handmade cookies prepared by MahodhyaAgriworks under incubation support was unveiled on Institute Foundation Day 05th September 2022. Mahodhya Agriworks generated gross returns of ₹ 30,888.00 from sale of handmade cookies by Delomeo brand.

- Incubation support on "Protocols on pulse milling" of existing incubatee "Mamta Agro India" was renewed for 2nd phase. The firm could sell 2916.56 kg processed pulses (Pigeonpea, Chickpea, Mungbean Urdbean, Lentil *dal* and Chickpea flour) and generated ₹ 3.01 lakh as gross returns.
- Agri-Business Incubation Unit, ICAR-IIPR generated ₹ 1,76,249/- till 31/12/2022 as total revenue from incubation fee, operational and royalty charges from incubatees.
- Workshop on "Agribusiness Opportunities in Pulses" was organized on 27th September 2022, wherein 200 students of Rama University, Kanpur and 11 faculty members participated.

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

A. Technological interventions under Farmer FIRST project during *Rabi* 2021-22

Technological interventions on bio-fortified (Var. DBW 187) and high yielding (var. DBW 222) wheat varieties

Biofortified wheat variety DBW 187 and high yielding wheat variety DBW 222 were introduced in Karchalpur, Khadra, Delemau and Shahpur villages in Devmai block of Fatehpur district covering 15 ha area. These interventions were partnered by 56 and 20 farmers for DBW 187 and DBW 222 varieties. Partner farmers received an average yield of 46.29 q/ha and 50.74 q/ha from demonstration plots under DBW 187 and DBW 222 varieties, respectively. Further, the partner farmers received yield advantage of 29.48 and 41.93 per cent and received average gross income ₹ 98,366.25/ha and ₹ 1,07,822.50/ha from DBW-222, respectively. Farmers preferred DBW 187 for number of tillers, plant height, and disease tolerance and fertilizer response.

Technological interventions on chickpea (var. GNG 2207)

Demonstration on Chickpea (var. GNG 2207) were conducted in Khadra, Delemau, Shahpur, Karchalpur and Mirai villages of Fatehpur in partnership of 60 farmers covering 9.10 ha area. Partner farmer received average of 16.76 q/ha yield in comparison to prevailing variety (12.02 q/ha). The Partner farmers received 39.43 per cent yield advantage and 39.43 per cent economic advantage from the demonstration plots. Besides yield superiority, farmers preferred the variety for bold seeds,seed coat color, plant vigor and resistance to wilt.

Technological interventions on field pea (var. IPFD 12-2)

Demonstrations on Field pea (var. IPFD 12-2) were conducted by 16 partner farmers covering 2.5 ha area. The partner farmers received average yield advantage of 4.74 q/ha and income advantage of ₹ 26,287.90/ ha in comparison to prevailing variety.

Table 1. Technological interventions under project during *Rabi* 2022-23

Crop	Variety	No. of demonstrations	No. of farmers	Area Coverage (ha)	Yield (q/ha)	Yield advantage (q/ha)	Income advantage (₹)
Wheat	DBW 187	56	56	15	46.29	10.54	22397.50
	DBW-222	20	20	5	50.74	14.99	31853.75
Chickpea	GNG 2207	60	60	9.10	16.76	4.74	26287.90
Field pea	IPFD 12-2	16	16	2.5	17.48	5.63	30965

B. Technological interventions under Farmer FIRST project during summer 2022 Demonstrations on summer mungbean production technologies (var. virat)

Mungbean interventions were implemented in project villages (Khadra, Shahpur, Karchalpur, Delemau and Holapur) in partnership with 113 farmers covering 23.56 ha area in summer 2022. The technology package demonstrated included quality seed of mungbean variety Virat, seed treatment with Imidacloprid 17.8% SL and use of plant protection chemical (chlorantraniliprole 18.5% SC) for timely management of *Spodopteralitura* infestation in the

crop.The partner farmers received an additional yield of 1.89 q/ha with ₹ 11,415/ha gain in income. Farmers showed preference for the variety for its short duration that helps it fit well into the paddy–wheat cropping sequence. Further, zero tillage technique was introduced in project village in summer mungbean to minimize the cost of cultivation. Three demonstrations on one hectare each were conducted in the project villages wherein average yield was recorded to be 12.45 q/ha, in contrast to 11.02 q/ha under farmers' practice. The income from the demonstration plot was recorded to be ₹ 93,375/ha in comparison to ₹ 82,650/ha from conventional practice.

Technological intervention on summer *Okra* (Navya)

High yielding hybrid of Okra Navya was introduced among partner farmers of Khadra, Karchalpur, Delemau, and Shahpur villages of Fatehpur district. Total 24 farmers partnered the interventions on 2.39 ha. Partner farmers received average yield of 18.26 t/ha in comparison to 13.82 t/ha from other popular hybrids in the region. The introduced hybrid fetched better market prices leading to an average gross return of ₹ 2.74 lakh /ha that was about 32.12 % higher than gross return from other hybrids/varieties. The hybrid was also perceived for ease in picking, resistant to yellow vein mosaic virus as well as the fruits were green, shiny and slender, that fetched better market price returns.

Table 2. Technological interventions under the project during summer 2022

Crop	Variety	No. of demonstrations	No. of farmers	Area Coverage (ha)	Yield (q/ha)	Yield advantage (q/ha)	Income advantage (₹)
Mungbean	Virat	113	113	27.32	11.51	1.89	11415
Mungbean (ZT)	Virat	3	3	0.097	12.45	1.40	10750
Okra	Navya	24	24	2.39	182.69	32.12	66630

C. Demonstrations of improved technologies during *Kharif* 2022 Technological interventions in paddy

Demonstrations (35) on high yielding hybrid of paddy (NDR 20-65) were conducted in Delemau, Khadra, Karchalpur, Mirai, Shahpur villages of Fatehpur district covering 13 ha area. Partner farmers received 61.89 q/ha yield in comparison to local varieties (40.62 q/ha). Partner farmers received yield advantage of 21.91 q/ha and gained income advantage ₹ 39,438.00.

Table 3. Technological interventions under the project during *Kharif* 2022

Crop	Variety	No. of demonstrations	No. of farmers	Area coverage (ha)	Yield (q/ha)	Yield advantage (q/ha)	Income advantage (₹)
Paddy	NDR 20-65	35	35	13	61.89	21.91	39438

D. Entrepreneurship development of women farmer group by pulse and wheat processing

For developing entrepreneurial skills and generating additional income by 11 women member of *Namami Gange Mahila Krishi Udyog Samiti* were given hands on training in pulse processing and value addition. In addition, I.I.P.R. Mini *dal* mill was provided to the women group and women group were also supported for marketing of their produce. The group is in the process of preparing products

including wheat flour of Bio-fortified wheat variety DBW 187, *moong dal, urad dal, chana dal* and gram flour *etc.*

Entrepreneurship Development for income and employment generation:

1. Interventions on Fish Farming

To promote entrepreneurial skills through improved fish farming, intervention on fish farming was conducted in project villages. To improve the technical knowledge and skills on fish farming, three days online farmers training programme on "Entrepreneurship development through fish farming" was conducted in collaboration with ICAR-NBFGR, Lucknow during March 15-17, 2022 for 18 partner farmers for scientific fish farming. After training, 02 partner farmers constructed model fish ponds of 9450 square feet meter in project villages. The interventions included 24 kg composite culture (Rohu, Katla and Mrigal) for use in these fish ponds. Experts from CAR-NBFGR, Lucknow supported for technical guidance.

2. Interventions on Poultry farming

Partner farmers were supported for poultry production in the project villages for additional income and employment generation. A three days online training on "Backyard poultry farming" was conducted in collaboration with ICAR-Central Avian Research Institute, Izzatnagar, Bareilly during 11-13 April, 2022 for 18 partner farmers. After training, partner farmers were provided 1400 chicks of CARI Nirbheek and CARI Shyama. CARI Nirbheek is dual purpose breed and can be used for egg and meat purpose both, while CARI Shyama preferred for meat purpose only. The required technical support on management aspects was taken from expert of ICAR-CARI, Izzatnagar, Bareilly.

3. Interventions on Mushroom cultivation

To tap the business opportunities in mushroom cultivation, rural youth and farm women were provided 07 days hands on training program on Mushroom Cultivation at Krishi Vigyan Kendra, Thariyawan, Fatehpur. The training program conducted in four phases (23-24 September2022, 11-12 October 2022, 27-28 October 2022 and 3-4 November 2022) partner farmers of Khadra and Karchalpur villages. Using knowledge and skills provided in training, partner farmers and farm women's are producing the mushrooms enthusiastically in the said villages

Project: Frontline Demonstrations on Pulses

A total of 140 Frontline Demonstrations (FLD's) were conducted in *rabi* 2021-22 that included 66 FLD's on Chickpea (var. GNG 2207), 39 FLD's on Field pea (var. IPFD 12-2) and 35 FLD's on Lentil (var. IPL 315) in 07 districts of Uttar Pradesh including Jalaun, Hamirpur, Kanpur Dehat, Banda, Fatehpur, Unnao, Fatehpur in different production situations covering about 56 ha. Partner farmers received yield advantage of 3.67 q/ha, 1.51 q/ha and 1.90 q/ha in fieldpea, lentil and chickpea demonstration plots, respectively.

Demonstrations on summer mungbean for additional income were conducted in Fatehpur, Kanpur Nagar, Kanpur Dehaat, Banda and Unnao districts of Uttar Pradesh. A total 24 demonstrations on mungbean (var. virat&shikha) were conducted covering 10 ha area. The demonstrations plots resulted in additional yield of 3.7 q/ha in comparison to farmers' practice and economic advantage of ₹ 28,922.00 per hectare were received.

Table 4. Details of *Rabi* FLDs during 2021-22

Crop	Districts	Variety	No. of farmers	Area (ha.)	Demo yield(q)	Farmer yield(q)	Yield adv.(q)	Economic advantage @MSP
Fieldpea	Jalaun, Hamirpur, Kanpur Dehat, Banda	IPFD 12-2	39	15	15.39	11.72	3.67	22020
Lentil	Unnao, Fatehpur, Hamirpur	IPL 220	35	18	10.08	8.58	1.51	8305
Chickpea	Fatehpur, Unnao	GNG 2207	66	24	10.52	8.63	1.90	9937
	Total		**140**	**56**				

Table 5. Details of FLD's conducted during summer 2022

Crop	Districts	Variety	No. of farmers	Area (ha.)	Demo yield(q)	Farmer yield(q)	Yield adv.(q)	Eco.Adv. @MSP
Mung bean	Fatehpur, Kanpur Nagar, Kanpur Dehat, Banda, Unnao	Virat, Shikha	24	10	13.4	9.7	3.7	28922

Demonstrations conducted under Schedule Tribe Component (STC) during 2021-22

1. *Kharif* demonstrations

For enhancing pulse production for food, nutritional security and rural livelihood of tribal farmers, 215 demonstrations on Pigeonpea were conducted in different districts of Madhya Pradesh and Chhattisgarh state. Farmers received an additional yield of 3.72 q/ha and 1.88 q/ha and economic advantage of ₹ 23,457.76 and ₹ 11,829.72 in comparison to farmer practice in Madhya Pradesh and Chhattisgarh state, respectively. A total 246 demonstrations including 120 demonstrations on urdbean (var. PDU-1, PratapUrad 1, PU-31) in Madhya Pradesh state and 126 demonstration (var. Pratap Urad 1, PU-31, Indira Urad Pratham) were conducted in Chhattisgarh state. Farmers received average yield of 7.4 q/ha and 6.8 q/ha and economic advantage of ₹ 15,273.30/ha and ₹ 8,858.80/ha from demonstrations plots in Madhya Pradesh and Chhattisgarh, respectively.

2. *Rabi* demonstrations

Demonstrations on chickpea (361) during *Rabi* 2021-22 including 286 demonstrations on chickpea (var. JG 12, RVG 202, JG 36) in Madhya Pradesh and 75 demonstrations on chickpea (var. RVG 202, GNG 2144) conducted in Chhattisgarh state. In Madhya Pradesh, farmers received 12.4 q/ha yield in demonstration plots in comparison to 8.6 q/ha in farmers practice. In similar lines, in Chhattisgarh state farmers received additional yield of 2.1 q/ha and economic advantage of ₹ 10,493.80/ha. A total of 31 demonstrations on lathyrus (var. Mahateora) were also conducted in Chhattisgarh state, wherein yield advantage of 0.8 q/ha and economic advantage of ₹ 2,664.50 was received.

3. Summer Demonstrations

A total of 80 demonstrations including 50 demonstrations on mungbean (var. IPM 205-7 IPM 410-3) in Madhya Pradesh and 30 demonstrations (var. IPM 410-3) were conducted in Chhattisgarh. Farmers recorded yield advantage of 2.4 q/ha and 1.1 q/ha from demonstration plots and received ₹ 17,544.1 and ₹ 8,014.60 as economic advantage in Madhya Pradesh and Chhattisgarh, respectively.

Table 6. Details of *Kharif* demonstrations during 2021-22 under STC

Crop	Districts	Variety	No. of farmers	Farmer yield(q)	Demo yield(q)	Yield adv.(q)	Eco. Adv. @MSP
Pigeonpea	Dindori, Mandla Shahdol, Annuppur of Madhya Pradesh	Rajeshwari, Rajeev Lochan	175	7.63	11.36	3.72	23457.76
	Baster and Surgurja of Chhattisgarh	Rajeev Lochan	60	6.44	8.32	1.88	11829.72
	Total		**215**				
Urdbean	Barwani, Balrampu Dhar, Jhabua of Madhya Pradesh	PDU-1, PU-31, Pratap Urad 1	120	5.0	7.4	2.4	15273.3
	Bastar, Jashpur Kanker, Surguja Narayanpur of Chhattisgarh	PratapUrad 1, PU-31 Indira Urad Pratham	126	5.4	6.8	1.4	8858.8
	Total		**246**				

Table 7. Details of *Rabi* demonstrations during 2021-22 under STC

Crop	Districts	Variety	No. of farmers	Farmer yield (q)	Demo yield (q)	Yield adv.(q)	Eco. Adv. @MSP
Chickpea	Madhya Pradesh Annuppur, Barwani, Balrampur, Dhar Dindori, Mandla	JG 12 RVG 202 JG 36	286	8.6	12.4	3.8	19306.9
	ChhattisgarhDante wada, Korea	RVG 202 GNG 2144	75	5.1	7.2	2.1	10493.8
	Total		**361**				
Lathyrus	Jashpur district Chhatisgarh	Mahateora	31	4.0	4.8	0.8	2664.5
	Total		**31**				

Table 8. Details of demonstrations during 2021-22 under STC

Crop	Districts	Variety	No. of farmers	Farmer yield (q)	Demo yield (q)	Yield adv.(q)	Eco. Adv. @MSP
Mungbean	Barwani, Dhar districts of Madhya Pradesh	IPM 205-7 IPM 410-3	50	5.4	7.8	2.4	17544.1
	Kanker district of Chhatisgarh	IPM 410-3	30	5.3	6.4	1.1	8014.6
	Total		**80**				

Network Project on Impact for Assessment of Agricultural Technology

Network project on impact assessment of agricultural technology was initiated at Institute as one of the cooperating center (CC) while ICAR-NIAP, New Delhi is the lead center of the project. Two varieties of chickpea *viz*; and IPA-203 variety of pigeonpea were selected for impact assessment. Maharashtra, Madhya Pradesh and Rajasthan for chickpea and Uttar Pradesh for Pigeonpea were selected for study. Primary data collection with the help of survey schedule and focused group discussion was initiated from Fatehpur district of UP for pigeonpea crop. A total of 20 farmers cultivating the variety were interviewed and data was collected.

IIPR Regional Station, Phanda, Bhopal

A. Institute Funded Projects

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

Sub-project 1: Genetic enhancement of kabuli chickpea for higher productivity and wider adaptability and better quality

Breeding materials generated

F_1's were grown to obtain F_2 seeds for generation advancement and selection. New crosses were attempted and F_1 seeds were obtained using KAK 2, Kripa and JGK 5 and exotic collection (Gokcee, X016TR89, Flip07-6C-S1 and Flip09-191C) during *rabi* 2021-22.

Evaluation of advance lines

Sixty two breeding lines collected from different sources were evaluated and superior lines were identified as donor for higher yield [X016TR 85 (3641.7 kg/ha, X016TR 50 (3432.8 kg/ha), FLIP 07-191 C (3335.4 kg/ha) and X016TR 46 (3218.6 kg/ha) as compared to check var. KAK 2 (3163.0 kg/ha) and Kripa (2082.3 kg/ha); for larger seed size [FLIP09-346C (66.6 gm), FLIP 09-104C (64.7 gm), FLIP 11-01C (62.9 gm), ICCV 211404 (60.2 gm) as compared to KAK 2 (43.2 gm) and Kripa (58.5 gm) and for earliness [ICCV 181302 (95 days), ICCV 181316 (97 days), ICCV 181306 (100 days) as compared to check var. KAK 2 (119 days) and Kripa (121 days).

Promising entries for extra-large seed size in *Kabuli* chickpea

Sub-project 2: Development of high yielding genotypes of chickpea having combined resistance against drought and heat stress

A part of the project trial was conducted at IIPR, RS, Bhopal for multi-location evaluation of advance genotypes of chickpea. Twenty-three entries of chickpea were sown along with three checks (JG 16, JG 24 and Phule Vikram) in three replications in RBD design on November 10, 2022. The same set of entries were also sown late on December 20, 2022 under identical design. Observations of flowering initiation and early disease score were recorded for the early sown trial. Phenological, morpho-physiological agronomic and yield and yield attributes will be recorded for evaluating the entries to identify heat tolerant genotypes.

Multi-location trials of chickpea conducted at IIPR, RS, Bhopal

AICRP trial on Chickpea Drought Tolerant Introgression Line

A set of seven coded entries of chickpea were sown in three replications in the rain-out shelter. Germination was excellent and the crop is at flowering stage. Observations on germination, early seedling mortality and flowering were recorded. Phenological, agronomic and yield and yield attributing traits will be recorded as per the AICRP DTIL trial guidelines.

Screening of drought tolerant introgression lines under rain-out shelter

Chickpea evaluation trials

a) MHT chickpea (*rabi* 2022-23)

Twenty entries were sown along with three checks (JG 16, JG 24 and Phule Vikram) in three replications in RBD design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

b) Irrigated timely sown chickpea (*rabi* 2022-23)

Twenty entries were sown along with three checks (JG 16, JAKI 9218 and Phule G 0405) in three replications in RBD design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

c) Rainfed timely sown chickpea (*rabi* 2022-23)

Twenty entries were sown along with three checks (JG 16, JAKI 9218 and Vijay) in three replications in RBD design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

d) Preliminary yield trial of chickpea (*rabi* 2022-23)

Forty-two entries were sown along with three checks in augmented design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield will be recorded for evaluating the entries.

Sub-project 2: Genetic enhancement of pulses crop for different Agro-ecological zones: Mid-early/medium duration pigeonpea

Breeding materials generated

Three new crosses *viz*. TJT 501/Asha, TJT 501/ IPA 15-06 and IPA 15-06/Asha were attempted. The F_1 seed harvested from these crosses will be subject to purity test and genuine F_1's will be advanced for deriving the next generation. The crosses namely, UPAS 120/Pusa Arhar 16 and UPAS 120/ *C. Cajanifolius* were raised for generation advancement. Five F_2 population derived from crosses namely, TJT 501 x CoRG 9701, JKM 189 x CoRG 9701, Asha x UPAS 120, Rajeshwari x BDN 711 and BSMR 736 x Manak were raised. Single plant selections were made for plant type and maturity for generating F_3 progenies.

Breeding material of pigeonpea

Utilization of wild species of pigeonpea for the introgression of specific traits

Wild relatives of pigeonpea harbour useful alleles against biotic and abiotic stresses. Few accessions of *C. scarabaeoides* have shown consistent resistance to *Fusarium* wilt and *Phythopthora* stem blight. In addition, some accessions of *C. scarabaeoides* have exhibited tolerance to pod borer. Pre-breeding activities were initiated at IIPR, Kanpur for transferring useful genes into the cultivated genotypes. Wide range of variations was observed in the segregating generations derived from wild crosses. Pre-breeding in pigeonpea is targeted for incorporating trait specific alleles with minimal aberration in the phenotype of advance derived lines. This is being achieved through rigorous selection and intermating among early segregants. Intermating was also followed among rigorously selected trait specific early generation segregants. One hundred twenty wild derivatives of UPAS 120/*C. scarabaeoides* (ICP 15685) were obtained from IIPR, Kanpur and screened for plant type, maturity, seeds per pod and other yield attributing traits and single plant selections were made from these wild derivatives. Seed is being multiplied from the non-segregating and uniforms fixed lines for their evaluation against nematodes, Fusarium wilt and Phythopthora stem blight resistance in the sick plot nurseries established at ICAR-IIPR, Kanpur.

Evaluation of medium duration pigeonpea genotypes

A population of pigeonpea was derived through multi-parent cross involving BSMR 736, Asha, PKV Tara, Maruthi and JKM 189. Single plant selections were made for plant type, maturity, seed weight and advanced through selfing. One hundred two advance lines were obtained from IIPR, Kanpur for their evaluation at Bhopal. These genotypes were sown in augmented design with TJT 501, Rajeshwari and IPA 15-06 as checks. The genotypes with good yield along with desirable agronomic traits were selected. The productivity of these lines will be compared with checks for their inclusion in the station trials.

Multiplication of drought tolerant pigeonpea genotype

Twenty medium duration lines were evaluated in RBD with two replications under irrigated and rainfed condition for three years at Bhopal during 2014-2017. These genotypes were also evaluated at Kanpur under rainfed condition. Based on the multi-year and location data, IPAD 5 has shown potential as drought tolerant line as showed least reduction in yield under rainfed condition as compared to irrigated plot over the year and location. A set of four genotypes namely, IPAD 5, RVK 275, JKM 189 and BSMR 736 were sown in three replications under rain-fed condition. Observations are being recorded

on yield parameters for confirming the worth of IPAD 5 and RVK 275 as drought tolerant genotype suitable for cultivation central zone.

Maintenance of wilt resistant lines and their derivatives

A population was reconstituted from intermating among IPAC 68, BSMR 853, BSMR 736, Maruthi, WRP 1, KPL 43, IPAC 66, C 11 followed by open pollination and selection for three generations. One hundred forty resistant plants were selected from this population from the wilt sick plot of IIPR, Kanpur for advancing the generation. A set of 30 lines are being stabilized through single plant selection at IIPR, RS, Bhopal. The fixed lines will be evaluated under wilt sick plot for the identification of stable wilt resistance.

One hundred five fixed lines derived through pre-breeding were screened in the wilt sick plot of IIPR, RS, Bhopal. These lines were stabilized for wilt resistance for five generations through single plant selection in the wilt sick plot. A set of nine lines were evaluated in the replicated trial with susceptible check for three years. The fixed wilt resistance lines were also sown in replicated trial at IIPR, RS, Bhopal in 2022 for checking the uniformity and performance.

Demonstration cum crossing block

Sixteen released varieties *viz*. Pusa Arhar 16, Pusa 992, PA 291, UPAS 120, Rajeshwari, BDN 711, BSMR 736, JKM 189, CoRG 9701, TJT 501, Manak, GNP 2, Maruthi, TS 3R, Asha, Rajeev Lochan were grown for the purpose of demonstration. The other objective is to produce pure seeds and use it for crossing programme.

Multi-location trials of lentil

a) Sixteen entries received from ICARDA were sown along with two checks (IPL 534 and IPL 316) with two replications in RBD design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

b) Twelve entries received from ICARDA were sown along with two checks (IPL 534 and IPL 316) in four replications in RBD design. Germination was good and the crop is at flowering stage. Observations of flowering and early disease data were recorded. Phenological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

Multi-location trials of lentil

Mega Project 2: PGR management and utilization

Sub-project 1: Genetic resource management in chickpea

Two hundred genotypes were procured from IIPR, Kanpur to initiate the germplasm augmentation and evaluation at Bhopal. The genotypes were sown in augmented design with two checks. These genotypes are being characterised for different qualitative and quantitative characters.

Sub-project 2: Genetic resource management in pigeonpea

Thirty-one accessions of pigeonpea germplasm, collected from three districts of Madhya Pradesh and two districts of Chhattisgarh were characterized for quantitative and qualitative traits. Variation was observed for yield per plant and other yield attributing traits. The accession IC 637068 had the highest yield per plant followed by IC 637039 and IC 637034, whereas the lowest yield was recorded in IC 637045. High variability for 100 seed weight was recorded wherein IC 637029 showed maximum 100-seed weight followed by IC 637040 and IC 637045, whereas the lowest seed test weight was observed in IC 637079.

Sub-project 3: Plant genetic resource management and genetic improvement of grasspea for high yield and low-ODAP content

Breeding materials generated

Low ODAP varieties and exotic landraces were used to obtain F_1 seeds. F_1's were grown 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. One mutant line *viz*. GML 2016-6 (0.03%) of M_5 wasvalidated as low ODAP lines as compared to check variety Mahateora (0.04%) during 2021-22. Gamma/electron beam irradiated (BARC) grasspea mutants of M_1 generation with 5 treatments (200, 300, 400, 500 and 600 kgy) are also grown and characterized for germination and phenology during *Rabi* 2021-22.

Variation for chlorophyll content and flower colour in M_2 population in grasspea

Identification of unique genotype

A unique genotype IC 296745 was submitted for germplasm registration for larger seed size (15-16.8 gm/100 seed weight) with grey seed coat.

Maintenance and evaluation of germplasm

Ninety five germplasm were purified and evaluated during rabi 2021-22.

ICARDA global trials

Four trials received from ICARDA were conducted. 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 were evaluated during *rabi* 2021-22.

Maintenance of explored germplasm and seed multiplication

Forty-one accessions of various pulses, namely pigeonpea (2), chickpea (3), urdbean (20), mungbean (9) and *Vigna unguiculata* (7) were collected from Betul and Harda districts of M.P. in collaboration with ICAR-NBPGR. The seed were multiplied and submitted to ICAR-NBPGR by the coordinator of the exploration for obtaining IC numbers. A set of collected germplasm were sown in separate replicated trials with appropriate checks for their characterization, evaluation and seed multiplication.

B. Externally funded projects

1. DBT project on Characterization of Chickpea germplasm Resources to accelerate Genomics-assisted Crop Improvement

One thousand chickpea germplasm were grown in the late sown condition under heat stress condition to identify the heat tolerant genotypes. Promising genotypes namely,ICC 4410, ICC 6471, EC 267221, ICC 4409 & ICC 6462 were identified on the basis of filled and unfilled pods and climatic data.

2. ICAR-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 29 quantitative / qualitative traits (NBPGR descriptor) during *Kharif* 2021-22. Genotype IC 523649 for earliness (118-120 days) and genotype IC 634397 (21.0-25.8 gm/100 seed) for extra-large seed size with brown seed coat colour were submitted for germplasm registration. Genotype IC 468496 (18.2-20.7 gm/100 seed), IC 525757 (23.5 gm) and IC 525760 (21.1 gm) were also identified and validated as extra-large seed size as compared to check varieties. Promising genotypes IC 525385 (70 days) and IC 245484 (70 days) for early flowering; IC 245484 (132 days) and IC 407467 (139 days) for maturity; IC 525385(91.4), EC 109901 (95.4) for plant height; IC 523403 (19.2) for secondary branches; IC 523476 (882.8) for maximum number of pods per plant; IC 525760 (9.3 X 0.8) and IC 525757 (8.1 X 1.1) for large size of pods; IC 527763 (8.0), IC 525385 (7.0) and IC 553036 (7.0), IC 548263 (7.0) for number of pods per cluster; IC 525760 (6.0) and IC 525757 for maximum number of seeds per pod; IC 525757 (23.5 gm) and IC 525760 (21.1 gm) for 100-seed weight; IC 527832 (153.6), IC 523461 (112.6) and IC 527906 (110.8) for yield per plant were identified for further evaluation and validation as a donor in pigeonpea improvement programme.

Field view of pigeonpea germplasm for no. of seeds /pod and larger seed size

3. CSIR-NBRI sponsored programme on Bio-efficacy testing of the four formulations using chickpea as a host crop trials

In this project, formulations developed by CSIR-NBRI, Lucknow were evaluated in replicated trial.

4. ICARDA Project on Biodiversity for Opportunities, Livelihoods and Development (Grasspea)

A collaborative project was initiated in *rabi* 2022 to identify the superior genotypes of grasspea with the objective to develop and identify genotypes having earliness, high biomass and low ODAP. Three trials namely, IGYT-E 2022-23 (48 entries + local check Prateek in two replications); IGYT-HB 2022-23 (48 entries + local check Mahatewada in two replications) and IGYT-LO 2022-23 (48 entries + local check Mahatewada in two replications) comprised for Earliness, High Biomass, Low ODAP. In addition, a Segregating Population Progeny Nursery *viz.* GISPN 2022-23 comprised 9 populations and two local checks namely, Prateek and Mahatewada, was also sown. Germination was excellent and vegetative crop growth is very good. Traits pertaining to phenological, morphological, agronomic and yield and yield attributes will be recorded for evaluating the entries.

5. Contract research on bio-efficacy of bio-stimulant in chickpea

An agronomic trial is being conducted as a part of multi-location trial for the evaluation of bio-efficacy of bio-stimulant molecules during *rabi* 2022-23. Sixteen treatments comprising of five bio-stimulant products, namely seedfort, vikelp, nutriflax, converter and hortis are being tested in RBD with three replications. Observations on morphological, physiological and agronomic traits are being recorded.

C. Facilities for disease screening and development of wild garden

1. Development of wilt sick plot for lentil, chickpea and pigeonpea

With an aim to develop wilt sick plot for lentil and chickpea at Regional Research Station, Phanda, Bhopal, highly wilt susceptible varieties *viz*., L-9-12 and JG-62, respectively were sown in the respective plots. *Fusarium oxysporum* f. sp. *lentis* (Fol) culture was mixed with lentil seeds and sown. Observations on wilt incidence and confirmation of Fol and *F. oxysporum* f. sp. *ciceris* (Foc) presence in the respective plots as well as occurrence of other soil borne pathogens will be made. Pigeonpea wilt sick plot is also under development.

2. Maintenance of wild genera / species of pulse crops

Two hundred eighty five accessions of wild species of pulses crop are maintained at IIPR, RS, Bhopal in the wild garden

(a) Chickpea: 96 accessions of 8 annual *Cicer* species

(b) Pigeonpea: 128 accessions of 11 species belonging to genera *Cajanus* and *Rhynchosia*

(c) Lentil: 39 accessions of 04 species

***(d) Vigna*:** 18 wild accessions of 09 species

(e) Grasspea: 02 accessions of *Lathyrus cicera*

(f) Horse gram: 02 accessions *Macrotyloma africanum*

D. Seed production

Sub-project 1: Enhancing breeder seed production for increasing indigenous production of pulses in India

Breeder seed production was undertaken under BSP and EBSP during *kharif* and *rabi* 2021-22 at IIPR, RC, Bhopal. The detail or given in the following Table:

Table 1. Breeder seed production during 2021-2022

Crop	Variety	Target (DAC+EBSP) (q)	Seed produced (q)
Urdbean	IPU 13-1 IPU 11-2 IPU 10-26 IPU 2-43 Uttara	9.12 8.50 5.00 8.00 8.00	0.64 1.82 1.20 0.06 0.28
Pigeonpea	Rajeshwari	3.00	4.70
Fieldpea	IPFD 10-12 IPFD 12-2 IPFD 2014-2 IPFD 11-5	30.00 30.00 20.00 30.00	30.89 28.80 20.00 30.40
Lentil	IPL 316 IPL 534	32.00 7.50	54.00 7.20
Chickpea	IPC 2006-77	10.00	23.40
Total		201.12	203.39

Sub-project 2: Creation of seed hubs for increasing indigenous production of pulses in India

In the seed hub project, seed business license of the Institute and registration of seed processing plant were renewed with MPSSCA, Bhopal for quality seed production, certification and seed processing. The detail of seed production under seed-hub project is given in the following table.

Table 2. Quality seed production at Bhopal centre during 2021-22,

S.N.	Crop	Variety	Target (q)	Production (q)	Place of production
	Summer				
1	Mungbean	Shikha, Virat, Samrat	150.0	154.0	Nasrullaganj, Sehore, Harda and Bhopal districts
2	Urdbean	IPU 11-02, IPU 13-01, IPU 10-26, Uttara	150.0	-	Sehore and Bhopal districts
3	Pigeonpea	Pusa Arhar,16	100.0	109.0	Sehore and Bhopal districts
4	Fieldpea	IPFD 12-2, IPFD 10-12	100.0	130.0	Vidisha districts
5	Lentil	IPL 316	100.0	100.0	Sehore and Bhopal districts
6	Chickpea	IPC 2006-77, RVG 203, RVG 202	400.0	547.0	Sehore and Bhopal districts
	Grand Total		**1000.0**	**1040.0**	

Activities under seed-hub project tagged with Hon'ble Minister of Agriculture Shri Narendra Singh Tomar

E. Extension activities

1. Frontline demonstrations conducted at IIPR, RS, Bhopal

Fifteen FLD in chickpea, 10 lentil and 5 in pigeonpea and urdbean were given to IIPR, RS, Bhopal. These frontline demonstrations were executed in Bhopal and adjoining districts for the dissemination of new pulses technologies. The information on FLD's are given in the following table.

Monitoring of seed plot of seed-hub

Table 3. Frontline demonstrations conducted during 2021-22

Crop	No. of FLDS	Village	Variety
Chickpea	15	Padali, Mograram, Chitawliyahema, Phandakala, Konajhir, Shikarpur, Barwai,Amlaha, Naunikhedi, Amoda,	RVG 202
Lentil	10	Mahodiya, Vidisha, Nipaniyakala Padli, Naunikhedi, Amlaha, Raipur Nayakheda, Jahangirpura, Ranayal	IPL 316
Pigeonpea	5	Ichhawar, Padli, Phanda, Khadampur, Kanhasaiy, LasudiyaChhap, Kothari,	Pusa Arhar 16
Urdbean	5	Phanda, Bijlon, Patniya, Jharkheda,	IPU 2-43

2. SC sub plan

Three hundred 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. Knap sac sprayers (100) were distributed under SC sub plan in two phases on 25.03.2022 to 33 farmers and on 11.03.2022 to 67 farmers

3. IIPR Model Pulses village programme

Village Padli was adopted to develop as a model pulses village in Sehore district. Farmers' participatory seed production and frontline demonstrations were conducted to popularize and promote the new pulses technologies. SCSP programme was also conducted in this village.

4. Other outreach programme

The scientists of IIPR, RS, Bhopal visited farmer's field to monitor Seed Hub farmer's trials (Pigeonpea crop) in a village Raipur Nayakheda of Sehore District of M.P.

F. Participation in *Swachh Bharat* Mission and *parthenium* awareness week

G. Visit of dignitaries, farmers and trainees at IIPR, RS, Bhopal

1. Visit of Assistant Director General (O&P), ICAR at IIPR, RS, Bhopal on 07th Oct. 2022

Interaction of ADG (O&P) ICAR with scientists and technical staff

2. Visit of ADG (O&P) and Director, ICAR-IISR, Indore at IIPR, RS, Bhopal on November 12, 2022
3. Visit of Director IIPR, and State Govt. Officials of Odisha at IIPR, RS, Bhopal
4. Visit of Director, ICAR-IIPR, Kanpur at Regional Station Bhopal on October 17-18, 2022

Interaction of Director IIPR with the scientists

5. Visit of District Magistrate, Sehore, M.P. on the occasion of demonstration of application of Drone to the farmers of nearby districts on 11th May, 2022

H. Infrastructure development activities at IIPR RC, Bhopal

- *Kachcha* road of farm and pond were renovated.
- The basement of rain-out shelter was strengthened by soil filling.
- The field adjacent to rain-out shelter was levelled.
- Retaining wall near *tumda* gate was constructed.
- The extension of RCC approach road from main gate is under construction.
- Culvert on large pond is under construction.
- Stone pitching of drainage channel is under construction.

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

Crop Improvement

Plant Genetic Resources : Management and its utilization through pre-breeding

Cowpea

Cowpea germplasm (n=280) were rejuvenated and characterized for different yield and yield attributing traits during summer and *Kharif* season of 2022. Observations such as plant growth habit, days to 50% flowering, days to maturity, pod bearing type (pendate, erect), number of pods per plant, pod length (cm), number of seeds per pods, seed colour, seed eye colour, seed length, seed shape and test weight are recorded. Ample amount of variability was observed for all the traits studied (Table 1).

Evaluation of Cowpea germplasm lines

Table 1. Descriptive statistics for various quantitative traits

Descriptive statistics					
Traits	**Mean**	**Max.**	**Min.**	**STD**	**CV**
Days to first flowering	46.78	64.00	32.00	8.00	17.10
Days to 50% flowering	53.00	80.00	36.00	11.00	20.75
Days to maturity	80.00	98.00	66.00	8.00	10.00
Pod length	12.40	20.20	8.40	2.95	23.79
Pods /peduncle	2.00	4.00	1.00	0.75	37.50
Pods/plant	12.00	30.00	10.00	5.00	41.67
Plant height (cm)	124.50	195.2	40.20	38.75	31.12
Seeds/pod	12.00	20.00	7.00	3.25	27.08
Test weight	10.45	20.43	2.45	4.50	43.01

Variability for qualitative traits

Variability studies for qualitative traits such growth habit, leaf colour, flower colour, pod shape, pod attachment to peduncle, seed shape, seed colour, seed eye colour, seed length (mm) were also studied.

Identification of trait specific donors

Cowpea germplasm (n=280) lines were evaluated and characterized for some of the traits. Specific donors have been identified for some of the important traits (Table 2).

Horsegram

Total 240 accessions of horsegram germplasm were maintained and evaluated for different morphological traits during *rabi*/spring season 2021-22. Wide range of variations were observed for different quantitative traits. The entries such as TCR 1740 (82 days), IC 341310 (86), IC 71776 (87 days), IC 342973 (89 days), and TCR 1758 (89 days) were identified as early maturing genotypes of horsegram. More than 30 pods per plant were observed in the genotypes such as IC 45753, GPM 65, IC 19447, TCR 1740, TCR 1552, GPM 08 and IC 71754. The entries such as GPM 28, IK 1, GPM 49, CRIDA 18R and PHG -62 showed resistance reaction to yellow vein mosaic disease under natural field conditions (Table 2).

Table 2. Trait specific donors identified in horse gram germplasm

S.No	Traits	Promising accessions identified
1	Early maturity (< 90 days)	TCR 1740, IC 341310, IC 71776, IC 342973
2	Plant height (>60 cm)	Lone 2, KBHG 1, GPM 32, DHG 04, GPM 93, GPM 23
3	No. of pods/plant (> 30)	PHG 62, IC 45753, GPM 65, GPM 08, GPM 28, CRHG 7 GPM 65, TCR 1740, TCR 1520
4	100 seed weight (> 3.50 gm)	GPM 26, CRHG 5, GPM 22, TCR 1781
5	Seed yield/plant (>6 gm)	VLG 45, TCR 1805, TCR 1801, GPM 02, TCR 1740

Mungbean mini-core evaluation

Total 296 accessions of mungbean mini-core were rejuvenated and evaluated under alpha lattice design for qualitative and quantitative traits during spring-summer season. The entries screened for various diseases such as anthracnose, Cercospora leaf spot and powdery mildew. The entries such as VI001408 BG, VI001419 BG, VI001509 AG, VI002529 B-BL, VI003019 BG and VI004933 AG were found to be resistance to anthracnose and powdery mildew under natural field conditions.

Urdbean

Total of 210 germplasm accessions were evaluated for different morphological traits, during summer seasons by following augmented design. Under this PGR management trial, many trait specific accessions were identified some of them are reported here, early maturing genotypes were PRAGYA (60 days), ADT-5 and ADT-6 (62 days) PLU-416 (63 days) UPU 83-2 (64 days) and PLU 96-6 (64 days). Genotypes IC-8219, IPU 99-147, IPU 99-240, IC-427978 possesses (>7) seeds/pod. Genotypes IPU 99-10, IPU 99-232, IPU 99-147, Pant U-35 and No-40 showed (>20) pods/plant. Hundred seed weight (>5 gm) were observed in genotypes IC 56048 (6.9 gm), Mukundra1 (5.6 gm), SPS 30 (5.5 gm), PDU 19 (5.45 gm) and IPU 99-79 (5.4 gms).

Urdbean: Biofortification trial

Germplasm accessions (n=120) were evaluated for seven different morphological traits and disease resistance during *Kharif* seasons. The trial was sown in an augmented design with three checks *viz*., IPU 94-1, IPU 02-43 and IPU 13-1. Screening for diseases such as *Cercospora* leaf spot and *Anthracnose* were carried out.

Pre-breeding garden

Total 26 wild *Vigna* wild species such as *V. umbellata, V. aconitifolia V. trilobata, V. stipulacea Vigna dalzelliana, Vigna glabrescence, Vigna hainiana, Vigna pilosa, Vigna sublobata, Vigna sylvestries, Vigna trinervia var.bourbeae, Vigna vexillata* and *Vigna luteola* were rejuvenated and evaluated for different traits during spring-summer season. They were also used in the interspecific hybridization crossing programme.

Genetic enhancement of pulse crops for yield, stability and quality

Evaluation of advance breeding lines of pulses

Cowpea: Advance breeding lines (10) derived from different crosses were evaluated during Summer season. Among them, genotype IPCW 20-202 (1125 kg/ha), IPCW 20-204 (1098 kg/ha) and IPCW 20-209 (1060 kg/ha) were found to be promising entries compared to checks DC-15 (940 kg/ha) and DCS 47-1 (960 kg/ha). These entries will be contributed to state trials / AINP on arid legumes for testing under MLTs.

Chickpea: Four station trials of chickpea (Mechanical harvesting trial, rainfed trial, G x E trial and *Kabuli* trial) and two preliminary yield trials of chickpea were evaluated for seed yield and component traits during *rabi* season.

a) Station trial-I (Mechanical harvesting): Twenty three entries of chickpea were evaluated in RBD design during *rabi* season. Promising entries of chickpea such as IPC-20-84 (>52 cm plant height, grain yield 2745 Kg/ha), IPC 18-80 (>49 cm plant height, grain yield 2628 Kg/ha) and IPC 18-87 (Plant height 54 cm. grain yield 2556 kg/ha) were found to be suitable for mechanical harvesting compared to

check GBM-2 (2364 kg/ha).

a) Station trial-II (Genotype x Environment) : Total 23 entries were evaluated during *rabi* season. The entries such as IPC 2020-143 (2960 kg/ha) and IPC 2020-94 (2781 kg/ha) were recorded higher grain yield compared to checks JAKI 2745 (2745 kg/ha) and JG 11 (2340 kg/ha) and SA 1 (1917 Kg/ha).

b) Station trial-III (Trait specific): Twenty entries of chickpea with three checks were evaluated during rabi season. IPC 20-199 (2585 kg/ha), IPC 19-229 (2460 kg/ha) and IPC 20-213 (2419 kg/ha) produced higher grain yield compared to JG 11 (2307 kg/ha), JAKI (2238 kg/ha) and SA-1 (1856 kg/ha).

c) *Kabuli* chickpea trial: seventeen advanced breeding lines with three checks were evaluated during *rabi* season. The entries such as IPCK 20-189 (2627 kg/ha) and IPCK 18-185 (2500 kg/ha) were found to be promising for cultivation in southern region.

d) Preliminary yield trials (PYT): In preliminary yield trial-I, 36 advanced breeding lines with three checks were evaluated in augmented design. IPC 21-25 (3494 kg/ha) and IPC 21-24 (3120 kg/ha) were the top yielders compared to check JG 11 (2330 kg/ha). In preliminary yield trial-II (adoptive trial) total 54 entries were evaluated for different traits during *rabi* season. IPC 20-159 (3058 kg/ha), IPC-19-244 (3000 kg/ha) and IPC 20-73 (2900 kg/ha) recorded higher seed yield compared to JG 11 (2500 kg/ha).

e) Special trial: In DTIL trial, total 13 entries were evaluated under rain out shelter during *rabi* season.

Evaluation of advance breeding lines of chickpea

Promising entries in state MLT:

Promising entries of chickpea (in Desi, IPC 18-59, IPC 17-292, IPC 19-222 and in kabuli IPCK 20-190 and IPCK 18-185) , mungbean (IPM 14-10, IPM 1205-2, IPM 1604-1) and urdbean (IPU 19-202, IPU 18-228, IPU 18-217, IPU 19-227, IPU 19-223 and IPU 18-212) were put to state multi-location trial (MLT) to assess their suitability for cultivation in different agro-climatic zones of Karnataka.

Generation of breeding material in pulses

Cowpea: Total 13 fresh crosses were attempted for incorporation of traits such as earliness, erectness, determinate habit, pod, seed traits, drought tolerance and resistance to foliar diseases such as rust, CMV; root rot and pests viz., pod borer, aphids, bruchid resistance, and grain yield into locally adopted varieties/promising breeding lines. The list of fresh crosses attempted were DC-15 x GC-3, DC-15 x PL1/PL2, DC-15 x RC 101, PL-4 x RC 101, Goa cowpea 3 x RC19, RC 101, DC-15 x ITK-499-35, DC-47-1 x GC-3, Goa cowpea 3 x PL1/PL2, DCS 47-1 x RC 101, DCS 47-1 x RC19, DCS 47-1 x IT97K-499-35, KBC-9 x GC-3, KBC-9 x PL1/PL2, Goa cowpea 3 x IT97K-499-35 and Crosses involving donors such as Jammu Lobia Super 60, TC901, PL-1, PL-4, EC-723909, Pant Lobia-7, KBC-12, CPD-119 and Co-7 were crossed with DC-15 and DC 47-1 has resulted in production of more than 280 F_1 seeds. Interspecific cross was attempted with *Vigna vexillata* for pest and disease resistance.

Selection of promising genotypes from segregating population and generation advancement

Cowpea: More than 230 SPS belonging to >25 crosses and >150 F_5 bulk have been developed. They will be further advanced, evaluated for different yield and yield traits. SPS were selected for different yield attributing traits they will be maintained and advanced for further multiplication and testing.

F_2 population: Crosses DC 47-1 x RC 101, DC 15 x RC 101, DC 47-1 X EC 47252, DC 15 x EC 47252, KBC 9 x RC 101, DC 47-1x C152, DC 15x C 152, KBC 9 x EC47252, DC 15 x RC 101, were raised and SPSs are made for generation advancement.

F_3 population: KBC 9 x PL 4, Co 2 x RC 101, RC 19 x RC 101, KBC 9 x RC 19, KBC 9 x ITK 499-35, RC 101 x Co2, Goa cowpea x ITK 499-35, were raised and SPSs are made for generation advancement.

F_4 Population: Belonging to seven different crosses such as, PL 4 x PL 3, GP 11 x PL 4, GP 60 x GP 7, EC

724615 x PL 4, Goa cowpea 3 x RC 101, PL 4 x GP 65 and RC 101 x Palm yard bean, were advanced and selected >200 SPS.

F6 Population: Selection from crosses PL-5 x PL-4, DCS 47-1 x Co-2, DC-15 x Co-2, GP-40 x GP-27, NB-4 x Alasando-1, DCS 47-1 x Co-6, PL-3 x PL-2, DC-15 x Co-4, GP-36 x GP-1 are in F_6 generation.

F_7 Population: Selections from crosses DC 47-1 x RC 101, DC 15 x RC 101, DC 47-1 x PL2, KBC 9 x RC 19, DC 15 x PL_2, KBC 9 x RC 101

The superior stabilized lines with high yielding ability and resistance to pest and diseases will be tested under station trials for contribution to state/AINP MLTs.

Horsegram: Fresh crosses (10) were generated in horsegram which involves donor lines with earliness, resistance to YMV, dry root and powdery mildew diseases (GPM 06 x Sabri Kulthi (BSP 17-3), GPM 06 x Chhattisgarh Kulthi 2 (BWH 1), GPM 06 X VLG 10, GPM 06 X GDH 1, CRIDA 1 -18R X GDH 1, CRIDA 1-18R X VLG 10, GPM 33 x Alakh Kulthi (BSP 17-1), GPM 33 x CRIDA 18R, TCR 1740 X Bilas Kulthi 15-1, VLG 10 x CRIDA 1-18R). 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.

Chickpea: Total 30 new crosses (IPC 18-55 x BGM 10216, JG 24 x IPC 18-80, JAKI 9218 x BGD 9971, IPC 2011-112 x BGD 9971, HC 5 x IPC 20-198, IPC 10-62 x IPC 10-121, IPC 10-121 x IPC 05-28, IPC 10-121 x IPC 05-28, JSC 37 x IPC 05-28, IPC 10-62 x ICC 8397) for different traits (Mechanical harvesting, Earliness, Wilt resistance, Dry root rot resistance, and high protein content *etc.*) were generated in chickpea during the off-season.

Urdbean: Ten crosses of belonging to photo-thermo insensitivity, heat tolerance (06 crosses) and drought tolerance (15 crosses) are in F_7 generation. 21 crosses belonging to different yield traits and multi parental crosses (09) are in F_6 generations. These lines have been stabilized and selected SPS based on yield performance coupled with resistance to pests and diseases. Many SPS were selected for resistance to foliar diseases such as *Anthracnose, Cercospora* leaf spot and powdry mildew resistance; they will be evaluated over the years and locations to confirm the resistance.

Off-season generation advancement of pulses

The chickpea breeding materials for off-season generation advancement received from various AICRP centres such as Junagadh (19), PAU Ludhiana, (170), Sriganganagar (5), Jabalpur (09 lines), Jhansi (7), Bijapur (76) and IIPR, Kanpur (50) during *kharif* 2022. The generation advancement was performed during the *Kharif* season and advanced breeding materials were sent to the respective AICRP chickpea centres. Segregating lines of Lentil (n=296) developed from IIPR, Kanpur, were advanced from F_4 generation to F_5 generation during *Kharif* 2022.

National off-season nursery of chickpea generation advancement

Evaluation and multiplication of collections collected from the germplasm exploration.

Collections (n=14) landraces were studied. Variation were observed for 25 different qualitative and quantitative traits. Spreading and indeterminate type, Pink coloured flowers, medium curved pods, concave pod shape, Green pod colour, Stringed pod types, pigmented pod, brown kidney shaped seed with testa variegation characters were found to be predominant. Genetic variability was observed for maturity duration ranging from (56-120 days), plant height (26.5 - 80.2 cm), number of primary branches varied from (2-4), no. of pods per plant (2.6-8.4), No. of seeds per pod (3.0-7.5), pod length ranged from (6.2 – 11.5 cm) and 100 seed weight (18.0-42.39 gm). Some of the early flowering type collections may be used in breeding programme for breeding for earliness.

Breeder/TL Seed Production

Total 600 kg of breeder seeds of mungbean cv. IPM 2-14 and urdbean cv. IPU 2-43 were produced during summer. TL seed production of chickpea varieties (JG 11/SA 1) were done during *rabi* and produced seed yield of about 350 kg. In horsegram, variety CRIDA-18 produced seed yield of 400 kg during *rabi*.

CROP PRODUCTION

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. The rabi Sorghum was sown on 11th November 2021 and harvested on 2nd March 2022, whereas chickpea was sown on 14th November 2021 and harvested on 12th February 2022. The crop season rainfall that fell during crop growth of chickpea and *rabi* sorghum was 151.4 mm during winter season of 2021-2022. During 2022, 1090.8 mm rainfall was received and it was higher by 45% over 36 years (1985-2021) mean rainfall of 752.0 mm. Mungbean and maize were sown on 7th June 2022 with an antecedent rainfall of 25.4 mm that fell from 28th May to 6th June 2022. The crop season rainfall was higher for mungbean (342.3 mm) and maize (572.6) mm.

The grain yield of winter sorghum and water use efficiency (WUE) were higher by 32% in T8 with application of 100% recommended rate of fertilizer (RRF) along with seed treatment of Microbial Consortia and application of $ZnS0_4$ and $FeS0_4$ at 25 kg ha over the farmers' practice of *rabi* sorghum cultivation (T1) during winter 2021. Higher grain yield in sorghum in T_8 was attributed to better plant growth with higher values of yield components i.e. earhead weight and seed weight plant, 1000 seeds weight. The straw yield of *rabi* sorghum increased by 24% (37.2 q ha) in T_8 over farmers' practice (30.01 q ha). Higher straw yields in T_8 were attributed to better root and plant growth with greater root weight (10.24 g/plant) over farmers' practice. The treatment T8 produced higher net returns by 63% (₹ 40,967 ha), B:C ratio by 17% (2.02) and energy use efficiency by 3% (16.40) over control (₹ 25,044 ha, 1.73 and 15.91, respectively).

The treatment T_8 with 100% RRF *i.e.* 25:50 N:P kg ha along with seed treatment of Microbial Consortia and 0.5% spray with $ZnSO_4$ and $FeSO_4$ at flowering recorded a significantly greater chickpea grain yield of 2362 kg/ha and WUE of 6.92 (kg/ha/mm) and was higher by 35% over farmers' practice (1744 kg/ha and 5.11 kg/ha/mm). The higher grain yields with T_8 are attributed to higher values of yield components *i.e.* number of pods/plant, pods weight, and seed weight/plant-1. Even the straw yield was higher by 34% (1856 kg/ha) in T_8 over farmer's practice (1383 kg/ha). Higher yields of *rabi* sorghum and chickpea in T_8 were attributed to better utilization nutrients and soil moisture over other treatments.The treatment T_8 produced higher net returns by 52% (₹ 65,923 ha), B:C ratio by 16% (2.43) and energy use efficiency by 6.7% (11.96) over control (₹ 43,380/ha, 2.10 and 11.21, respectively)

The higher crop season rainfall for mungbean especially in July 186.4 mm resulted in water stagnation and lower crop growth and yield in mungbean. The treatment T_8 with 100% RRF *i.e.* 25:50 N:P kg/ha recorded significantly 62% greater mungbean yield of 250.1 kg/ha over farmers' practice (154.5 kg/ha). Higher grain yield in T_8 are due to higher values of yield components i.e. number of pods/plant, pods weight/plant, and seed weight plant. Straw yield was higher by 79% (4.78 q/ha) in T_8 over T_1. Higher crop season rainfall with lower grain yield of mungbean in 2022 produced lower WUE in T_8 (1.18 kg/ha/mm)and was higher than T_1 (0.73 kg/ha/mm). Treatment T_8 recorded 43% higher B:C ratio (0.80) over T_1 (0.56).

The maize grain yield and WUE increased by 48% in T_8 over T_1 during *kharif* 2022. Higher yield in maize in T_8 was attributed to better plant growth with higher yield component values *i.e.* cobs weight, seed weight plant, 100 seed weight & total dry matter production/plant. Straw yield of maize was higher by 42% (6029 kg/ha) in T_8 over T_1 (4259 kg/ha). Higher yields in T8 were attributed to better root & shoot growth with higher values of yield components over T_1. Treatment T_8 recorded 24% higher B:C ratio (2.24) over T_1 (1.80).

Effect of soil and foliar application of zinc and iron in chickpea in Vertisols of Dharwad, Karnataka

A field experiment was conducted to assess the effect of iron and zinc nutrition on growth and yield attributes of chickpea (*Cicer arietinum* L.) during rabi 2021-22 at the Research farm of IIPR Regional Research Station, UAS Campus, Dharwad, Karnataka. The experiment consisted of five treatments *viz.*, Control, Application of 50 kg DAP/Application of 50 kg/DAP+ Soil application of Feand Zn at 25 kg/ha, Application of 50 kg/ha DAP+ Foliar spray at 5% of Fe and Zn at flowering, and Application of 50 kg DAP/ha Soil application of Feand Zn at 25 kg/ha+ Foliar spray at 5% of Fe and Zn at flowering with four replications. The results of experiment indicated that growth and yield parameters *viz.*, dry matter accumulation per plant, number of branches per plant, number of root nodules per plant, test weight of seeds and seed yield per ha increased significantly with application of 50 kg DAP/ha + Soil application of Fe and Zn at 25 kg/ ha+ Foliar spray at 5% of Fe and Zn at flowering. The increase in seed yield was around 38% with application of 50 kg DAP/ha + Soil application of Fe and Zn at 25 kg/ha+ Foliar spray at 5% of Fe and Zn at flowering over control being adopted by farmers in the region.

Table 3. Effect of soil and foliar application of iron and zinc on growth, yield parameters and seed yield of chickpea

Treatment	Number of nodules per plant	Total Dry Matter (g/plant)	Number of branches	100-seed weight (g)	Seed yield (kg/ha)
Control	21.8	19.89	2.37	19.78	1094
Farmers, practice	23.4	22.60	2.58	20.65	1236
Application of RRF + Soil application of Fe and Zn at 25 kg/ha	24.2	23.95	2.37	21.40	1310
Application of RRF + Foliar spray at 5% of Fe and Zn at flowering	24.9	23.94	2.41	21.91	1374
Application of RRF through DAP + Soil application of Feand Zn at 25 kg/ha + Foliar spray at 5% of Fe and Zn at flowering	26.3	25.95	2.41	21.97	1512
LSD at 5%	NS	3.35	NS	NS	246

Farmers Practice-Application of 50 kg DAP per ha

CROP PROTECTION

Evaluation of mungbean minicore set and germplasm lines against yellow mosaic disease

A total of 296 mungbean minicore set and 90 germplasm lines were evaluated against mungbean yellow mosaic virus (MYMV) during summer season 2022. Among which 12 entries of mini-core namely, VI002012BG, VI002274B-BL, VI002529B-BL, VI003470BG, VI003725BG, VI003734B-BR, VI004145B-BLM, VI004789-BG, VI004973B-BLM, VI005022BG, VI005024B-BL and VI005030BY and seven entries of mungbean germplasm namely, AVMU 1688, AVMU1563, AVMU1653, AVMU1690, AVMU1689, AVMU1688 and AVMU1676 were identified as resistant for MYMV. Disease severity and incidence ranged from 0-100%.

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

A total of forty entries were evaluated against PM resistance under natural conditions. Observations were recorded during flowering and podding stage of the crop. Out of 40 entries, three entries GP 1, VCP 18-013 and PGCP 20 were identified as resistant and seven entries namely, PGCP 73, IPCP 18-12, KBC-9, DC 5, DC 15, Pant Lobia 3 and Pant Lobia 4 were identified as moderately resistant against powdery mildew. Rest of all the entries showed susceptible to highly susceptible reaction against powdery mildew disease. Per cent disease index was ranged between 1.1 and 100%.

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

A total of fifteen entries were evaluated against powdery mildew disease. Observations were recorded during flowering and podding stage of the crop in which, none of the entries were showed resistant reaction. However, two entries VLG 54 and VLG15 were moderately tolerant to PM and per cent disease index was ranged between 53.3 and 100%.

Horsegram screening against PM disease

Evaluation of pigeonpea genotypes against sterility mosaic disease

A total of 184 entries were evaluated against SMD disease by leaf stapling technique under field

conditions. Among which, 43 entries namely,BDN 711, BDN 2013-2, BDN 2013-5, IPAL 20-1, IPAL 20-24, IPA 19-26, MAL 53, IPA 15-21, IPA 19-43, IPA 19-6, IPA 14-6, IPA 18-8, IPA 19-45, IPA 14-2, IPA 19-42, IPA 18-4, IPA 15-19, IPA 7-2, MAL 13, MA 6, BRG 1,-3,-4, -5, BSMR 175, BWR 246, BWR 853, BWR 553, BWR 316, BSMR 1, BWR 164, BWR 254, BWR 153, ICPWS 1930,-39,-38, -25, -16, -11, -19, -14, -12 and 27 were identified as resistant. Seventeen lines namely, CRG 16-12, ICPIL 17103, NAM 151, RVSA 2020-6, RVSA 2020-8 , LRG 275, WRG 391, CRG 18-007, GJP 1915, IPA 15-1, IPA 18-33 and KA 19-05, BSMR 164, BSMR 79, BSMR 736, BSMR 2 and BWR 133 were identified as moderately resistant. However, susceptible check showed 100% disease incidence and disease incidence in test entries was ranged between 0 and 100%.

Management of major diseases of mungbean by new fungicides

Efficacy of eight fungicides (Hexaconozole5EC, Difenconazole25EC, Thiophanate-Methyl 70% WP, Tebuconazole 50% + Trifloxystrobin 25% WG,Fluopyrum 7.6% + Tebuconozole 17.6% w/v, wettablesulphur 80WP, Azoxystrobin (20% W/V)+Difenoconazole (12.5% W/V) and Carbendazim 50 WP) were evaluated against powdery mildew disease under field conditions. Among which, Two fungicides *viz*., Fluopyram 17.6%+Tebuconazole 17.6% or Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V) at 0.1% were found effective for Powdery mildew and leaf spots disease management and increased mungbean yield up to 41.2 and 36.1, respectively. More than 96 per cent of powdery disease severity reduction was observed with the above fungicides.

Estimation of yield losses due to foliar fungal diseases of mungbean (Var. IPM 2-14)

The experiment was carried out to assess avoidable economic loss to farmers due to foliar diseases namely, Cercospora leaf spot (*Colletotrichum truncatum*), Antracnose (*Colletotrichum truncatum*) and powdery mildew (*Erysiphe polygoni*) during *kharif* season 2021-22. A fungicide Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V) was used as check, which is effective against *Cercospora, Anthracnose* and powdery mildew disease. Three foliar sprays of fungicide 0.1% at 10 days interval reduced *Cercospora, Antracnose* leaf spot and powdery mildew disease severity to the tune of 60.7, 39.3 and 98.4 per cent respectively. Reduction in yield loss was 32.7, 35.1 and 52.9 per cent in single, two and three sprays of fungicide, respectively. Three sprays of fungicide Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V) resulted in the highest benefit cost ratio of 1:2.3. Loss of additional returns of ₹ 33,523/- per hectare can be avoided.

Estimation of yield losses due to powdery mildew disease of horsegram

The experiment was carried out to assess avoidable economic loss to due to powdery mildew (Erysiphe polygoni) disease during *kharif* season 2021-22. A fungicide Azoxystrobin (20% W/V) + Difenoconazole (12.5% W/V) was used as check, which is effective against powdery mildew disease in many pulse crops. One, two and three foliar sprays of fungicide 0.1% at 10 days' interval immediately after appearance of disease reduced powdery mildew disease severity to the tune of 85.8, 98.8 and 100 per cent, respectively. Reduction in yield loss was 28.5, 32.9 and 34.9 per cent in single, two and three sprays of fungicide, respectively.

Incidence of emerging insect pest cowpea seed moth *Cydia ptychora* (Lepidoptera: Tortricidae) and its natural enemies.

Cowpea seed moth, cydia ptychora is an emerging pest problem during *Kharif* season in the transitional belt districts of Northern Karnataka. It is a post-flowering pod borer and its peak activity was observed during August to November. The female moths of *C. ptychora* oviposit on senescent sepals and prefer young or maturing pods. Upon hatching, larvae enter the pod and feed on the maturing seeds. In each pod on an average, 2-4 larvae were recorded. The pod damage and seed damage in cowpea was around 47.11 % and 52.67 %, respectively. Among the natural enemies, two larval parasitoids of Braconid wasp were found to parasitize the pod borer larvae to the extent of 33.3 to 75 %.

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. There was no significant difference in the incidence of sucking pests like whitefly and jassids in mungbean (IPM 2-14) crop sown at three different sowing dates. The average YMV disease in IPM 2-14 was around 0.20% as compared to susceptible check variety DGGV-2 (42. 33%). Highest incidence of YMV disease (47.66%) was recorded in DDGV-2 sown in second fortnight of March.

Effect of different intercrops on incidence of major insect pests in cowpea

During *Kharif* season, the sole cowpea and cowpea intercropped with nine different intercrops (3:1) without any control measures was found highly susceptible and infested with the cowpea seed moth *Cydia ptychora*. The per cent pod damage by the pest was around 86.57-95.25 and the per cent seed damage was around 54.33-66.67 in different treatments.

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

In cowpea, 16 advance lines were evaluated against pod borer during *Kharif* season. All the lines were found susceptible to pod borer and the pod damage ranged between 67-100%. Five lines of cowpea were infested with few individual black aphids and the scale rating was 1.

In urdbean, 48 entries were evaluated against pod weevil and pod borer during *Kharif* season. The number of adult pod weevil/plant ranged between 1.2 and 7.20. Out of 48 entries, the lowest pod weevil less than 2 adults per plant was recorded in 11 entries. The per cent pod damage by weevil ranged between 14.19 and 100. The lowest (less than 20%) pod damage was observed in three urdbean entries (UKE-22-36, UKE-22-22 and UKE-22-14).

EXTENSION ACTIVITIES

FLDs and visits to farmers' fields

Total ten FLDs on chickpea and eight FLDs on cowpea and horsegram, and four FLDs on mungbean were conducted in different farmer's fields of Narendra, Rayapur, Sangreshkoppa, Harikoppa, Yettinagudda, Mangalgatti of Dharwad district during summer seasons. The scientists visited the fields of pulse growing farmers during different seasons and interacted with them.

Implementation of SCSP Programme in Dharwad District

Under SCSP programme, selected total 87 beneficiary farmers from 9 cluster villages of Dharwad, Belgaum and Gadag Dists. Various farm inputs like, seeds (Chickpea, Fodder sorghum), Biopesticides, plant specific nutrients, Medicines & mineral mixtures for animals, sex pheromone traps with nano lure, cycle weeder, sprayers, small farm tool kit, feeding turf set, improved poultry chicks, cow mat were distributed to the beneficiaries.

Distribution of farm inputs to beneficiaries

Two animal health camps were conducted under SCSP program on 02.2.2022 and 25.3.2022 in Lokur and Shrirur villages of Dharwad district in collaboration with KVK, Dharwad and officials of State Animal Health Dept., GoK. Farmers participated in the camp with their farm animals and health checkup and treatment was given to more than 150 different animals for various animal health related problems

Farmers field day on pulses

Field Day on Pulses was conducted on Feb 15, 2022 at Shirur village in Navalgund Taluk of Dharwad district under SCSP Programme. More than 50 farmers participated in the programme. Disseminated about improved pulse varieties of IIPR, low-cost technologies for pulses cultivation to farmers. Emphasis was made on adoption of IIPR-Mini *Dal* mill for post-harvest processing of pulses for *Atmanirbhar*.

Technology demonstrations in Pulse Model Village

Demonstrations on improved technologies in chickpea, horsegram were conducted during *Rabi* season in pulse model village, Narendra in Dharwad Dist. On an average, there was 15% yield increase in chickpea, and 20% in horsegram as compared to farmers practice. Promoted cultivation of mungbean and cowpea during summer season in Pulse Model village, and seeds of mungbean (cv. IPM 2-14) and cowpea (DC 15) were distributed to farmers.

Scientific staff members visited different farmers' fields of Narendra village and interacted with the pulse growing farmers and advised the farmers.

Popularization of IIPR-Mini *Dal* mill

Demonstration on "IIPR Mini *Dal* Mill for pulse processing" was conducted to 22 farmers of NGO, SCOPE, and FPO Krishijyothi from Kalaghatagi and Navalgund taluks of Dharwad Dist. on June 10, 2022. IIPR mini *Dal* mill" for pulse processing and value addition was popularised among the pulses growing farmers of Dharwad Dist. A leaflet/pamphlet on IIPR

mini *Dal* mill in local language was distributed to the farmers for awareness.

Demonstration of IIPR Mini *Dal* Mill to Farmers

Dissemination of IIPR Technologies to KVK Heads of Southern Zone

Information on improved technologies of IIPR and Mini *Dal* Mill was given to 50 KVK, Heads from Karnataka, Kerala and Lakshwadeep on June 22, 22 during KVKs Zonal Workshop 2022 held on 19th June 2022 at UAS, Dharwad. A lecture was delivered to participants on "Role of pulses in Integrated Farming System" and "Demonstrated use of IIPR Mini *Dal* Mill for pulse processing."

Participation in *Krishi Mela*

IIPR-RRS participated and displayed IIPR technologies during KVKs Zonal Workshop 2022 held on 19th June 2022 at UAS, Dharwad. Hon. Central State Minister for Agriculture and Farmers Welfare, Smt. Shobha Karandlje, Agril. Minister of Karnataka, Shri BC Patil, other Ministers from Karnataka State, Hon. VC, UAS, Dharwad, KVK Heads from Karnataka, Kerala and Pondicherry and other officials visited the IIPR stall.

IIPR-RRS participated and displayed IIPR technologies during *Krishi Mela* organised by UAS, Dharwad from 17-20, Sept, 2022. Extension folders and leaflets on improved varaities of IIPR and mini *dal* mill; were distributed to visiting farmers and other officals in *Krishi Mela*.

***Kisan Mela* at UAS, Dharwad**

IIPR-RRS, Dharwad participated in *Kisan Mela* organised by KVK, Dharwad on the occasion of *Kisan* Bhageedari Prathamikata Hamari Programme at Dharwad on April 24, 2022. Displayed various improved technologies of IIPR. More than 100 farmers visited the stall and some interested farmers also visited the pulse crops field in RRS farm.

Kisan Mela at KVK Dharwad

Visitors to RRS

- Dr. Venkatsubramnian, Director, ATARI, Bengaluru visited the research farm and interacted with the staff members of IIPR-RRS, Dharwad station on April 23, 2022.
- On the occasion of *Krishi Mela*, the progressive farmers from Gadag, Belagavi and Dharwad visited the research farm on April 23, 22 and interacted with staff members on use of IIPR-Mini *Dal* mill.
- Dr. C.P. Nath, Scientist from IIPR Kanpur visited Dharwad from June 8-10, 2022 for physical verification of permanent and consumable items of IIPR-RRS, Dharwad.
- Fifty KVK Heads from Karnataka, Kerala and Lakshwadeep visited RRS, Dharwad on June 22, 2022
- Dr. Bansa Singh, Director, IIPR, Kanpur visited RRS, Dharwad to review research activities and developmental works from October 2-5, 2022.
- AICRP arid legume monitoring team from RARI, Duragura visited the centre on 19th October, 2022.

ICAR- IIPR, Regional Centre, Bikaner

Project : Genetic enhancement in arid pulses for abiotic and biotic stresses: Mothbean and Cowpea

Mothbean

In *Kharif* 2022, 75 mothbean accessions procured from ICAR-NBPGR, RRS, Jodhpur and evaluated under the hot and arid climate at RRC, Bikaner, Rajasthan, to estimate the presence of genetic variability and to identify suitable donors in augmented design. Data were recorded on 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-14148 take only 29 days to flowering compared to the check varieties (33 days). While accessions IC 329037, IC 329040, IC 370467, IC 402283 and IC 402290 were also identified as early types. Accessions IC 8891A, IC 9103, IC 21064, IC 140663, IC 370467 and IC 35928 were exhibited yield advantages over the check varieties.

Creation of variability in mothbean

A. Hybridization

1. With emasculation a total of 10 crosses were attempted but the seed set was 0%.
2. Without emasculation, a total of 25 crosses were attempted and the seed set was 32%.

B. Mutation

Two mothbean varieties (RMO 225 and RMO 435) were selected for mutation breeding and irradiated at different doses (100Gy, 200Gy, 300Gy and 400Gy) of gamma radiation. The treated seed was sown with the check and harvested individually for further advancement.

Cowpea

Evaluation and advancement of cowpea segregating material

The segregating material of F_4 and F_6 generations of cowpea evaluated under arid climatic condition at RRC, Bikaner. In F_4 generation, 190 SPP were evaluated and promising single plants were selected and in F_6 generation, 200 individual lines were evaluated and harvested separately for further advancement and evaluation.

Fig. 1: Field of cowpea segregating material

Sub Project: Enhancing input use efficiency and productivity of pulses in arid ecosystem

Tillage, residue and nutrient management in different cropping system under arid ecosystem

A field experiment was started during *Kharif* 2020 to study the different cropping systems under conservation agricultural practices in arid ecosystem. The experiment was conducted under split plot design with three replications. Main plot consists of three 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.* Pearlmillet-chickpea and clusterbean - mustrad and two levels of nutrient management in sub-sub plot viz. 100% recommended dose of fertilizer (RDF) for both *Kharif* and *Rabi* crops and 75% recommended dose of fertilizer (RDF) for both kharif and rabi crops. The result reveales that grain yield of component crops were not significantly influenced under tillage management options and recorded maximum under CT-CT followed by CT-ZT and ZT-ZT, respectively. However, the increase in grain yield was significant under cropping systems and recorded significantly higher in clusterbeanmustard system as compared to pearlmillet-chickpea system. Among nutrient management options, 100% RDF recorded significantly higher yield of the component crops over 75% RDF in the first year. However, next year, it was not showed any significant difference with 75% RDF in terms of the yields of both season crops.

Table 1. Effect of tillage, residue and nutrient management on productivity of component crops

Treatment	Grain Yield (kg/ha)					
	Kharif crops			*Rabi* crops		
	2020	2021	Mean	2020-21	2021-22	Mean
Tillage & residue management						
CT-CT	1390	1692	1541	1327	1900	1614
CT-ZT	1258	1648	1453	1275	1808	1542
ZT-ZT	1331	1536	1433	1242	1752	1497
CD (P=0.5)	NS	NS	NS	NS	NS	NS
Cropping systems						
Pearlmillet-Chickpea	1169	1835	1502	1126	2119	1623
Clusterbean-Mustard	1484	1416	1450	1436	1521	1478
CD (P=0.5)	119	231	NS	177	494	NS
Nutrient management						
RDF 100%	1452	1681	1566	1405	1822	1614
RDF 75%	1201	1569	1385	1157	1818	1488
CD (P=0.5)	128	NS	87	134	NS	105

System productivity in terms of chickpea equivalent yield (CEY) was not significantly affected under all the tillage management options. While in cropping systems, clusterbean-mustard cropping system was recorded significantly higher CEY (2575 kg/ha) over pearl millet –chickpea system. Further 100% RDF gave significantly higher CEY (2531 kg/ha) over 75% RDF.

Net return and benefit cost ratio was recorded higher under CT-CT followed by CT-ZT and ZT-ZT, respectively. However, they were statistically equivalent to each other. Among the cropping systems, clusterbean –mustard cropping system was found more remunerative in comparison to Pearlmillet- chickpea cropping system. Under nutrient management options, the 100% RDF was also significantly improved the net return and BCR over 75% RDF.

Salient findings

Clusterbean-mustard cropping system was found more productive, economic and energy efficient as compare to pearlmillet-chickpea system in arid conditions.

Application of 100% recommended dose of fertilizer recorded significantly higher grain yield and system productivity over 75% recommended dose of fertilizer.

Tillage & residue management practices did not prove any significant difference in grain yield, system productivity, net return and benefit cost ratio under different tillage and residue management options.

Irrigation and nitrogen management in arid legumes

A field experiment was carried out during *Kharif* 2020 & 2021 to study the effect of nitrogen and irrigation management in mothbean for enhancing nutrient and water use efficiency under arid conditions. The treatments consist 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 design with three replications. The 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 and flowering stage + pod formation stage registered

significantly higher yield of mothbean over single irrigation at vegetative/branching stage. The maximum yield obtained with two irrigations at vegetative/branching + pod formation stage and least in single irrigation at vegetative/branching stage.

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	677	1697	2373	29
15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at pod development stage	739	1915	2654	28
15 kg N + 40 kg P_2O_5 + foliar spray of urea (2%) at flowering and pod development stage	887	2349	3236	28
CD (P=0.5)	101	355	445	NS
Irrigation Management				
Vegetative/branching stage	619	1569	2188	28
Vegetative/branching + pod formation stage	874	2266	3140	28
Flowering stage + pod formation stage	810	2125	2936	28
CD (P=0.5)	101	355	445	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 P2O5 along with foliar spray of 2% urea at flowering and pod formation stages over single foliar spray of urea at flowering and pod formation stages. The water productivity (physical and economical) was also significantly improved under two foliar spray of urea over single spray. 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.

Salient findings

Significant improvement in grain yield, net return and BCR was recorded with 15 kg N + 40 kg P_2O_5 along with foliar spray of 2% urea at flowering and pod formation stages. Further, it was also recorded significantly higher water productivity.

Grain yield, biomass yield and net returns were significantly improved with two irrigations at branching + pod formation stages and flowering + pod formation stage over that alone in branching stage.

Evaluation of diversified cropping systems in arid ecosystems

A field experiment was initiated during 2020-21 to assess the diverse cropping systems in term of productivity and soil quality under hot arid condition. Total nine cropping systems (Clusterbean–Chickpea, Clusterbean–Mustard, Mothbean –Chickpea, Mothbean –Mustard, Mothbean–Cumin, Pearl millet–Chickpea, Pearl millet–Mustard, Mungbean – Chickpea and Mungbean - Mustard) were tested under randomised block design with three replications. The results showed that clusterbean based cropping systems (Clusterbean–Chickpea & Clusterbean–Mustard) improved significantly higher system productivity and profitability as compare to the other cropping system. The clusterbean –mustard cropping system recorded the highest system productivity (2789 kg/ha) followed by clusterbean –chickpea system (2725 kg/ha). However, Clusterbean based cropping systems (Clusterbean-chickpea & Cluster bean-Mustard) did not significantly differ with mungbean based cropping systems (Mungbean–Chickpea & Mungbean-Mustard). The lowest system productivity recorded under pearl millet based cropping systems; pearl millet-mustard (1904 kg/ha) & pearl millet-chickpea (2038 kg/ha).

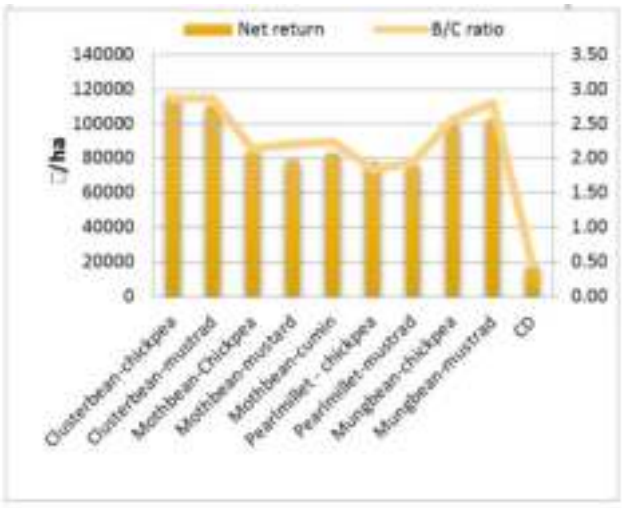


Fig. 2: System productivity (CEY) and economics of diversified cropping systems

Net return and benefit cost ratio was also indicated the similar trends with higher in clusterbean based cropping systems (Clusterbean–Chickpea & Clusterbean–Mustard) followed by mungbean based cropping systems Mungbean–Chickpea & Mungbean-Mustard) and least in the pearlmillet based cropping systems (pearl millet-mustard & pearl millet-chickpea).

Project Improving soil health and minimizing the yield gap in pulses through resource conservation technologies in arid ecosystem

Experiment 1. Effect of tillage and residue on productivity and sustainability of pulse inclusive cropping systems

A field experiment was initiated at the ICAR-IIPR, RRC, Bikaner research farm in Rabi 2020 to evaluate the performance, economics, input use efficiency and weed dynamics of four different cropping systems (Pearl millet – Mustard, Pearl millet – Chickpea, Mothbean – 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 (chickpea eq. yield) of different cropping systems. The zero-tillage treatment resulted in a higher net return (13.88%) and B:C ratio (36.60%) compared to conventional tillage practices. The net return and B:C ratio were reported identical under different cropping systems. In the first-year higher net return and B:C ratio was recorded with residue removal treatment due to higher market value of crop residue. Higher density and dry matter of *Kharif* weeds were recorded under moth bean followed by cowpea and pearlmillet.

Findings

1. Higher infestation of weeds were reported under Mustard- Mothbean cropping system.
2. There was no significant difference reported of tillage, cropping system and residue management on system productivity.
3. Maximum net return and B:C ratio were observed under zero tillage and residue retention practices. The effect of the cropping system on net return and B:C ratio was found non-significant.

Exp 2. Integrated nutrient management for improving soil health and sustainability of pulse based cropping systems in arid-ecosystems

The present field experiment was carried out during *Rabi* 2020-21 and Kharif- 2021 in Pearl millet – Mustard, Mothbean – Mustard, Pearl millet – Chickpea, Clusterbean + Sesamum (6:2) - Chickpea system to study the effect of nutrient management practices ((1.) Recommended fertilizers (100% RDF) (2.) 75% RDF + 5 t FYM (3.) 75% RDF + 5 t FYM + Biofertilizers (4.) 50% RDF + 5 t FYM + Biofertlizers + Crop residue) on crop performance, economics, energetics, nutrient and input use efficiencies. The result of the study revealed that clusterbean + Sesamum (6:2)-chickpea cropping system gave the higher chickpea eq. yield (23.04 q/ha), net return (-81,554) and B:C ratio (2.02) as compared to rest of the cropping systems. Nutrient management practices significantly improve the crop yield. Application of 5 tone FYM with 75% RDF and biofertilizers gave the higher chickpea eq. yield (5.92%), net return and B:C ratio as compared to 100% RDF.

Findings

1. Higher system productivity, net return and B:C ratio were recorded under Clusterbean+Sesamum (6:2)-Chickpea cropping system.
2. Application of 75% RDF+5 t FYM + Biofertilizers significantly improves the grain yield and increases the net return.

Project: Enhancing productivity and resource use efficiency of pulses through agronomic management in arid region

Team: B. Lal, LK Rolaniya, SK Meena, Narendra Kumar

Experiment 1: Efficacy of growth supplements on performance of clusterbean and mothbean cultivars

Exogenous application of growth supplements is known to improve plant resistance

against abiotic stresses A field experiment was conducted with seven growth supplement i.e. thiourea (1000 ppm), K_2SO_4 (0.2%), Salicylic acid (100 ppm), Urea (2%), NPK solution (0.5%), Acetic acid (20mM), $MgSO_4$ (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. Dry matter accumulation (DMA) was remained non-significant up to 30 days after sowing, however, at 60 DAS and at maturity, exogenous supply of potassium sulphate resulted in significantly higher DMA which was statistically at par with Thiourea and acetic acid.DMA in CB and MB was 14.5 and 10.0% higher with K_2SO_4 and 13.6 and 8.5% higher with thiourea application, respectively over water spray. Among the cultivars, RGC 936 of CB and CZM 2 of MB responded better to application of growth supplements. Leaf area also followed the similar trend as of dry matter accumulation showing potassium sulphate as best treatment followed by thiourea and acetic acid. 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 1). In clusterbean, RGC 936 and in mothbean, CAZRI Moth 2 responded better to growth supplements and reported higher yield as compared to other cultivars. Application of potassium sulphate, acetic acid and thiourea resulted in 7.5-15.6% higher seed yield over water spray. Application of growth supplements significantly improved the growth, plant water status and seed yield of clusterbean and mothbean under rainfed situation and this could be also attributed to some extent in improving leaf area, photosynthesis and harvest index probably due to more partitioning of photosynthates to the seed.

Experiment 2: Identification of suitable intercropping system and row ratio for legume cultivation in arid region

A field experiment was conducted during 2021-22 at Regional Research Centre, Bikaner to evaluate the performance of mothbean var. RMO-2251, clusterbean var. RGC1066, with pearl millet (Pennisetum glaucum) var. MPMH 17 intercropping systems in hot arid rainfed conditions. Three intercropping combinations of pearl millet with cluster bean (CB) and mothbean (MB) in (1:1, 2:1 and 3:1 ratio) along with sole crop treatment were executed in firstweek of July with the onset of monsoon. The experiment was conducted in RBD during *Kharif* season and in the rabi season, all the plots were distributed in two equal parts and mustard and chickpea crop was taken in cropping sequence in all the treatments of *Kharif* season to see the effect of residual effect of *Kharif* crops on mustard and chickpea. Pearl millet equivalent (PMEY) was significantly higher in all intercropping combinations of PM, CB, and MB than that of sole PM. PM+CB in 1:1 and 2:1 row ratio recorded around 105 and 76.8% higher equivalent yield as compared to sole PM. Better seed yields under lower and delayed rainfall and higher selling prices for pulses relative to millet were responsible for higher equivalent yields of the PM+CB ratio. Production efficiency worked out on the basis of PMEY and biomass yield in order to assess the system efficiency per day basis. PE based on PMEY was significantly higher in CB sole-mustard due to higher seed yield and selling price of CB and mustard. PE based on BY was significantly higher in PM+CB (1:1)-mustard followed by PM+CB (2:1)-mustard. Although the PM sole based system incurred the minimum production cost, it also showed the lowest ME and B:C ratio, because of lower yields and low selling price of bajra. Maximum B:C ratio and ME was recorded in CB sole – mustard, although it was statistically at par with PM+CB (1:1)-mustard followed by PM+CB (2:1)-mustard. Looking to overall economics, all pulses and pulses intercropping treatments were significantly more profitable over sole PM due to higher yield advantage of pulses in sole and intercropping system and higher selling price.

Fig. 3: Pearl millet and mothbean intercropping in 1:1 row ratio

Farmer-Scientist interaction and input distribution programme at Regional Research Centre, Bikaner

A scientist-farmer interaction and input distribution programme was conducted at ICAR-IIPR, Arid Pulses Research Centre, Bikaner on March 16, 2022 under Scheduled-Caste Sub-Plan. The purpose of interaction was the importance of pulses

and strategies to improve the pulses productivity in arid region. On this occasion, seeds of clusterbean and mothbean was distributed to 100 scheduled caste farmers of Bikaner district. For pest protection, one knapsack sprayer was also given to each farmer along with seeds. Around 100-150 farmers participated in the programme & interacted with scientists. The programme was organized by Dr. B. Lal, and who introduced the farmers with the different innovations in pulses production. On this occasion, Dr. A. Sahoo, Director, ICAR-NRCC, Bikaner was the Chief guest, Dr .N.D. Yadav, Head, CAZRI, RRS, Bikaner was the guest of honour and Dr. H.K. Narula, Head, CSWRI, ARC, Bikaner was the special guests. During the interaction, Dr. A. Sahoo guided the farmers about role of agriculture & animal husbandry in arid region and also encouraged farmers for mixed farming. Dr. N.D. Yadav described the role of pulses in sustainability of arid region and advance scientific pulse farming for enhancing profitability of farmers and making them self-sustainable. Dr.Narula encouraged the farmers for simultaneous cultivation of pulses and sheep rearing for sustainability of arid region. At the end, Dr .S.K. Meena & Mrs. Monika Punia explained and showed the pulses technology in technology farm of centre. The programme was co-ordinated by Dr. L.K. Rolaniya and vote of thanks was offered by Dr. S.K. Meena.

ICAR-IIPR Regional Station Khordha, Odisha

Research Achievements

Project-Epidemiology and search for resistance against of major diseases of mungbean and urdbean

1. Screening of urdbean genotypes against yellow mosaic diseases (YMD)

- Five genotypes of urdbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check urdbean (MDU 1) were screened against YMD during *Kharif* season & found that the YMD was observed only in IPU 13-3, susceptible check (MDU-1) with DI of 100 %, DS of 73% & rest others urdbean line were free from YMD.
- Five genotypes of urdbean (IPU 13-3, IPU 13-7, IPU 10-1, IPU 96-6, IPU 99-220) with susceptible check MDU1 & DGGV2 were evaluated against YMD during *rabi* and in summer season only. MDU-1 was used as susceptible check & found that the YMD was observed only in IPU 13-3, susceptible check (MDU-1) with DI of 100 %, rest others urdbean line and were free from YMD during *rabi* and summer season.

Fig. 1: Screening of urdbean genotypes against YMD during *kharif* season of 2022

Fig. 2: Screening of urdbean genotypes against YMD during *rabi* season of 2021-2022

Fig. 3: Screening of urdbean genotypes against YMD during summer season of 2022

2. Screening of mungbean genotypes against yellow mosaic diseases

- Eighteen genotypes of mungbean (IPM 1718-1, 2/8 IPM 312-18, IPM 1732-2, IPM 205-7, 2/5 IPM 312-18, IPM 1704-14, IPM 512-1, IPM 14-12-12, IPM 1703 -1, IPM 1732-1, IPM 1718-3, IPM 2K -14-9, IPM 1715-2, 2/10, IPM 312-18, IPM 11/2 (M×U) IPM 03-1× SPS-5, IPM 16-5, IPM 410-3, IPM 1704-18), with susceptible check MDU 1 were evaluated against YMD during *Kharif, Rabi* and summer season.
- The YMD was observed in susceptible check (MDU-1) with a disease incidence of 100% and all the lines of mungbean were free from YMD.

1 2 MDU-1 3 4 MDU-1 5 6 MDU-1 7 8 MDU-1 9 10 MDU-1 11 12 MDU-1 13 14 MDU-1 15 16 U-1 17 18 MDU-1

Fig. 4: Screening of mungbean genotypes against YMD

- Seed production of mungbean (Virat- 3.0 q; Shikha – 1.0 q), urdbean (IPU 2-43 -0.5 q; IPU 11-2- 0.5 q) in *Rabi* season and rice seed 140 quintals in *Kharif* season.

3. Infrastructure/equipments developed

a. Infrastructure

- Laboratory-cum-office building-Under construction
- Farm office & threshing floor- Under construction
- Seed processing plant- Under construction
- Main gate- Under construction
- Pump house- Under construction

All India Co-ordinated Research Projects
Chickpea

Crop Improvement

Varieties identified for release

S No	Crop	Variety	Area of Adoption	Salient features
1	Chickpea	GNG 2461	North West Plain Zone comprising of Punjab, Haryana, western Uttar Pradesh, Delhi, North Rajasthan and Jammu	• *Desi* chickpea variety suitable for Rainfed condition of NWPZ. • Medium large brown attractive seed size of 24.5 g/100 - seed. • Maturity: 140-145 days. • Average yield of 21.4 q/ha. • Pedigree: (KWR 108 x GNG 1861) x (Pant G 186 x GNG 1958). • Toleranc to *Fusarium* wilt.
2	Chickpea	NC 7	Central Zone comprising Madhya Pradesh, Maharashtra and Gujarat	• A drought tolerant introgression line (DTIL) of chickpea variety JG 16, developed through introgression of "QTL hot spot" for drought tolerance from ICC 14649, is suitable for cultivation under timely sown condition . • It has bold brown attractive seed size of 26.6 g/100 seed . • Maturity: 107 days • Average yield of 13.6 q/ha. • Moderately resistant to *Fusarium* wilt.
3	Chickpea	BGM 10221	Central Zone comprising Madhya Pradesh, Maharashtra and Gujarat	• A drought tolerant introgression line (DTIL) of chickpea variety JG 16, developed through introgression of "QTL hot spot" for drought tolerance from ICC 4958, is suitable for cultivation under timely sown condition . • It has bold brown attractive seed size of 25.6 g/100 seed. • Maturity: 111 days. • It has an average yield of 13.5 q/ha.
4	Chickpea	RKGK 13-416	South Zone comprising of Andhra Pradesh, Telangana and Karnataka	• Pedigree: BG 1044 x BG 1110. • *Kabuli* chickpea variety is suitable for cultivation under timely sown irrigation condition. • It has attractive beige coloured seed of size 26.8 g/100 seed. • It has an average yield of 16.2 q/ha. • Maturity: 96-102 days. • Tolerance to *Fusarium* wilt.

- Nine chickpea varieties were released and notified for cultivation in the country during 2021-22. These include Nandyal Gram 857 (Desi, SZ), CG Akshay Chana (Desi, SZ),IPCK 2013-163 (*Kabuli*, NWPZ),Gujarat *Kabuli* Gram 1 (ELSK, NWPZ), Kota *Kabuli* Chana 3 (*Kabuli*, WCZ), Karan *Kabuli* 4 (*Kabuli*, SZ),Samriddhi (Desi-MABC, CZ),IPC L 4-14 (Desi-MABC, NWPZ) and Pusa Chickpea 4005 (Desi-MABC, NWPZ)
- Eight germplasm lines were registered with NBPGR. These include IC0633092 (Fusarium wilt resistance), EC 720481 (BGM resistance), EC 720438 (*Ascochyta* Blight resistance), EC 267301 (*Ascochyta* Blight resistance), IC 248147 (*Ascochyta* Blight resistance), IC 640699 (>2.5 seeds/pod), IC 640700 (Post Emergence herbicide tolerance) and IC 272450 (Heat tolerance).
- Total 15,654 accessions were maintained at 23 centres. These accessions were evaluated for morphological traits and are being maintained.
- Total 8656.43 q of breeder seed of 65 chickpea varieties was produced against DAC indent of 6098.69 q.

Crop Production

Agronomy

- Oxyfluorfen, a pre-emergence herbicide in chickpea was evaluated alone or in combination with POE herbicides (quizalofop-p-ethyl, propaquizafop and topramezone) at different locations/zones. In NWPZ, pre-emergence (PE) application of oxyfluorfen 150 or 250 g/ha and post-emergence (POE) application of quizalofop-p-ethyl 100 g/ha performed better whereas, combined application of PE + POE observed better in NEPZ. In CZ & SZ, oxyfluorfen 150 g/ha (PE) + propaquizafop 100 g/ha (POE) was found effective.
- The variable response of topramezone (dose & application time) was observed at different zones and locations in controlling weeds in chickpea. In NWPZ at Ludhiana, topramezone 25.7 g/ha at 21 DAS showed superiority among other doses and application time. In NEPZ & SZ, topramezone 20.6 or 25.7 g/ha at 21 DAS has shown superiority whereas in CZ, topramezone 20.6 or 25.7 g/ha applied at 14 DAS proved better option.
- Customized fertilizer was evaluated at six locations across the zones. The significant response of application of customized fertilizer was observed in increasing the grain yield of chickpea across the zones at all locations. Based on the study, customized fertilizers (NPKSZnMo) based on recommendation 100% can be recommended for obtaining higher yield of chickpea.
- Under rainfed situation, Hydrogel application improved the grain yield of chickpea. Maximum grain yield of chickpea was recorded under Hydrogel 5.0 kg/ha and least under control.

Microbiology

- Multilocation testing of eight elite *Mesorhizobium* strains at five different centers showed that strain KBR 16-18 (Kalaburagi) and BIONPK-NBAIM out yielded all other strains with an increase of 16% in grain yield over the un-inoculated control. However, CR 53 (Pantnagar) enhanced yield by 15.1%, over the un-inoculated control. Delhi Strain DMR-1 was found at par with 20 kg N/ha treatment for grain yields by 13.2% over control.
- Application of microbial consortium for alleviating moisture stress in chickpea revealed treatment T7-RFC 117+MCII (IIPR-Kanpur) followed by T6-RFC 117+ Archeal Bioformulation- NBAIM improved the grain yield by 19.3 % and 18. 1% over Farmers, practice on the basis of pooled data across the four locations.

Crop Protection

Plant Pathology

- Eight *Trichoderma* strains obtained from various sources, including NCIPM, NBAIR, NRRI 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. On an average seed treatment with *Trichoderma* mutant was the most effective followed by *T.harzianum* T6 + Propineb (@ 10 g + 1.5 g/kg seed) in minimizing wilt/DRR incidence.
- One hundred six entries showing resistant/moderately resistant reaction to wilt were screened for confirmation of wilt resistance at different location having established wilt plots. Sixty six entries *viz.* PG 237, BG 4018, GNG 2462, GG 14, GLK 17032, BCP 61, BDNG 2017-44, GNG 2461, GL 16056, BCP 49, RSGD 1071, BDNG 2017-49, FLIP 88-85C-1FC-S1, IFLRP F4-S2, FLIP 09-191C-IFC-S2, IFLRP F4-S5, RVSSG 89, RVSSG 97, IGK 2021-116, RVSSG 94,FLIP 10-89-IFC-S2, IGK 2021-116,FLIP 09-243C-S4, GNG 2461, GNG 2510, GJG 1815, GJG 1803, GJG 1907, GJG 1809, GJG 1912, Phule G 1221-1, Phule G 1210-01, Phule G 1131-4, NBeG 798, NBeG 690, H 09-90, H 16-05, H 17-16, GJG 2005, GJG 2006, GJG 2019, NBeG 789, NBeG 690, H 09-90, H 16-05, H 17-16, GJG 2005, GJG 2006, IG 2021-109, IG 2021-107, IG 2021-300,IG 2021-284, IG 2021-281, IG 2021-106, IG 2021-108, IG 2021-258, IG 2021-383, ICCV 05530, ICCV 98503, ICCV 07111, ICCV 16134, ICCV 13616, ICCV 16505, ICCV 05534 and ICCV 07104 expressed resistance/tolerance to wilt at five or more

locations, confirming the previous year results.

- GNG 2461, GJG 1907, IPCKB 2016-133 and IG 2021-104 were found moderately resistant to DRR in multilocation testing.

Entomology

- In evaluation of ecofriendly approaches (NBAIR) for the management of gram pod borer, *H. armigera* the treatment Chlorantraniliprole 18.5 SC % @ 0.25 ml/litre had recorded significantly lower pod damage, less larval population and highest grain yield of chickpea than all other treatments. Among bioinsecticides, HaNPV NBAIR1 @ 4 ml/L, Mahastra 0.5% Bt @ 4g/litre and *Bacillus thuringiensis* NBAIR Bt G 4 @ 20 ml/litre water and home made neem @10% were significantly superior than control and were at par with each other in terms of larval population, pod damage and grain yield of crop.
- The IPM module (NCIPM) resulted in lesser larval load of *H armigera*, lower pod damage and higher grain yield as well as more natural enemies as compared to the farmer's practice, resulting in higher net returns.
- In bio-intensive management of pulse bruchids in chickpea under storage conditions, Deltamethrin 2.8 EC @ 0.04 ml/kg followed by Neem oil @ 5ml/kg and Diatomaceous earth @ 5 g/kg were found significantly superior in reducing the bruchid infestation at various intervals ie; (3, 6, 9 and 12 months) with lowest per cent infestation after 12 months of storage.

Frontline Demonstrations

- Four hundred and twenty demonstrations were conducted on package technology. On an average, 1611 kg/ha of yield was obtained through package technology against 1306 kg/ha by farmers, practice with an increase in grain yield by 23.3 percent.
- Seventy-five demonstrations were conducted on package technology in rice fallow. The overall mean grain yield of package technology in rice fallow was 1319 kg/ha and mean yield of local practice was 1014 kg/ha. The percent increase in grain yield was 30.1%.
- Five demonstrations were conducted on Insect pest management technology. The overall mean grain yield through IPM was 1592 kg/ha and mean yield of local practice was 1332 kg/ha. The per cent increase in grain yield was 20.2.
- Six hundred and fifty demonstrations were conducted in tribal areas under Tribal Sub Plan which gave an average yield of 1352 kg/ha which was 26.0% higher than yield obtained through traditional practices and varieties (1073 kg/ha).

All India Co-ordinated Research Projects
Pigeonpea

Crop Improvement

Varieties released:

BDN 2013-2 (Renuka) and Phule Tur 10-1 (*Phule Trupti*):

The candidate varieties Phule Tur 10-1 (Phule Trupti) and BDN 2013-2 (Renuka) were released and notified for rainfed cultivation under central zone mid early (151-165 days) duration group. Both the varieties exhibited the yield superiority over the best checks and moderately resistance to wilt and sterility mosaic disease. Based on the per se yield advantage the committee identified both the varieties namely Phule Tur 10-1 (Phule Trupti) and BDN 2013-2 (Renuka) for central zone comprising of Madhya Pradesh, Maharashtra, Gujarat and Chhattisgarh.

***PhuleTur* 11-4 (*Phule Kaveri*):**

The variety Phule Tur 11-4 (Phule Kaveri) was released and notified for rainfed cultivation under south zone mid early (151-165 days) duration group. The variety exhibited the yield superiority over the best checks and moderately resistance to wilt and sterility mosaic disease. Hence, the committee identified the variety Phule Tur 11-4 (Phule Kaveri) for the South Zone comprising of Tamil Nadu, Karnataka, Andra Pradesh, Telangana and Odisha states.

AKTM 1637 (PDKV Ashlesha):

The candidate variety **AKTM** 1637 (PDKV Ashlesha) was submitted for rainfed cultivation under central zone medium duration (165-185 days) group. The variety exhibited the per se yield superiority over the best checks and moderately resistance to wilt and sterility mosaic disease. Hence the committee identified AKTM 1637 (PDKV Ashlesha) pigeonpea variety for Central Zone comprising of Madhya Pradesh, Maharastra, Gujarat and Chhattisgarh.

Promising Pigeonpea Entries:

In All India Coordinated Pigeonpea Varietal Evaluation Programme (2021-22), seven trials *viz.*, IVT (Extra early: <130 days) in NWPZ; IVT (Early: 131-150 days) in NWPZ, SZ, CZ and NEHZ; AVT-1+AVT-2 (Early: 131-150 days) in NWPZ, SZ, and CZ; IVT (Mid-early: 151-165 days) in CZ and SZ ; AVT-1+ AVT-2 (Mid early:151-165 days) in CZ; IVT (Medium: 166-185 days) in CZ and SZ and AVT-1 + AVT-2 (Medium: 166-185 days) in CZ were executed at 96 locations of four zones. Under these trials, a total of 92 genotypes were evaluated along with suitable zone specific checks and promising genotypes observed under these trials are mentioned in the summary table as given here under:

Summary Table of *Kharif* 2021-2022 Trials

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 (Extra Early <130 days)	**NWPZ**	IPAB 18-21	1561	8.55	77	127	8.56
		AL 2324	1515	5.35	73	119	8.79
		Pusa Arhar 21-60	1511	5.08	74	126	9.16
IVT (Early 131-150 days)	**CZ**	NAAM 88	2389	46.56	90	153	12.08
		PA 662	1745	7.06	91	142	9.78
		Pusa Arhar 21-29	1722	5.64	79	141	11.25
	SZ	NAAM 88	1588	12.07	91	150	10.64
AVT-1 (Early 131-150 days)	**NWPZ**	PA 650	1883	10.70	100	144	8.33
IVT (Mid-early: 151-165 days)	**CZ**	Daftari Manik	2765	42.82	111	162	13.21
		TDRG 272	2579	33.21	113	164	11.21
		ICPIL 17103	2575	33.00	115	166	10.96
		PT 12-19-2	2312	19.42	111	163	12.13
		AKTE 19-05	2161	11.62	113	163	10.51
		WRGE 134	2146	10.85	111	164	10.73
	SZ	PT 12-19-2	1569	23.45	105	164	12.12
		WRGE 134	1558	22.58	108	165	10.77
		ICPIL 17103	1505	18.41	116	171	11.41
		TDRG 272	1453	14.32	112	170	11.82
		Daftari Manik	1443	13.53	107	167	13.52
		AKTE 19-05	1440	13.30	110	167	11.17
		AKTE 16-12	1383	8.81	107	166	10.38

AVT-1 (Mid-early: 151-165 days)	**CZ**	PT 2017-2	2253	16.25	105	162	11.20
		WRGE 124	2163	11.61	108	164	10.44
		RVSA 14-2	2152	11.04	105	163	9.65
AVT-2 (Mid-early: 151-165 days)	**CZ**	PT 10-1-1-2	2159	11.40	107	165	10.50
		BDN 2013-2	2135	10.17	109	168	12.03
	SZ	PT 11-4-4-1	1572	23.68	108	166	11.41
IVT (Medium: 166-185 days)	**CZ**	SKNP 1715	1710	6.01	118	181	11.27
		PT 12-5-5-1	1706	5.77	115	175	11.13
		AKTM 1914	1699	5.33	118	177	10.09
		BDN 2013-5	1698	5.27	123	183	10.61
	SZ	SKNP 1715	1953	14.28	123	176	11.65
		RVSA 2021-8	1849	8.19	125	177	10.97
		CRG 18-007	1813	6.09	120	175	11.77
		RVSA 2021-6	1809	5.85	122	173	11.39
		PT 12-5-5-1	1807	5.73	117	171	12.16
		GJP 2011	1806	5.68	128	179	11.12
		AKTM 1914	1804	5.56	123	176	11.40
AVT-1 (Medium: 166-185 days)	**CZ**	PT 11-16	1955	10.45	114	175	10.61
AVT-2 (Medium:166-185 days)	**CZ**	AKTM 1637	1948	10.06	113	174	11.03

Pigeonpea Breeding Materials:

During Kharif 2021, a total of 79 new crosses were achieved with sufficient quantity of F_1 seed under pigoenpea national crossing programme. Universally targeted traits across the zones for the national crossing programme were resistance to wilt, sterility mosaic disease, phytophthora blight, pod fly and pod borer. Along with aforementioned the zone specific traits were also taken into consideration for developing the new crosses. Generation of photo-thermo insensitive extra early and early maturing breeding materials was mainly focused for all the zones. The centre namely Ludhiana, Pantnagar, IIPR, Kanpur, Kota, Akola, Coimbatore, Virinjipuram, Nagaland and Tripura have generated the successful F1 crosses involving early maturing parents. Different AICRP on pigeonpea coordinating centers has a pool of 272 fresh F_1 crosses, 286 F_2 populations and 5503 breeding lines derived from different crosses. During Kharif 2021 a total of 634 fixed lines were evaluated under preliminary yield trials and/or their respective station trials by different centers.

Pigeonpea Genetic Resources:

AICRP on, pigeonpea has the total of 6664 germplasm collections with its 19 differerent coordinating centers spreading across the different zones. Of the total collections 145accessions are of wild type belonging to 17 different species. The highest germplasm holdings are with Badnapur (1375) followed by SK Nagar (1141), Coimbatore (1062), Gulbarga (515) and Ludhiana (428) centre. SK Nagar center has 145 wild pigeonpea accessions belnging to 17 different species followed by Badnapur having 9 accessions belonging to 9 different species. During kharif 2021 a total of 1337 pigeonepa germplasms 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 of3.2 percent germplasm utilization was re,corded. The highest percent utilization was reported by Badnapur (0.5%) followed by Warangal (0.47%). During Kharif 2021 a total of 115 new germplasm collecitons were added by different AICRP on pigeonpea centers. Lam centre made the highest (40) number of collecions followed by Rahuri (25)

Pre-Breeding in Pigeonpea:

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 pigeonpea improvement during Kharif 2020. 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/ land races with unique traits; resistant donors for wilt, sterility mosaic disease and Phytophthora stem blight, resistant/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. AcutifoliusandC. albicans*are being used for widening the genetic base in pigeonpea

Shuttle Breeding In Pigeonpea:

During *Kharif* 2021 following nine centres were selected for pigeonpea shuttle breeding programme in different zones. Each centre in the zone will exchange the donors for attempting crosses, segregating populations and fixed lines and other breeding materials and if some products comes out credit will be shared, sharing a part of the breeding material with each other increases the efficiency of the programme. Brief detail about the centre and programme is as given below.

Development of Mapping Populations and Adoption of Marker Assisted Breeding/ Selection:

During the recent past the research on genetics and genomics have led to the development of tremendous resources in pigeonpea for precision breeding and rapid genetic gain. Nevertheless, there is a need to enhance the efficiency of breeding programmes under AICRP on Pigeonpea. The underutilization of genomic tools was due to lack of desired mapping population for trait of interest. Keeping this in view, the new initiatives were taken to develop trait specific mapping population in pigeonpea for application of DNA Marker in breeding programme. Towards this end, development of multi-parental populations like MAGIC will serve the dual purpose of gene discovery and varietal development. In this regard four centres namely, Gulbarga, Warangal, IIPR-Kanpur and IARI, New Delhi were selected for generation of mapping population and the genotyping of these populations will be done at ICAR- NIPB, New Delhi.

Agronomy

Evaluation of Pigeonpea + specialty corn and parching sorghum intercropping system:

This trial was allotted to Badnapur, Rahuri, Kota (CZ), Bangalore, Berhampur, Gulbarga, Coimbatore, Warangal (SZ), Nagaland, Tripura (NEHZ), and Jammu and Kashmir (NWPZ) (11 centres).

Central Zone: Pigeonpea + baby corn (1:2); intercropping system recorded a significantly higher pigeonpea equivalent yield (PEY). However, it was at par with sole baby corn. The gross and net monetary returns followed a similar trend. **South Zone:** Pigeonpea + baby corn (1:2) intercropping system recorded maximum production (25.48 q/ha PEY). Pigeonpea + baby corn found economically superior with ₹ 160495/ha gross return, ₹ 86,395/ha net return and a B:C ratio of 2.17. Pigeonpea was intercropped with bajra in (1:2) row proportion (928 kg/ ha). **North Eastern Hilly Zone (NEHZ):** Pigeonpea + baby corn intercropping (1:2) recorded a higher pigeonpea equivalent yield (3,353 kg/ ha) than other systems. Similarly, the same treatment recorded the higher gross, net returns and a higher B: C ratio.

Evaluation of post-emergence herbicides in Pigeonpea:

This trial was allotted to Badnapur, Rahuri, Chitrakoot and Kota of the Central Zone, whereas Bangalore, Berhampur, Gulbarga, Coimbatore and Warangal of the South Zone (9 Centres).

Central Zone: Weed-free treatment produced significantly higher seed yield of pigeonpea (2,567 kg/ ha), however, it was at par with treatments receiving two hand weedings at 20 and 40 DAS/ Inter cultivation (2,534 kg/ ha); Pendimethalin 30 EC @ 0.75 kg ai/ha (PE) followed by Imazethapyr 10 SL @ 100 g ai/ha at 20-25 DAS fb + one Inter cultivation at 50 DAS (2,371 kg/ ha); Propaquizafop 2.5 % + Imazethapyr 3.7 % w/w @ 50+75 = 125 g ai/ha at 20-25 DAS (2,488 kg/ ha), and Imazethapyr + Imazamox @ 100 g ai/ ha at 20-25 DAS (2,366 kg/ ha). GMR, NMR and B:C ratio followed the similar trend. **South Zone:** Higher pigeonpea seed yield was recorded (1244 kg/ ha) with post emergence application of Sodium Acifluorfen 16.5 % + Clodinafop propargyl 8 % @ 245 g ai/ha at 20-25 DAS + One Inter cultivation at 50 DAS followed by Imazethapyr + Imazamox @ 100 g ai/ ha @ 20-25 DAS (1184 kg ha^{-1}) and Imazethapyr 10 SL @ 100 g ai/ha at 20-25 DAS (1,051 kg/ ha). The highest B:C ratio (2.38) was recorded with the application of Sodium Acifluorfen 16.5 % + Clodinafop propargyl 8 % @ 245 g ai/ha at 20-25 DAS followed by Imazethapyr + Imazamox @ 100 g ai/ ha at 20-25 DAS + one Inter cultivation at 50 DAS (2.27).

Agronomic fortification of pigeonpea with Zn and Fe:

This trial was allotted to Jammu (Rakhdiansar) (NWPZ), Badnapur, Akola, Rahuri, S.K. Nagar, Junagadh, Chitrakoot, Kota (Central Zone), Berhampur, Coimbatore, Gulbarga, Warangal, Bangalore (South Zone), and Pantnagar (NEPZ) (14 centres).

North Western Plain Zone: At Jammu (Rakhdiansar), RDF + soil application of 25 kg $ZnSO_4$ + 5 kg $FeSO_4$/ ha recorded significantly higher grain and stover yield and higher seed Zn concentration (34.47 mg/ kg). RDF + soil application of 25 kg $ZnSO_4$ + 5 kg $FeSO_4$/ ha recorded significantly higher seed Fe concentration. **Central Zone:** RDF + foliar application of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at flower and pod initiation recorded significantly higher seed yield and B: C ratio. The effect of Zn and Fe management treatments on the seed yield, stalk yield (kg/ ha), and harvest index (%) of pigeonpea was non-significant. RDF + foliar application of 0.50% $ZnSO_4$ at flower and pod initiation (T_5) recorded significantly higher seed Zn concentration. RDF + Foliar application of 0.50% $FeSO_4$ at flower and pod initiation (T_6) and treatment RDF + Foliar application of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at flower and pod initiation (T_7) recorded significantly higher seed Fe concentration. **South Zone:** Foliar application of $ZnSo_4$ 0.5 % + Fe So_4 0.5 % at the flower and pod initiation stage recorded a significantly higher seed yield. **North Eastern Plain Zone:** Basal application of RDF + 25 kg $ZnSO_4$ + 5 kg $FeSO_4$ being at par with RDF + Soil application of 25 kg $ZnSO_4$ recorded a significantly higher yield.

Response of Pigeonpea to tillage and mulching practices under NEHZ:

This trial has been allotted to Nagaland and Tripura

centres. At Nagaland, the effect of the tillage management treatments on the pigeonpea growth, yield parameters, and yield was non-significant. However, conventional tillage (one ploughing + one harrowing) recorded 14 per cent more yield than the zero tillage. Higher gross and net returns were observed with the conventional tillage than the zero tillage. The B: C ratio was also higher with the conventional tillage system.

Organic nutrient management in Pigeonpea:

This trial was allotted to S.K.Nagar, Junagadh (Central Zone), Nagaland, and Tripura (NEHZ) (04 centres). Based on the three years of pooled data analysis, higher seed yields of 834, 1517, 1588, and 1313 kg/ha were recorded with treatment RDF during 2019-20, 2020-21, 2021-22, and in pooled results, respectively as compared to organic nutrient management.

Microbiology

Isolation of multi-trait *Rhizobium* for improving nodulation and nitrogen fixing potential of pigeonpea was carried out in four centres viz., Akola, Kalaburagi, Kanpur and Ludhiana. A total of 34 rhizobial isolates were obtained. Strains *via* GAKPR-4-21 from Akola, GAKPR-1-21, V4ERB1, V4RB3 and V5ERB from Ludhiana, and IIPR-PR-24-21, IIPR-PR-32-21 and IIPR-PR-57-21 from Kanpur were identified as potential candidates. 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 2021-2022. It was observed that the native rhizobial strains *via Rhizobium* strain GAKPR-16 (22.27 nodules/plant &1854 kg grain yield/ha) at Akola and KRR-18-05 (25.25 nodules/plant & 1035 kg/ha of grain yield) at Kalaburagi are performing better than alien strains including national check at concerned testing centres. 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 the bacterial endophytic strain PGPR-18-14 enhanced the yield of pigeonpea.

Pathology

I. **Host Plant resistance:** In ICAR-IIPR, Pigeonpea Pathology's screening trials against major diseases; total 259 entries along with respective resistant and susceptible checks were evaluated against *Fusarium* wilt, sterility mosaic disease, *Phytophthora* stem blight, *Macrophomina* blight, fungal leaf spot like *Cercospora* and *Alternaria* leaf spot. Overall average percent disease incidences cum scales were considered for evaluating pigeonpea entries against major diseases and highlights of those are mentioned below.

A. **Wilt:** Out of two hundred screened pigeonpea entries (along with repeatedly used resistant and susceptible checks), total fifteen entries were resistant and one hundred and twenty three entries were moderately resistant and eighty six entries were susceptible against wilt disease by considering the overall average percent of wilt incidences obtained from total thirteen centers for different twelve trials. Among those germplasms, few entries *viz.*, BDN 2019-5, IPAL 20-5 and ICP 8863 were found resistant for multi-locations under wilt sick plot.

B. **Sterility mosaic**: Out of two hundred screened pigeonpea entries (along with repeatedly used resistant and susceptible checks), forty three entries were resistant. However, eighty eight entries were moderately resistant and eighty nine entries were susceptible by considering the overall average percent sterility mosaic disease incidence obtained from ten centers. Out of those 43 resistant entries, few resistant material are mentioned here *viz.,* BDN 711, ICPIL 17103, IPAL 14-6, MA 6, BRG 1, BRG 3, BSMR 175, BSMR 79, BWR 553, BWR 316, BSMR 2, BSMR 65, BSMR 1, BWR 164, BWR 254, BWR 153 and ICP 2376.

C. ***Phytophthora* stem blight**: Out of one hundred and sixty five screened pigeonpea entries (along with repeatedly used resistant and susceptible checks), none of entry was resistant. However, six entries were moderately resistant as lowest figure of incidence in few locations and one hundred and eighty three entries were susceptible against *Phytophthora* blight disease during *Kharif* 2021.

D. ***Macrophomina* stem blight:** Amongst one hundred fifty three entries, seventeen entries were resistant, one hundred and eleven entries were moderately resistant and forty seven entries were susceptible against *Macrophomina* blight during *Kharif* 2021. Entries *viz.*, PAU 881, Pusa Arhar 21-61, PA 663, AL 2276-1, Pusa Arhar 21-24, IPA 18-4 and MA 6 were recorded resistant reaction against *Macrophomina* blight during *Kharif* 2021.

E. ***Cercospora* Leaf spot:** Out of one hundred and forty six entries, not single entry was resistant to *Cercospora* leaf spot disease. However, fourteen entries were moderately resistant and ninety eight entries were moderately susceptible against *Cercospora* leaf spot disease. Forty two entries susceptible and six entries were highly susceptible to *Cercospora* leaf spot disease during the season *Kharif* 2021.

F. ***Alternaria* Leaf spot:** Out of one hundred and fifty three entries, not single entry was resistant as well as moderately resistant to *Cercospora* leaf spot disease. However, twenty four entries were

moderately susceptible and seventy five entries were susceptible against *Alternaria* leaf spot disease. Rest of sixty eight entries were highly susceptible to *Alternaria* leaf spot disease during the season *Kharif* 2021.

II. Epidemiology

1. Epidemiology of *Phytophthora* stem blight: Four centers *viz*., Ludhiana, Nagaland, Kalaburagi and Tripura were reported that *Phytophthora* stem blight disease was positively correlated with humidity during the *Kharif* season 2021. In case of Sehore, Epidemiology of *Phytophthora* stem blight was studied on susceptible cultivar ICP 7119 sown on 1st July 2021 in sick plot. The disease was first observed on 27.7.21 and its incidence was 3.09 per cent. The disease progressed maximum up to 91.56% gradually at the end of September.

2. Epidemiology of *Macrophomina* blight: During the *Kharif* season 2021 also, rainfall and rainy days were more than average which resulted in retaining high moisture in soil throughout the season 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. High moisture retained in soil during the *Kharif* season 2021 at terminal stage of crop which resulted in low incidence of *Macrophomina* blight disease.

3. Epidemiology of *Cercospora* Leaf spot: In case of Sehore, the epidemiology of *Cercospora* leaf spot was studied on susceptible cultivar UPAS 120 sown on 1st July 2021. The disease was first observed on 28th July and its incidence was 3.46 per cent. The disease progressed maximum up to 66.12% gradually at the end of December. Kalaburagi centre also mentioned similar trend.

4. Epidemiology of *Alternaria* Leaf spot: The correlation study was shown that with increase in average rainfall and change in temperature, the disease also increases. Nagaland and Kalaburagi centers were reported positive correlation between rainfall and *Alternaria* Leaf spot disease during *Kharif* 2021.

III. Monitoring of race of *Fusarium udum*: The reaction on pigeonpea host differentials in wilt sick plot at twelve locations during the *Kharif* season 2021 across different three zones indicated the possibility of presence of variability in *Fusarium udum* population across centers tested by showing variation in reaction of test entries against wilt disease. Kanpur centre proposed race categorization *viz*., Race 1 to Race 5.

IV. Variability study regarding pigeonpea sterility mosaic disease : The study indicated presence of variability in the pigeonpea sterility mosaic virus pathogen (PPSMV) exists in the different eight centers *viz*., Dholi, Varanasi, Badnapur, Rahuri, Bengaluru, Coimbatore, ICRISAT and Warangal on the basis of pigeonpea host differential reaction against virus at these centres.

V. Pigeonpea disease detection through Artificial Intelligence: All the twenty four centers were submitted photographs of major pigeonpea diseases. More than ten thousand images collected as raw data. Step of data analysis and augmentation was carried out. Alone Badnapur centre was collected seven thousand images related to AI. In case of sterility mosaic, 87 per cent accuracy resulted for detection of sterility mosaic diseases of pigeonpea through artificial intelligence and experiment has been concluded with this result.

VI. Management of pigeonpea diseases: Incidences of respective diseases were significantly reduced and yield of treated pigeonpea crops were significantly gaining higher than untreated control treatment which shown the importance of management of diseases. A result detail of each management trial is mentioned in this report for the year 2021.

VII. Survey: On various farmers' fields or the research fields of different the centers, incidences of major diseases were indicated the status of the wilt, sterility mosaic, *Phytophthora* blight, *Macrophomina* blight, *Cercospora* and *Alternaria* leaf spot. Few centres were also reported the incidences of Collar rot, *Phoma* blight and Phyllody disease and also sent the photographs of those diseases.

VIII. ICAR-ICRISAT's screening trials: Forty nine germplasm were screened against *Fusarium* wilt, sterility mosaic disease and fourteen entries were screened against *Phytophthora* stem blight disease and reactions mentioned in the annual report.

IX. Basic studies on *Phytopthora* blight disease: Total seven centers are working on this aspect *viz*., Ludhiana, Pantnagar, Kanpur, Badnapur, Varanasi, Kalaburagi and Sehore. Four different isolations from different locations of Marathwada region maintained and studied by Badnapur centre. Kalburagi centre reported thatt disease initiated immediately four to six days of heavy rainfall with water stagnation and continuous run off. Initial symptoms of infection were noticed on stem and collar region with purple lesions gradually enlarging both towards upper and lower side of the stem. More than 90 per cent of infected plants wilted within next 8 to 10 days. Early infection especially at 15 to 20 days after sowing stage was more vulnerable to severe damage. Continued

water stagnation/ runoff/ soil moisture above saturation favored the disease development. The disease was at lower pace during 50 to 70 days of the crop stage however, further it increased from 75 days onwards and majority of stem blight with severe girdling and cankers were visible at this stage of the crop. Infected plants were lodging and often top portion got detached from the main stem.

X. **Recommendation on the package of practices for integrated diseases management in pigeonpea crop cultivation:** Many of the centers are reported that package of practices for integrated diseases management in pigeonpea crop cultivation resulted in higher yield and lower disease incidence in case of pigeonpea crop at field compare to conventional practices.

XI. **Up gradation in pigeonpea disease (Wilt, SMD, PBD and MBD) rating scales for screening under sick plots and nurseries:** After detailed study and comparison between the observations of sick plots with farmers field existing rating scale shall be modified but due to variations in opinions and stated result, this experiment has to be continued for another two years.

Entomology

Under preliminary screening, among 238 germplasm lines of different maturity group, 84 lines were promising against pod borer complex with less grain damage and registered pest resistance rating (PRR) of 2 to 5 which were considered under resistant to moderately resistant category. The promising lines were promoted for further screening at their respective centres. Under early maturity advanced varietal trial (AVT 1 & 2), the test entries, RVKT 333 at Badnapur and Raipur; IPAE 15-08 at Kalaburgi, Coimbatore and Rahuri; CRG 16-12 and RVKT 333 at S.K. Nagar; PA 650 at Panthnagar; and AH 17-13 at Ludhiana were found to register less grain damage due to pod borer complex over rest of the entries. Under mid early maturity advanced varietal trail (AVT 1 & 2), the test entries, RVSA 14-12 and PT 2017-2 at Badnapur; PT 11-4-4-1 at Bengaluru, Virinjipuram and Warangal; PT 10-1-1-2 at Rahuri and Raipur; PT 2017-1 at S.K. Nagar were found to register less grain damage due to pod borer complex over rest of the entries. Under medium maturity advanced varietal trial (AVT 1 & 2), the test entries, LRG 471 at Bengaluru, Guntur, Virinjipuram and Warangal; PT 11-16 at Rahuri; PT 11-16 and GRG 622 at S.K. Nagar; GJP 1915 and GRG 622 at Badnapur were found to register less grain damage due to pod borer complex over rest of the entries. Evaluation of different Hybrid entries against pod borer complex revealed that PAH 5 at Ludhiana; and PHA 16 at both New Delhi and Panthnagar were found to register less grain damage due to pod borer complex over rest of the entries.

Experimental results on evaluation of different insecticides against pod fly revealed that flubendiamide 480 SC @ 30 g a.i/ha at Badnapur, Raipur and Virinjipuram; Thiamethoxam 25 WP @ 50 g a.i/ha along with Jaggery (5.0 g/l) at Coimbatore, Guntur and Warangal; Dinetofuron 20 SG @ 40 g a.i/ha at Bengaluru; Thiacloprid 21.7 SC @ 76 g a.i/ha at Tripura; Diafenthiuron 50 WP @ 350 g a.i/ha at Kalaburgi were found effective against pod fly and registered less grain damage with more grain yield.

Experimental results on bio-efficacy of different insecticides against pod boring weevil revealed that Cypermethrin 25 EC @ 50 g a.i/ha at Guntur and Nagaland; and Lambda cyhalothrin 5 EC @ 25 g a.i/ha at Tripura were found effective against pod boring weevil and registered less grain damage with more grain yield. Experimental results on evaluation of bio-pesticides against pod borers in pigeonpea revealed that Bacillus thuringiensis var. kurstaki 0.5 % WP serotype 3a, 3b, 3c strain DOR Bt 1 @ 2.5 g/l was found effective in all the centers, except at Panthnagar where Azadirachtin 1500 ppm @ 5.0 ml/l was found effective.

Experimental results on monitoring of major insect pests on pigeonpea revealed that in CZ 42-50, in SZ 46-50, in NWPZ 38 – 44 and in NEHZ 38-48 standard meteorological weeks were crucial for *Helicoverpa* and *Maruca* which corresponds to active vegetative to pod development stage. Farmer's field surveys carried out during 2021-22 revealed that in CZ, pod damage due to gram pod borer and pod fly ranged between 1.0 – 10.4% and 1.0 to 13.6%, respectively. In SZ, pod damage due to gram pod borer, pod fly, Spotted pod borer and SMD incidence ranged between 0.8 – 16.0%, 7.2 – 28.4%, 1.4 – 19.8 and 4.0 – 40.0%, respectively. In NEHZ, 4.8 Maruca webs/plant, 6.6 pod weevils/ plant and 5.4 blister beetles / plant were recorded. In NWPZ, Maruca and pod bugs were moderate to high and blister beetles were low to moderate.

Out of 13 entries screenedagainst root knot nematode, *Meloidogyne* spp, at PUSA, Samastipur 6 entries viz., BDN 711, UPAS 120, PT 10-1-1-2, RVKT 333, AKTM 1637 and IPA 15-21 showed Moderately Resistant reaction and at NDUAT, Ayodhya only one entry GJP 1915 showed Moderately Resistant reaction against *M. incognita.* At IIPR Kanpur, 8 entries viz., BDN 711, PA 291, UPAS 120, PT 10-1-1-2, RVKT 333, PT 11-4-4-1, IPA 15-21 and CRG 16-12 showed Moderately Resistant reaction against *M. javanica.*

Out of 13 entries of pigeon pea,against pigeonpea cyst nematode, *H. cajani* the entry BDN716 showed resistant reaction and four entries BDN711, PA291, UPAS120, PT10-1-1-2 and PT11-4-4-1 were found Moderately Resistant. Thirteen pigeon pea entries obtained through PC AICRP on MULLaRP were screened against root knot nematode, *Meloidogyne incognita* and *M. javanica* at centres viz., RPCAU Pusa, NDAUT Ayodhya, AAU Anand, IIPR Kanpur. The categorization of entries based on screening data was carried out based on 1-5 scale of gall index as follows.

Frontline Demonstration

During Kharif 2021, a total of 460 pigeonpea Front line Demonstrations (FLDs) was targeted and all the demonstrations were executed on six different components *viz*., Full package technology (345 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 26 coordinating centers spread across the pigeonpea growing areas of the country. All together, 450 demonstrations on six different components have reported the results from all the centres except Khargone for intercropping (10 No.) demonstrations. Full package technology increased grain yield by 20.73% (243 kg/ha), 26.48% (264 kg/ha), 39.28% (335 kg/ha) and 28.46% (216 kg/ha) in NWPZ, CZ, SZ and NEHZ respectively. Across the zone, the full package technology was 28.74% (265 kg/ha) superior over the farmers' practice and 53.04% (400 kg/ha) superior over the district average yield. Full package technology demonstration recorded the double benefit over every rupee cost invested in the production of pigeonpea (B: C=2.01:1) 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 center Warangal (62.42 %, 749kg/ha). Similarly in the central zone the demonstration yielded 91.53% (874 kg/ha) over the farmers practice of sole crop. Demonstrations on pre and post emergent weed management recorded 18.78% (239 kg/ha) and 18.96% (223 kg/ha) more grain yield over improper weed management in farmers practice in central and south zones respectively. Further, the ratio of benefit on every rupee investedwas 1.82 over farmers practice. Insect pest management was recorded 33.28% (308 kg/ha) higher grain yields with ₹ 1.41 benefit to every rupee costs in 25 demonstrations conducted at Lam, Warangal and Gulbarga centres. Combined effect of growth promoter and insecticide (Effect of combined application of insecticide with growth regulator on yield.) by applying this 37.22% (320 kg/ha) more grain yield was obtained than the local practice

Breeder Seed Production

A total of 364.62 quintals of breeder seed was produced against the consolidated indent of 252.21 quintals for 56 varieties received from Department of Agriculture, Co-operation & Farmers' Welfare (DAC &FW), Ministry of Agriculture, Govt. of India for crop season Kharif 2021. Of the total 56 indented varieties, 10 varieties (BSMR 736, BAHAR, NDA 1, Manak (H 77-216), Laxmi (ICPL 85063), UPAS 120, ICPL 8863, ICPL 87119 (Asha), ICPL 87 (Pragati)) were more than 15 years old. Fourteen varieties recorded deficit in production against the total indent received namely BDN 716 (-1.70), BRG 5 (-0.55), CRG 2012-25 (CO9) (-3.10), BAHAR (-0.70), Narendra Arhar-2 (-0.05), Narendra Arhar-1 (-5.75), Manak (H-77-216) (-0.06), Pusa 2002 (-0.10), Bheema GRG-152 (-4.02), PAU-881 (-1.01), Pant 251 (-20), Phule Bharti (JL 776) (-4), Phule 12 (-6) , MAL 13 (-3.1). Nevertheless, the surplus of 112.41 quintals has been produced during *Kharif* 2021.

Tribal Sub Plan

Under the umbrella of AICRP on pigeonpea, three centres namely Ranchi from Jharkhand, Raipur from Chhattisgarh and Khargone from Madhya Pradesh are executing the Trible Sub Plan (TSP) on pigeonpea. Under this scheme, several tribal farmers were trained on different aspects of pigeonpea production and post-harvest technologies.

All India Co-ordinated Research Projects
MULLaRP

Crop Improvement

A. Crop varieties released and notified

Mungbean

ML 1808: This elite mungbean variety is a product of inter-specific hybridization and developed from a cross between ML 1349 (Mungbean) and Mash 1-1 (Urdbean). This variety is suitable for *Kharif* season in Punjab and has resistant to MYMV. Its maturity duration is 70-75 days and yield is 12-13 q/ha.

PM 707-5 (Phule Chetak): Mungbean variety PM 707-5 (Phule Chetak) is a derivative of SML-668 x Naval. This variety is moderately resistant to MYMV, Powdery mildew and CLS. This variety has been recommended for Maharashtra state for *Kharif* season. It matures in 70-72 days with average yield of 10-12 q/ha and 4.77 g per 100- seed weight.

MGG 385 (Madhira Pesara): Mungbean variety MGG 385 (Madhira Pesara) has been developed from a cross of Madhira mung x Asha 2-4. This variety is resistant to leaf crinkle, leaf curl and moderately resistant to YMV. It is suitable for Telangana state for *Kharif*, summer, *Rabi* and rice fallow cultivation**.** Its maturity duration is 70-75 days and average yield is 12-13 q/ha. The protein content is 29.05%.

Pusa 1641: This mungbean variety has been developed from a cross of IPM 99-125 x Pusa Vishal. This variety is resistant to MYMV and low incidence of major insect pests. It has been recommended for cultivation in summer season for NCR Delhi state (near Haryana, U.P. and Rajasthan). Its maturity duration is 62-64 days and yield is 12-13 q/ha. The protein content is 25.4%.

Urdbean

Pant Urd 12: This urdbean variety has been developed from a cross between Pant U 31 x TU 94-2 and exhibited significant yield superiority of 18.92% over the best check. It has resistance to MYMV, ULCV and LC disease. This variety is suitable for NWPZ comprising states of western Uttar Pradesh, northern Rajasthan, Delhi, plains of Uttarakhand, Punjab, Haryana and part of Jammu and Kashmir for *Kharif* season. Its maturity period is 80-85 days and yield is 14-15 q/ha.

Kalinga Urd 41 (OBG 41): The urdbean Kalinga Urd 41 (OBG 41) has been derived from a cross of PU 19 x KU 96-3. This variety has resistance to MYMV, ULCV and LC disease and suitable for cultivation in SZ comprising states of Tamil Nadu, Andhra Pradesh, Karnataka, Telangana and Andman & Nicobar, Odisha during *Kharif* season. Its maturity duration is 70-75 days with average yield of 11-12 q/ha.

Kota Urd 5 (KPU 52-87): This urdbean variety has been developed from a cross between RBU 1012 x KU 96-3. It has resistant to MYMV and suitable for cultivation in SZ comprising states of Tamil Nadu, Andhra Pradesh, Karnataka, Telangana, Andman & Nicobar and Odisha. It matures in 72-75 days with average grain yield of 10-11 q/ha.

Mash 1137: This urdbean variety is developed from a cross of KUG 269 x UG 563. It has resistant to MYMV and suitable for cultivation in Punjab state during spring season. It matures in 72-77 days with average yield of 10-11 q/ha.

CO 7 (COBG 10-05): This variety is a product of inter-specific hybridization between VBN (Bg) 5 x *V. mungo var.silvestris*. This variety has resistant to MYMV and suitable for *Kharif* and *Rabi* season of Tamil Nadu state. It matures in 60-65 days with average yield of 10-11 q/ha.

LBG 791: The urdbean variety LBG 791 has been developed from a cross of UPU 97-10 x DPU 88-31. This variety has shown resistance to MYMV and suitable for its cultivation in Tamil Nadu during *Kharif*, summer, rice fallow and *Rabi* season. Its maturity duration is 75-80 days and average grain yield is 9-10 q/ha with 5.0 g 100-seed weight

IPU 17-2: The variety has been developed by crossing PGRU 95027 x DPU 88-31. This variety has shown multiple diseases resistant and suitable for *Kharif* season cultivation in Madhya Pradesh. It matures in 73-74 days with average grain yield of 10-11 q/ha.

Birsa Urd 2 (RUB 12-02): Urdbean variety Birsa Urd 2 (RUB 12-02) has been developed from a cross of Pant U 19 x Mash 114. This variety has resistant to CLS and moderately resistant to YMV. It has been recommended for *Kharif* cultivation in Jharkhand state. It matures in 80-85 days with average grain yield of 10-12 q/ha.

Lentil

Kota Masoor 4 (RKL 58 F 3715): This large seeded variety is a derivative of spontaneous mutant of DPL 62. It is early maturing (105 days) with average grain yield of 1876 kg/ha. It has resistance to rust & *Stem phylium* blight and moderate level of resistance to wilt. It has been released and notified for central zone (CZ) comprising states of Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, Bundelkhand region of Uttar Pradesh and Southern–East parts of Rajasthan.

Pant L 11 (PL 164): A large seeded lentil variety derived from the cross of DPL 15 × L 4188. It is resistant to rust and moderately resistant to pod borer. It matures in 122 days with average grain of yield 11-12 qt/ha. It has been released and notified in 2021 for cultivation in state of Uttarakhand.

IPL 329: This is a large seeded variety developed by crossing KL 178 and DPL 62 as parents. It matures in 115-134 days with 1012 kg/ha average grain yield. It has resistance to major diseases of lentil like wilt and rust. It has got released & notified for the cultivation in whole Uttar Pradesh.

IPL 225: This is a small seeded variety derived from three way cross (DPL 44 × DPL 62) × DPL 58. It matures in 105-120 days with an average yield of 10-11 qt/ha. It is resistant to wilt and rust disease. It is released & notified for cultivation in whole Uttar Pradesh.

Bidhan Lentil 16 (BL 16): A small seeded variety developed from the cross of LL 56 × L 4710. It matures in 109-132 days with average yield 1552 kg/ha. It is resistant against Stem phyllium blight and Collar rot. It has 24.5 per cent protein. Thus variety has been released and notified for cultivation in West Bengal.

Jammu Lentil 144: This is small seeded variety derived by crossing ILL10829 × ILWL 30 as parents. It takes 120-125 days to mature and produce 11-12 q/ha average grain yield. It is resistant to wilt and root rot. This variety has been released and notified for cultivation in Jammu and Kashmir.

Jammu Lentil 71: A medium seed size variety developed from the cross of ILL 8006 × ILWL 62. This variety matures in 140-145 days with average grain yield of 10-11 q/ha. It is resistant to major diseases like wilt and root rot. It has been released and notified for cultivation in Jammu and Kashmir.

Fieldpea

HFP 1428: It is dwarf type variety with grain yield potential of 25-26 q/ha and matures in 120-125 days. It is resistant to powdery mildew, *ascochyta* blight & root rot and moderately resistant to rust. This variety has been released and notified for the North Western Plain Zone (NWPZ) comprising states of Punjab, Haryana, Delhi, Rajasthan, Uttarakhand, parts of J & K and western Uttar Pradesh.

Pant Pea 347 (Pant P 347): This is a dwarf type variety derived from the cross of Pant P 13 × IPFD 08-3. The average yield of this variety is 25-26 t/ha and it matures in 124 days. It is resistant to powdery mildew & ascochyta blight and moderately resistant to rust and root rot. This variety has been released and notified for the North West Plain Zone comprised of Punjab, Haryana, Delhi, North-West & Central Rajasthan, Western Uttar Pradesh and Plains of Uttarakhand and Jammu & Kashmir.

Pant P-195: This variety is developed from the cross between Pant P-13 and IPFD 1-10. Its' average grain yield is 1479 kg/ha with maturity duration of 123 days. It is resistant to powdery mildew and rust disease and moderately resistant to pod borer. It is released and notified for cultivation in Uttarakhand.

IPFD 16-3: This variety is derived from the cross of IPFD 99-13 and VRP-3. It has yield potential of 2733 kg/ha with average grain yield of 1646 kg/ha. It is resistant to powdery mildew, rust and *Ascochyta* blight diseases. It has medium, round, smooth and creamish white colour seed with yellow cotyledon. It has been released and notified for cultivation in entire Uttar Pradesh.

Rajmash

Badwerwah Rajmash 104 (BR 104): This variety is derived from the local germplasm line through selection. This variety matures in 125-130 days with average grain yield 6-8 q/ha. It has tolerance to the most of the prevailing diseases. It is released and notified for cultivation in *Kharif* season in Jammu and Kashmir.

Sikkim Rajmash 1 (SKR 57A): This variety is also developed by selection from the local germplasm line. It matures between 100 and 105 days with average grain yield potential of 10-12 q/ha. It is tolerant to BCMV and *anthracnose* disease. It has been released and notified for *Rabi* season cultivation in Sikkim.

Breeder Seed Production

In mungbean, the total breeder seed production was 1074.44 q against the indent of 460.22 q for 44

indented varieties.

In urdbean, the breeder seed production was 594.87 q against the indent of 405.00 q for 57 indented varieties.

In lentil, the total breeder seed production was 857.36 q against the indent of 547.44 q for 45 indented varieties.

In fieldpea, the total breeder seed production was 940.45 q against the indent of 782 q for 25 indented varieties.

In lathyrus, the total breeder seed production was 90.55 q against the indent of 109 q for four varieties.

Plant Genetic Resources

A total of 11,825 germplasm lines of mungbean and rdbean were maintained at different centres during 2021-22, out of this, total 6949 germplasm of mungbean and 4876 germplsm lines of urdbean.

A total of 13,204 accessions including lentil (6,104), fieldpea (1,885), lathyrus (2,553) and rajmash (2,662) were maintained at different centres and many of them were evaluated for different traits during *Rabi* 2021-22.

Crop Production

Foliar application of NPK (18:18:18) @ 2% + $ZnSO_4$ @ 0.5 % twice at pre-flowering and pod initiation was found effective for maximizing the grain yield, net return and B:C ratio in mungbean and urdbean.

Biofortification through foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at flower initiation and pod initiation was found better for higher grain yield (1186 kg/ha) and economic return (net return ₹. 38,606/ha and B:C ratio 2.26) of mungbean.

Application of Fomesafen @ 220 g + Fluzifop p butyl at 220 g/ha at 20 DAS as post-emergence was found effective in mungbean and urdbean for controlling weeds and gave higher grain yield, net return, B:C ratio and maximum weed control efficiency at 30 and 45 DAS over weedy check (76.8 and 68.7 per cent) closely followed by application of Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS (891 kg/ha).

Fortification of zinc and iron in lentil and fieldpea either through foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at flowering and pod initiation or through soil application of $ZnSO_4$ @ 20 kg/ha played important role in realizing higher grain yield and economic return and B:C ratio.

Sowing of fieldpea seeds either soaked in water for 6 hours or primed with 1% KNO_3 in standing rice field as relay crop @ 120 kg/ha was found effective for enhancing grain yield (1,000-1,200 kg/ha).

Sowing of lathyrus seeds (soaked in water for 3-4 hrs) in standing rice field as relay crop @ 80 kg/ha followed by foliar application of NPK 19:19:19 @ 0.5 % at pre flowering and pod initiation was found effective for enhancing grain yield.

Rhizobium isolate AKMR-19 (Akola) outperformed the others evidenced by 21.1% higher grain yield over the uninoculated control in multilocation trial of mungbean.

Combined use of PGPR (*Bacillus cereus* NE-10) in mungbean with *Rhizobium* improved root nodulation and grain yield, by 7.2%, over *Rhizobium* alone.

Stenophomonasrhizophila PUK 171 (Pantnagar) in combination with *Rhizobium* was found superior to other PGPRs in urdbean by producing 7.3% more grain yield than *Rhizobium* alone inoculation across the locations.

Rhizobium inoculation + soil application of 20 kg P_2O_5 + 25 kg $ZnSO_4$/ha produced maximum grain yield of lentil than the dual inoculation of different nutrient mobilizing bacteria with *Rhizobium*, being 25.6% more over uninoculated control and 8.4% more over *Rhizobium* alone inoculation.

Consortia biofertilizer application in lentil as fortified FYM of Pantnagar and Ludhiana gave higher mean grain yield of 4.7% and 3.4%, respectively at three locations (Pantnagar, Ludhiana and Mohanpur) than their seed treatment. These treatments at these locations showed 12.1 and 8.9% more mean grain yield, respectively as compared to seed treatment through *Rhizobium* alone.

Application of *Rhizobium* + Bioformulation *Archaea Halolamina*sp CD7 + BioNPK (NBAIM) was found superior to other evaluated formulations by recording the highest root nodulation and mean grain yield of 13.0% over inoculation by *Rhizobium* alone and 26.6% over farmer's practice across the locations.

Crop Protection

Field screenings for identification and validation of promising genotypes for multiple diseases and insect-pest were conducted in all crops.

Development of IPM modules for management of major insect pests of mungbean by

minimum insecticide useconducted at different locations to compare with local farmers practices. The IPM modules found effective in reducing insect-pests incidence and gave more yield and net return

The management of pod bug, *Clavigralla gibbosa* on mungbean conducted at different locations indicated that foliar sprays of homemade *neem* formulation @ 3,000 ml/ha followed by Deltamethrin 2.8 EC @ 500 ml/ha found effective as incidence of pod bug were at par with two foliar spray of chemical insecticide.

In urdbean, the IPM modules comprises 1. Seed treatment with (Tebuconazole 50%+Trifloxystrobin 25WG) @ 1.5 ml/kg seed, thiamethoxam 35 FS @ 5.0 g/kg and *Rhizobium* inoculation, 2. Growing of millet crop in one row around the field as barrier crop, 3. Monitoring with yellow sticky trap @ 50 per ha (sucking in sect pests), 4. Monitoring of *Helicoverpa* from flowering initiation stage with pheromon etraps @ 10/ha (Pod borer), 5. Spraying of *Neem* based insecticides at 30 days after sowing, 6. Need based application of the insecticides Diafenthiuron 50 WP @ 312.5 g a.i./ha or Pyriproxyfen 10 EC 100 g a.i/ha for sucking insect pests (Location where sucking pest is major problems),7. Need based application of the insecticides Chlorantarniliprole 18.5 SC @ 20 g ai/ha for pod borer complex (Location where pod borer is major problems) were conducted at four locations (Shillongani, Ranchi, Ludhiana and Vamban) over local farmers practices. The IPM modules found effective in reducing insect-pests incidence and gave more yield and net return.

Management of pod bug, *Claviralla gibbosa* in urdbean using foliar sprays of commercial Azadirachtin 1% EC @ 1,000 ml/ha followed by Dimethoate 30 EC @ 500 ml/ha found effective in reducing pod bug population and gave higher yield.

Incidence of insect-pests in relation to weather parameters in lentil revealed that the aphid incidence was significantly positively correlated with minimum & maximum temperature as well as sunshine hours and significantly negatively correlated with minimum RH at Mohanpur. Pod borer incidence had non-significant correlation with the weather parameters at all other locations.

Evaluation of the bio-intensive IPM module (BIPM) against major insect pests of fieldpea revealed that the BIPM module was more effective as compared to the farmers' practice. The BIPM module resulted in reducing the population of the sucking pests (aphid, leaf miner, jassid, *etc*.) and pod borer, as well as pod damage due to the pod borer.

Incidence of insect-pests in relation to weather parameters in fieldpea indicated that aphid incidence was significantly positively correlated with maximum RH and evening RH at Pantnagar and Varanasi, respectively and significantly negatively correlated with maximum temperature and sunshine hours at Varanasi. Pod borer infestation was significantly positively correlated with minimum & maximum temperature as well as wind speed at Mohanpur and Varanasi and significantly negatively correlated with maximum temperature at both Varanasi and SK Nagar.

Among the biorational and chemical insecticide treatments, T4 comprising of foliar spray of Imidacloprid 17.8 SL @ 0.3 ml per litre was found significantly superior over rest of the treatments in terms of per cent reduction of aphid population in lathyrus.

Frontline Demonstrations

Package technology in *Kharif* mungbean and urdbean witnessed 27 and 25 per cent higher grain yield, respectively, over local farmers practices.

Adopting package technology in *Rabi* season in mungbean and urdbean accomplished 20 and 17 per cent increase in grain yield, respectively.

Package technology in lentil showed 23 per cent increase in grain yield over the farmers' practices with 32 per cent more monetary benefits in terms of net return.

Under rice fallow situation, 32 per cent increase in grain yield of lentil was recorded over the farmers' practices with 32 per cent more monetary benefits in terms of net return.

Package technology exhibited 36 per cent growth in grain yield in field pea over the farmers' practices with more than 35 per cent monetary benefits in terms of net return.

All India Co-ordinated Research Projects
Arid Legumes

Crop Improvement

Variety Developed:

Cowpea

GC 7 (Banas Tejas) GC 1501: This variety is derived from the cross of GC 2 x PGCP 1 followed pedigree method. It has medium, attractive lustrous seeds of 7.85 g test weight with light brown colour. It showed very less infection ofroot rot, yellow mosaic virus and *Cercospora* leaf spot diseases. The average yield of this variety is 1092 kg/ha with 69 days maturity and 21.18 per cent protein content. Hence, it has been recommended for cultivation in the state of Gujarat.

Phule Sonali: This elite variety is evolved from a cross of RC 101 x Phule Vithai. It is early with compact growth habit suitable for multiple cropping patterns. It is resistant to dry root rot andmoderately resistant to YMV. This variety has an average yield of 1392 kg/ha with 72-75 maturity duration. Hence, it has been recommended for cultivation in the state of Maharashtra.

Shalimar Cowpea-2 (SKUA-WCP-149): The variety Shalimar cowpea-2 is developed from two local landraces, SKUA-WCP-17 and SKUA-WCP-76. This variety is resistant to cowpea mosaic virus and Ascochyta blight. It is tolerant to drought stress and can be grown under rainfed conditions. This variety has an average yield potential of 1200 kg/ha with 110-116 maturity duration. Thus, it has been recommended for cultivation in Jammu and Kashmir.

Clusterbean

RGr 18-1 (Karan Guar-14): This variety has been developed through pedigree method from the hybridization between RGC 1038 and RGC 1017. Suitable for both irrigated and rainfed conditions under normal fertility levels in *Kharif* season. This variety has resistant to major diseases like bacterial blight and root rot & insect pests and has good gum content with high viscosity profile. This variety average yield is 1222 kg/ha with 92-100 days maturity. Hence, it has been recommended for cultivation in Rajasthan, Gujarat, Haryana and Maharashtra.

National Crossing Programme

For generating variability intra and inter-specific hybridization crosses were attempted, and desirable recombinants were selected and advanced further. A total of 252 crosses were synthesized comprises of 150 in cowpea, 54 in horsegram and 48 in clusterbean.

Multi-location Evaluation

Multi-location trials were carried out to identify high yielding and disease resistant varieties of arid legumes. Under plant breeding programme during *Kharif* 2021, newly contributed entries and promoted entries were evaluated through 8 main centres and 33 voluntary centres. Overall, 66 trials were allotted to different centres and results of 66 trials were reported. Out of 66 trial's data, 53 were used for computing the average yield of zone. At some locations, trial failed due to erratic weather condition. Data of few centres could not be accepted due to high C.V. or very poor yield (Mean yield of the location was very law).

Plant Genetic Resources

A total of 4,281 germplasm lines were maintained at centres. Out of this, Cowpea 2185, Guar 844, Horsegram 952 and Moth bean 300.

Breeder Seed Production

In the case of four Arid Legume Crops, BSP indent of 138.03 q was received from DAC & FW. Total of 188.97 quintals of breeder seed was produced against the allocation of 154.90 q. In the case of guar, 147.79 q of breeder seed was produced against the national indent of 74.33 q of 10 varieties. In cowpea, an indent of 34.30 q of 5 varieties was received and 16.95 q of breeder seed was produced. In mothbean, DAC indent of 20 q of RMO-2251 was received and 7.0 q of breeder seed was produced. In horsegram, indent of 9.40 q of 7 varieties was received. Total 17.23 q of breeder seed was produced against the allocation of 11.50 q.

Agronomy

Experiments conducted: 7

In case of cowpea & clusterbean, foliar application of soluble NPK (19:19:19) @ 1% at flower initiation & pod formation stage, while in horsegram

at pod formation stage recorded significantly higher seed yield) as compared to all other treatments.

Cultivation of *Kharif* cowpea with 30 cm row spacing along with basal application of 75% RDF (15 kg N and 30 kg P_2O_5 kg/ha) gave higher net returns and benefit cost ratio.

In horsegram, two hand weedings at 15-20 DAS and 35-40 DAS gave the highest seed yield (960 kg/ha). Amongst herbicidal treatments, the highest seed yield (880 kg/ha) was obtained with treatment (T6) imazethapyr @ 40 g a.i./ha as PoE at 15 – 20 DAS.

For integrated nutrient management in clusterbean, 100% RDF + seed treatment with *Rhizobium* + PSB + 1% 19:19:19 spray gave the highest seed yield of 1247 kg/ha.

To understand the effect of broad-spectrum post emergence herbicide on weeds in horsegram trial was conducted and the post emergence application of Clodinafop propargyl 8% + Aciflourfensodium 16.5 @ 500 ml/ha at 15- 20 DAS gave more seed yield (1085 kg/ha) over other weed control treatments.

Plant Pathology

Experiments conducted: 7

For the management of *Alternaria* blight of clusterbean, an experiment was conducted at Bikaner, RSKVV, Gwalior; RARI, Durgapura, and S.K Nagar, Gujarat. At ARS, Bikaner, Gwalior, and S. K. Nagar, foliar spray with Tebuconazole 250 EC @ 0.1% was found the most effective in reducing *Alternaria* blight intensity and increasing grain yield, while, at RARI, Durgapura centre, minimum *Alternaria* blight (4.8%) was recorded in foliar spray with Propiconazole 25 EC @ 0.1% followed by foliar spray with Chlorothalonil @ 0.2 % (5.00%).

To estimate the yield loss for the major diseases at hot spot, location trial was conducted in mothbean and cowpea. In the case of mothbean treated seeds, yield was higher in all three varieties as compared to untreated seeds and yield losses were 32.97, 23.52 and 21.20%, respectively. In cowpea, results revealed that the minimum disease incidence and maximum yield observed in susceptible variety with management practices seed treatment with thiram @ 2 g/kg seed+carbendazim @ 1 g/kg seed as compared to without management practices and maximum disease incidence for *Anthracnose*, root rot, collar rot observed in susceptible variety without management practices.

Entomology

Experiments conducted: 3

Two sprays of Azadirachtin 1,500 ppm @ 4 g/lit. or Beauveria *bassiana* 1.15 WP 5g/lit 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 cowpea at Bikaner.

Spray of *Verticillium lecanii* or *Beauveria bassiana* @ 1.15 WP 5 g/litre was found effective and economical for the management of sucking insect pests in cowpea at Durgapura.

Quality characters

In guar IVT genotypes, the highest carbohydrate content was recorded in the DRLGG 13-39 (44.06%) and maximum endosperm content (33.80%), gum content (29.67%), and viscosity (3562 cp) were observed in GD 565. Similarly, in AVT genotypes, the highest carbohydrate content was recorded in the national check RGC 1066 (43.88%). While, maximum endosperm content (32.93%), gum content (28.87 %), and viscosity (3525 cp) were observed in RGr 20-7.

In cowpea, IVT genotypes protein content ranged between 23.02 and 25.93 per cent and the highest protein content was in the DC 18-1 (25.68%). The cooking time of cowpea genotypes was in the range of 23 to 53 minutes and maximum and minimum cooking time was recorded in GP-1 (49 min) and PMCP 1018-1 (24 min), respectively.

Frontline Demonstrations

A total of 125 frontline demonstrations were allotted to 15 cooperating and voluntary centres of AINP on Arid Legumes. One hundred and two demonstrations were organized by different centres in cowpea, guar, mothbean, and horsegram.

- Adopting package technology in cowpea achieved a 25 per cent yield advantage over the farmers' practices.
- Package technology adoption in clusterbean witnessed 24 per cent higher grain yield over local farmers' practices.
- In mothbean, the grain yield advantage of 20 per cent was obtained using package technology over the local practices.
- Package technology demonstrated 29 per cent grain yield superiority over the traditional practices in horsegram.

Transfer of Technology

Training Programmes

S. No.	Activity	Duration	No. of participants	Participants
Training conducted under Farmers FIRST project				
1.	Three days women farmers of *Namami Gange Mahila Krishi Udyog Samiti, Khadra*, Fatehpur training programme on "Pulses Processing Technology"	08/02/2022-10/02/2022	11	Farmers of Fatehpur district under Farmer FIRST project
2.	One day training Programme on "Pod borer management in chickpea"	07/03/2022	56	Farmers of Fatehpur district under Farmer FIRST project
3.	Online training programme on "Fish farming for entrepreneurship development" in collaboration with ICAR -National Bureau of Fish Genetic Resources, Lucknow and ICAR - IIPR, Kanpur	15/03/2022-17/03/2022	18	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project
4.	Three days online collaborative training programme on "Improved Poultry Production" in collaboration with ICAR - Central Avian Research Institute, Izzatnagar, Bareilly and ICAR-IIPR, Kanpur, Uttar Pradesh	11/04/2022-13/04/2022	18	Farmers of Fatehpur district under Farmer FIRST project
5.	Farmers training programme on "Improved paddy production technologies"	14/06/2022	30	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project
6.	Farmers training programme on "Efficient & balanced use of fertilizer"	21/06/2022	53	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project
7.	Farmers training programme on "Production technology of *kharif* pulses"	21/06/2022	129	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project
8.	Training programme on "Entrepreneurship development in mushroom production"	23-24/09/2022, 11-12/10/2022, 27-28/10/2022, 3-4.11/2022	07	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project
9.	Farmers training programme on "Improved production technology of rabi pulses"	17/10/2022	129	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project

S. No.	Activity	Duration	No. of participants	Participants
10.	Farmers training programme on "Crop protection technology on *rabi* pulses"	05/12/2022	42	Farmers of Fatehpur district under Farmer
Trainings/Workshop conducted under Division /ABIU				
11.	Workshop on "Agribusiness Opportunities in Pulses"	27/09/2022	204	Graduate & Post Graduate students of Rama University, Kanpur
12.	Training programme sponsored by NABARD Arise Foundation for farmers of Gwalior, Madhya Pradesh	07/03/2022-08/03/2022	21	Farmers of NABARD Arise Foundation, Gwalior, M.P.
13.	Training programme on "Improved Pulse Production Technology" under ATMA, Narsinghpur, Madhya Pradesh	14/03/2022-17/03/2022	08	Narsinghpur, Madhya Pradesh
14.	Farmers training programme under ATMA, Ayodhya	21/03/2022	41	Farmers of Ayodhya, Uttar Pradesh
15.	Training programme of farmers of ATMA, Deoriya	23/03/2022	55	Farmers of Deoria, Uttar Pradesh
16.	Inter-state training programme on improved production technologies of *kharif* pulses for farmers under ATMA, Pakur, Jharkhand	26/03/2022-28/03/2022	36	Farmers of Pakur, Jharkhand
17.	Training programme of Udghos Agro Farmer Producer Organization members of Khajuha, Fatehpur	28/03/202-29/03/2022	04	Udghosh Agro FPO members of KhajuaFatehpur
18.	Inter-state training programme under OIIPCRA, Keonjha, Odisha	08/04/2022	20	Keonjha, Odisha
19.	Training programme for board of Directors and CEO of Atmashakti Evam Divyashakti Farmers Producer Organization	14/06/2022-16/06/2022	19	Directors and CEO of Atmashakti Evam Divyashakti, FPO Fatehpur
20.	Training programme of Board of Directors and CEO of Udghos Agro Farmer Producer Organization members of Khajuha, Fatehpur	28/06/2022-30/06/2022	12	Directors and CEO of Udghos Agro Farmer Producer Organization members of Khajuha, Fatehpur
21.	Online Collaborative training programme on "Entrepreneurship Development in Pulses" organized by ICAR -IIPR, Kanpur & MANAGE, Hyderabad	03/08/2022-05/08/2022	150	Farmers, Students, Researchers, Acadmecian & Stakeholders of all over India
22.	Online Collaborative training programme on "Entrepreneurship Development in Pulses" organized by ICAR -IIPR, Kanpur & MANAGE, Hyderabad	01/11/2022-03/11/2022	64	Farmers, Students, Researchers, Acadmecian & Stakeholders of all over India

Interaction with stakeholders

S. No.	Activity	Duration	No. of participants	Participants
1.	Farmer-Scientist interaction on "Pulse processing and value addition technology for farmers of Fatehpur, Uttar Pradesh	27/03/2022	50	Farmers of Fatehpur district of Uttar Pradesh under Farmer FIRST project

Exposure visit at ICAR-IIPR, Kanpur

S. No.	Date	No. of participants	Details of participants
1.	18/01/2022	38	Farmers of Jhansi district of Uttar Pradesh under ATMA, Jhansi
2.	21/02/2022	14	Farmers of Ashok Nagar district of Madhya Pradesh
3.	28/02/2022	18	Farmers of Bhind district of Madhya Pradesh
4.	26/08/2022	47	Farmers of Auraiya district of Uttar Pradesh
5.	17/09/2022	40	Input dealers of Unnao district of Uttar Pradesh under DAESI project
6.	30/09/2022	38	Input dealers of Unnao district of Uttar Pradesh under DAESI project
7.	17/11/2022	33	Farmers of Shaajahanpur, Uttar Pradesh
8.	24/11/2022	38	Under- Graduate students of Narauli, Jaunpur, Uttar Pradesh
9.	14.12.2022	32	Farmers of Satna, Madhya Pradesh under ATMA project
10.	15.12.2022	124 (120 Students & 04 Faculty members)	Under-graduate students and faculty members of Chhatrapati ShahuJi Maharaj University, Kanpur, Uttar Pradesh

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Online Lecture on "Transgenic Seed Production Technology in Pulses and their certification system", at Training on "Seed Quality Parameters and Production Technology of Pulses Crops", 8th February, 2022, IIPR, Kanpur)(Alok Das)

Online Talk on "Pulses and their Improvement for Food and Nutritional Security", at ICAR-Indian Institute of Horticultural Research, Bengaluru, 10th February, 2022)(Alok Das)

Online talk in International conference on "Biotechnological initiative for climate resilient agriculture" from January 7-9, 2022 through hybrid mode by Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar,(Meenal Rathore)

Online lecture onRole of DNA Marker Technology in Refining Maintenance Breedingin Training programme on Maintenance breeding in Pulse crops, 24-25 January, 2022 at ICAR-IIPR,Kanpur. (Meenal Rathore)

Oral Presentation "Pulses at Crossroads: Time to embrace Innovations", Session I (Biotechnological Intervention for Crop Improvement), International Conference on Biotechnological Initiatives for Climate Resilient Agriculture-2022, Dr Rajendra Prasad Central Agricultural University, Samastipur, Pusa, 8th January, 2022 (LEAD TALK)(Alok Das)

Oral Presentation on "Gene Editing in Pulses", Workshop on Genome Editing in Agriculture: Science, Potential and Policies, NBRI, Lucknow, 6th July, 2022)(Alok Das)

Oral presentation on Biotechnological interventions for pulse improvement in NAHEP funded training on Pulses as the climate smart crops for resource conservation and economic intensification/diversification of cropping systems' on 3.3.22 at ICAR-IIR, Kanpur (Meenal Rathore)

Plant Physiology Webinar Highlighting "Gene Editing and its Applications" American Society of Plant Biology, USA, 28 April, 2022)(Alok Das)

Role of plant chitinases in chickpea defence systems in response to herbivory" in the annual convention and national e-Conference on "Emerging Trends in Agricultural and Biological Sciences (ETABS-2022)", Session VII: Agricultural Sciences II, on January 15, 2022, 1400–1530 hrs. on a virtual platform organised by Society of Bioinfromatics and Biological Sciences (SBBS), Prayagraj, India. (Lead speaker- Aravinda K Konda)

Special Lecture on "Genome Editing in Plants", Department of Life Sciences and Biotechnology, Chhatrapati Shahu Ji Maharaj University, Kanpur, 25 August, 2022)(Alok Das)

Talk on "Plant Tissue Culture based innovations for genetic gain in chickpea (*Cicer arietinum* L.), International Symposium on "Advances in Plant Biotechnology and Nutritional Security" & 43 rd Annual Meeting of Plant Tissue Culture Association (India), ICAR-National Institute of Plant Biotechnology, New Delhi, 28-30 April, 2022)(Alok Das)

Talk on "Genome Editing in Plants" National Conference on Recent Innovations in Agricultural and Allied Sciences for Livelihood Security, Rama University, Kanpur, 21-11 October, 2022 (LEAD TALK)) (Alok Das)

Virtual talk: From Innovative Ideas to Scholarly Books and Open Access in Biological Sciences organized by Taylor and Francis and BRSI, India on 17.10.22 (participation – Meenal Rathore)

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Abstract/executive summary

Datta, A. "Impact of elevated CO2, temperature on soil-plant phosphorus relations, physiological functions, and yield of chickpea (Cicer arietinum L.) in alkaline Vertisol of central India" in 'XV Agricultural Science Congress & ASC Expo' organized by National Academy of Agricultural Sciences and Banaras Hindu University at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi from November 13-16, 2021.

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Training and Capacity Building

- Lamichaney Amrit organised 7 days training programme on Seed quality parameters and production technology in pulse crops on February 3-9, 2022 at ICAR-IIPR, Kanpur.
- Lamichaney Amrit organised 2 days training programme on Maintenance breeding in pulse crops on January 24-25, 2022 at ICAR-IIPR, Kanpur.
- Lamichaney Amrit organised 2 days training programme on Management of storage pest in Pulses on March 14-15, 2022 at ICAR-IIPR, Kanpur.
- Parween N, Sekharwar RS, Kumar Y, Mondal B, Syed Md Quatadah, Singh N, Yadav D (2022). Phenotypic and genetic analysis of chickpea genotypes and role of heat tolerance indices in selection of heat tolerance lines. In: Regional Conf. on prioritizing crop specific technologies for sustainable profitability jointly organised by National Education Empowerment and Development Foundation (NEEDEF) & ICAR-IISR from 29-30 April 2022 at Lucknow
- Srivastava AK, Kumar Y, Kumar R, Jha UC, Mondal B, Dixit GP (2022) Screening chickpea breeding lines for resistance against race 2 of Fusarium wilt in India. In: Intern Conf on Pulse Research (ICPR-2022) under theme Stress physiology: adaptation and management of abiotic and biotic stress organized by Society for plant and agricultural sciences (SPAS) on 10.02.2022
- AK Parihar attended lecture of Prof. Hermann Buerstmayr, Univ of Natural Resources and Life Sciences, Vienna, Deptt. of Agro biotechnology Tulln, Institute of Biotechnology in Plant Production, Konrad Lorenz Str. 20, Tulln delivered on Challenges for crop improvement in times of global change during Azadi Ka Amrut Mahotsav organized by CCSHAU Hisar on 1.12.2021
- AK Parihar attended a brainstorming session on Intensification and sustenance of Pulses in NHZ organized in hybrid mode by IIPR; CSKHPKV, Palampur and ISPRD on 24.09.21.
- AK Parihar attended a webinar on 'Sustaining growth in pulses' organized by ICAR-IIPR, Kanpur and ISPRD on the occasion of 'World Pulses Day' celebration on 10th February 2022.
- AK Parihar attended AGM on spring/ summer/rice fallow (2020-21) on 6.12.2021 (Online).
- AK Parihar attended International Webinar on 'Role of Legumes and Pulses in Sustainable Cropping System of Hot Arid Zone' at SKRAU, Bikaner (India) on 17.07.2021.
- AK Parihar attended XXV Meeting of ICAR Regional Committee-III by ICAR on 11.12.2021 (virtual)
- AK Parihar participated in 'An Evening with World Food Prize Laureates' Discussion on Global Food and Nutrition Security to meet the SDGs during and after Covid 19 Pandemic on the occasion of World food day celebration (16.10.21)
- AK Srivastava participated in International Conference On Pulse Research (ICPR-2022) (Online) on 10 February, 2022
- AK Srivastava participated in Webinar on KRISHI Portal (Online) on 14 February 2022
- AK Srivastava participated in Webinar on Sustaining growth in pulses on 10 Feb 2022
- AK Srivastava participated in Webinar on Use AI and ICT in Agriculture Information Access and Dissemination (Online) on 14 March 2022
- AK Srivastava participated in Webinar on Biofortified Crops for Balanced Nutrition and Immunity Boosting (Online) on February 28, 2022
- Basavraja T has served as Poster Session Committee in National WebCon on Sustaining Pulse Production for Self-sufficiency and Nutritional Security Feb. 9-11, 2021
- Basavraja T has served as publication committee member in National WebCon on Sustaining Pulse Production for Self-sufficiency and Nutritional Security Feb. 9-11, 2021
- Basavraja T was attended Online International Training Program on "Bio fortification: A Key to Nutritional Security" during July 12-14, 2021 at MANAGE and organised by MANAGE, Hyderabad and Harvest plus partners

- Basavraja T was organized Field Meeting for visit of CIAT & Alliance of international Biodiversity scientist for reviewing Common bean biofortification experiment on 15th February, 2O21 at Main Research farm & NRC, IIPR, Kanpur
- Basavraja T was participated and presented poster in National WebCon on sustaining pulse production for self-sufficiency and nutritional security organized by IIPR-ISPRD & ICAR New Delhi Feb. 9-11, 2021.
- Basavraja T was participated in AICRP on MULLaRP Annual group meet on Rabi Crops on August 117-18, 2022 oraganised by IIPR at IGKV Raipur, Chhattisgarh.
- Basavraja T was participated in AICRP on MULLaRP Annual group meet on Kharif pulses Crops organised by IIPR Kanpur though virtual mode/Zoom meeting on May, 27-28, 2021.
- Jitendra Kumar participated in National Webinar on Genome Editing in Vegetable Crops for Improvement of Quality and Stress Tolerance, ICAR-IIVR, Varanasi, UP, 26th April, 2022
- Jitendra Kumar participated in Annual Group Meet of AICRP on Rabi Pulses (Aug 17-18, 2022), IGKVP, Riapur, Chhattisgarh
- Jitendra Kumar participated in Webinar on Intellectual Property Rights, NIPAM, DPIIT, GoI, Kolkata, 21April 2022.
- Yogesh Kumar attended in brainstorming meeting during World Pulse Day jointly organized by ISPRD and ICAR-IIPR Kanpur on 10.02.2022 (Online)
- Yogesh Kumar attended in the UP State Varietal Release Committee meeting at Krishi Bhawan, Lucknow, Uttar Pradesh (Online) on 23.03.2022
- Yogesh Kumar attended International Conference on Pulses Research (ICPR-2022) organized by society of plant and agricultural science 10.2.2022 online
- Yogesh Kumar attended training 'Maintenance Breeding in Pulses Crop' organized by ICAR-IIPR Kanpur from 24-25 Jan 2022 at Kanpur
- Yogesh Kumar participated in NASF project presentation meeting organized by ADG, NASF, ICAR, New Delhi for externally funded project jointly submitted by ICAR-IIPR & ICRISAT Hyderabad on 'Utilizing novel genes from wild Cicer species for restructuring plant type, disease resistance and post-emergence herbicide tolerance in chickpea'
- Yogesh Kumar participated in the Farmers-Scientist interaction meet on 20.01.2022 at Krishi Vigyan Kendra, Belatal, Mohoba under BAUT, Banda, Uttar Pradesh
- Yogesh Kumar participated in the Farmers-Scientist interaction organized by ICAR-IIPR Kanpur on 23.12.2022 at Khadra village of Fatehpur district, Uttar Pradesh
- Organized webinar on webinar on "Sustaining growth in pulses on 10.2.22 in collaboration of ISPRD and ICAR-IIPR, Kanpur (Meenal Rathore)
- Hands on Training on "Genetic Engineering of Pulses and Beyond" 16-18 November, 2022 organized by Division of Plant Biotechnology, ICAR-IIPR, Kanpur and sponsored by Society for Plant Biochemistry and Biotechnology, New Delhi. (Organizing secretaries: Dr Alok Das and Dr Meenal Rathore; Committee memebers-Sudhir Kumar, Neetu S kushwah, Soren KR, Aravinda Konda, Shanmugavadivel PS, Antara Das, Malkhan Singh))
- Two Institutional Biosafety Committee Meetings (23 July, 2022 and 30 December, 2022) (Alok Das as Member Secretary, IBSC)
- Ten days virtual training program on "QTL analysis and genome-wide association studies" from February 15-24, 2022.The training was organised byDivision of Agricultural Bioinformatics, ICAR-Indian Agricultural Statistics Research Institute, New Delhi (Meenal Rathore, Neetu S Kushwah, Sudhir Kumar)
- Seven days training on "Genetically Engineered (GE) Plants: Biosafety Considerations, Policies, Challenges and Detection Strategies" from 19-25 July, 2022. The training was organised byICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi (Neetu S Kushwah).
- Three-day workshop on "Basic statistical techniques and its applications in genetics" during August 03-05, 2022 at ICAR-Indian Agricultural Statistics Research Institute, Library Avenue, Pusa, New Delhi. (Neetu S

Kushwah).

- Namrata Laskar attended ICAR sponsored 10 days short course on "Pulses as the climate smart crops for resource conservation and economic intensification/diversification of cropping systems" organized by ICAR-Indian Institute of Pulses Research, Kanpur, UP during 2-11 March, 2022.
- DP Patel delivered lecture on "Plant ideotype and physiological approaches for climate change adaptation and mitigation in plants" in ICAR- Sponsored Short- Course on "Pulses as the climate smart crops for resource conservation and economic intensification/ diversification of cropping systems" organized by ICAR-IIPR, Kanpur during March 2-11, 2022.
- DP Patel delivered lecture on "Nutrient Management in Pulses" in a Farmers training programme on "Improved Pulse Production Technology" organized by Social Science Division, ICAR-IIPR, Kanpur held during March 14-17, 2022.
- Manmohan Deo attended a webinar on texture analysis organized by CIAE, Bhopal on 29-07-2022.
- Manmohan Deo attended one day workshop on Precision agriculture organized by INAE in online mode on 10-01-2022.
- Manmohan Deo attended virtual workshop on Global food and nutritional security, and sustainable development through major and minor pulses organized by NAAS, New Delhi on 14-10-2022.
- Manmohan Deo attended webinar on "Interface between innovators and industry" in online mode organized by NRFMTTI, Hisar held on 28-04-22.
- Narendra Kumar attended 3rd International Weed Conference on "*Weed problems and management challenges: Future perspectives*" during 20-23 December, 2022 at Anand Agricultural University, Anand, Gujarat (India).
- Narendra Kumar attended 8th International Weed Science Congress on "Weed Science in a Climate of Change" (IWSC2022) during 4-9 December, 2022 at Bangkok, Thailand.
- Raghvendra Singh attended "Meeting on finalization of project proposal, Incentivizing Non-paddy Crops and System Intensification with Kharif pulses through Improved Production, Aggregation, Value addition and Marketing of Arhar in Odisha,' under the scheme IAP State plan 2022-23 on Feb 24, 2022.
- Raghvendra Singh attended and presented paper in 5th Organic Asia Congress and the 10th IFOAM Asia Anniversary held in Gosean County, South Korea during October 13-15, 2022.
- Raghvendra Singh attended Kisan Pathshala and delivered lecture on "Zaid FaslonkeUtpadan ki VaigyanikTakniki-DalhaniFaslen" at NIC Kanpur organized by Govt. of Uttar Pradesh.
- Ms Kancheti M attended ICAR-sponsored short course on "Pulses as the climate-smart crops for resources conservation and economic intensification/ Diversification of cropping system" organized by ICAR-IIPR, Kanpur during March, 2-11, 2022.
- Narendra Kumar visited Thailand for attending 8th International Weed Science Congress on "*Weed Science in a Climate of Change*" (IWSC2022) during 4-9 December, 2022.
- Dr. Raghvendra Singh visited South Korea to attend 5th Organic Asia Congress and the 10th IFOAM Asia Anniversary during October 13-15, 2022.
- CP Nath visited Israel for attending a New agricultural innovation programme on 'Achieving Food Security Using Smart Farming Solutions' at Galilee International Management Institute, lsrael during 13-19 September, 2022.
- Narendra Kumar attended training on 'Managing Technology Value Chains for Directors and Division Heads' during July 25 - 29, 2022 at Administrative Staff College of India, Hyderabad.
- Manmohan Deo attended ICAR-sponsored short course on "Pulses as the climate-smart crops for resources conservation and economic intensification/ Diversification of cropping system" organized by ICAR-IIPR, Kanpur during March, 2-11, 2022.
- Manmohan Deo attended 5 days of training for Drone remote pilot at Drone Destination Private Limited (a DGCA Certified agency) during

September 2022.

- Ms Kancheti M. attended DST-sponsored summer school on "Geospatial science and Technology applications in Agriculture" organized by TNAU, Coimbatore during May, 11-31, 2022.
- Ms Kancheti M. attended online training programme on "Analysis of Multi-Environment Trials" organized by ICAR-NAARM during November, 3-8, 2022.
- Ms Kancheti M. attended training programme on "Agricultural system modelling for natural resource management" organized by ICAR-NAARM during September, 19-24, 2022.
- CP Nath attended 'Achieving Food Security Using Smart Farming Solutions' at Galilee International Management Institute, Israel during 13-19 September, 2022.
- Agreement for licensing of technology of "Utilization of pulse milling by-products for edible use – Protein & Fiber Rich Biscuits" with M/s MahodhyaAgriworks, Kanpur.
- Memorandum of Agreement signed between ABI Unit, ICAR-IIPR, Kanpur and M/s Mahodhya Agriworks, Kanpur.
- Revanasidda delivered lecture on 'Management of stored grain pests of pulses' during 7 days' training programme on 'Seed quality parameters and production technology of pulse crops' organized by ICAR-IIPR, Kanpur between 3-9 Feb. 2022.
- Revanasidda delivered a lecture on 'Insect pests in storage, biology, and nature of damage and their management' during e-Training course on ICAR JRF/SRF, NET/ARS Exam preparation' organized by MPKV, Rahuri between 15th Feb. to 10th Mar., 2022.
- Revanasidda delivered lecture on 'Practical identification of bruchid stages and their infestation in different pulses' during 2 days' training programme on 'Management of storage pests in pulses' organized by ICAR-IIPR, Kanpur between 14-15 March 2022.
- Anup Chandra delivered a lecture on 'Dalhani fasalo me keet prabhandhan takniki' during 4 days' training on 'Unnat dalhan utpadan takniki' organized by ICAR-IIPR, Kanpur between 14-17th March 2022.
- Devindrappa, has been presented a poster entitled "Eco-friendly suppression of *Meloidogyne javanica*in Fieldpea (*Pisum sativum* L.) Through organic amendments and biocontrol agent" in International Conference on Pulse Research (ICPR-2022) organized by the Society for Plant and Agricultural Sciences (SPAS) on the occasion of World Pulses Day (February 10th, 2022).
- Devindrappa, has been presented paper entitled "Evaluation of rhizobacterial isolates antagonism to *Meloidogyne incognita* infecting tomato" in 8th International conferences on dry zone agriculture (ICDA)-2022, held at University of Jaffan, Sri Lanka, 14th September, 2022.
- Devindrappa, has been presented paper entitled "Effect of rhizobacteria onnematode suppression and soil microbes as compared to nematicide" in 1.Biotic stress management in crops through eco-friendly approaches" in the National e- Conference held at ICAR-National Research Centre of Integrated Pest Management, New Delhi, India on May 21, 2022.
- R.K.Mishra delivered a lecture on Diseases management of major pulses crops during training programm on Entrepreneurship opportunities in Pulses" organized during 1-3 November 2022 at ICAR-IIPR, Kanpur
- Surendra Ghritlahre attended training programme on Environmental and social impact assessment and gender mainstreaming in development projects held at Indore during 14-16 September, 2022.
- Surendra Ghritlahre attended Lauch of Madhya Pradesh Science, Technology & Innovation Policy-2022 held at Swarna Jayanti Sabhagrah, RCVP Noronha Prashasan Academy, Arera Colony, Bhopal on 26th December, 2022.
- Surendra Ghritlahre delivered lecture on "Plant breeding and its role in crop improvement programme" at Department of Agriculture, IES University on 29.8.2022.
- Dibendu Dutta (In-charge of the station) and Dr. Surendra Ghritlahre delivered a lecture cum field visit for BSc. (Ag.) students (38) of Department of Agriculture, IES University, Bhopal on 05th November, 2022 on their visit to IIPR Regional Station Bhopal.

- Surendra Ghritlahre attended the trainees of ATMA programme from Raisen district of M.P. and delivered a lecture cum filed visit at IIPR Regional Station, Bhopal on 05th November, 2022
- Surendra Ghritlahre delivered lecture on "Background of IIPR-RS Bhopal establishment and its research, seed production and extension activities" to Agri-Clinic and Agri-Business Centre (ACABC) Scheme Trainees at IIPR-Regional Station, Phanda, Bhopal on 20.12.2022
- Surendra Ghritlahre delivered lecture on "Scientific Cultivation of Pulses Crops" at Centre for Advanced Research & Development, Bhopal on 27.12.2022
- S.K. Ghritlahre, Archana Singh, Farindra Singh, I.P. Singh and N. P. Singh (2022). Hybridization between Mid-early and Medium Duration Pigeonpea Genotypes with Wilt and SMD Resistant Cultivars, under the theme "Crop Improvement and Crop Protection", in the 1st International Conference of the GKV Society, Agra, India, held during February 18-20, 2022.
- Archana Singh participated in International Webinar cum Workshop on Seed testing and Quality Assurance under the Ages of Indo-Grerman Cooperation on seed sector Development sponsored by Ministry of Agriculture and Farmers Welfare, GOI and organised virtually by Indian Institute of Seed Science, Mau, India during February 21-24,2022 in virtual mode.
- Archana Singh participated in 2nd International Agrobiodiversity Congress, held virtually during 15-18 November, 2021held in Rome .and presented two research papers.
- Hemant Kumar, SatheeshNaik and IP Singh (2022). "Simultaneous selection for yield and stability in pigeonpea of North East Plain Zone of India". In: 73rd Annual Conference of the Indian Society of Agricultural Statistics (Hybrid mode) at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K, India during 14-16 November, 2022.
- Rekha Rani, Uma Sah, Hemant Kumar, Jitendra Ojha and Mohit Katiyar (2022) attended. Growth performance and decomposition analysis of mungbean in Rajasthan" 73rd Annual Conference of the Indian Society of Agricultural Statistics (Hybrid mode) at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K, India during 14-16 November, 2022.
- Rekha Rani completed 21 days online training program on "Analytical Techniques for Decision Making in Agriculture" organised by ICAR-National Institute of Agricultural Economics and Policy Research (ICAR-NIAP) during 05 - 25 February 2022.
- Rekha Rani participated in the training programme on "Science and technology for rural societies for women" during 19-23, 2022 at Indian Institute of Public Administration, New Delhi.
- Devraj attended webinar on "Use of AI and ICT in Agriculture Information Access and Dissemination" jointly organized by CDAC, Noida, BASU Patna and BAU, Ranchi on March 14, 2022.
- Hemant Kumar attended training workshop on "Analysis of Multi-Environment Trials" (Online Mode) Organized by ICAR-NAARM, Hyderabad during 3-8 November, 2022
- Rekha Rani participated in the conference on "Promotion of Kisan Drones: Issues, challenges and way forward" on May 2, 2022 at New Delhi.
- Rekha Rani attended the video conference meeting on "Price policy for rabi crops 2023-24" marketing season on June 3, 2022 under the chairmanship of Chairmen CACP, New Delhi.
- Uma Sah delivered lecture on "Digital extension advisory services for pulse farmers: experiences & way forward" at collaborative online training programme on "Pulses Production Technologies of Rabi Season" during 03-05 August, 2022 at ICAR-IIPR in association with MANAGE Hyderabad.
- Uma Sah delivered lecture on "Agribusiness Incubation Opportunities: Status and Scope" at collaborative online training programme on "Entrepreneurship Development in Pulses" during 01-03November, 2022 at ICAR-IIPR in association with MANAGE Hyderabad.
- Hemant Kumar delivered lecture on "Procedure of advance estimate of crop production" at collaborative online training programme on "Pulses Production

Technologies of Rabi Season" during 03-05 August, 2022 at ICAR-IIPR in association with MANAGE Hyderabad.

- Devraj delivered lecture on "Status and prospects of ICTs in pulses production system" at collaborative online training programme on "Pulses Production Technologies of Rabi Season" during 03-05 August, 2022 at ICAR-IIPR in association with MANAGE Hyderabad.
- Rekha Rani delivered lecture on "Potential and perspectives of farmer producer organization in Indian perspectives" at collaborative online training programme on "Pulses Production Technologies of Rabi Season" during 03-05 August, 2022 at ICAR-IIPR in association with MANAGE Hyderabad.
- Pratap, A. attended pre-RMP programme on 'Management development programme on leadership development, organized by NAARM, Hyderabad 13-24, December 2021.
- Aditya Pratap visited Australia to participate in international TropAg Conference and to participate in IMIN side meeting at Brisbane, October 31-November 03, 2022.

- Pratap, A. Organizing Secretary, brainstorming meeting on "Intensification and sustenance of Pulses in North Hill Zone of India" was organized on 24th September 2021 at CSK Himachal Pradesh KrishiVishvavidyalaya (CSKHPKV), Palampur.
- 43rd Annual meeting of plant tissue culture association (India) & International symposium on Advances in Plant biotechnology and nutritional security-2022 on 28.4.22 (participation – Meenal Rathore)
- IP Awareness/Training program under National Intellectual Property awareness mission held on 21st April 2022 organized jointly by NIPTA M and ITMU, IIPR, kanpur22 (participation – Meenal Rathore, Sudhir Kumar)
- Amrut Mahotasav Lecture Series ,a lecture organised at ICAR- Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh on Genome Editing in Vegetable Crops for Improvement of Quality and Stress Tolerance on 26.4.22(participation – Meenal Rathore)
- Amrut Mahotsav Lecture series on *Biodiversity Governance: Global and National Perspectives by* Dr. V B Mathur, Chairperson, National Biodiversity Authority, Govt. of India on 15.6.22 (participation – Meenal Rathore)
- Amrut Mahotsav Lecture series on Women in Leadership Role in India by Ms. Rekha Sharma, Chiarperson, National Commission for Women, India on 20.6.22., organized by ICAR (participation – Meenal Rathore)
- Global Congress on Plant Biology and Biotechnology" Virtual Event. 24-26 March 2022. P 44-45.(Soren KR)
- Online brainstorming meeting organized jointly by the ICAR-IIPR and ISPRD on "Sustaining growth in pulses" on the occasion of 'World Pulses Day'(10 Feb. 2022).(Meenal Rathore, Sudhir Kumar)
- Webinar "International Conference On Pulse Research (ICPR-2022) organised by Society for Plant and Agricultural Sciences" on 10 Feb 2022.(Sudhir Kumar)
- National Webinar on Biofortified Crops for Balanced Nutrition and Immunity Boosting organized by ICAR-NIPB New Delhi on Feb. 28, 2022 (Sudhir Kumar)
- Genome Editing in Agriculture: Science, Potential, and Policies" on July 6, 2022, at the CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow , organized by the UP Council of Agricultural Research (UPCAR) in association with Biotech Consortium India Limited (BCIL), New Delhi (Aravnda K Konda)
- DBT-sponsored training on "Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments, and Issues" during August 2–11, 2022, organized by ICAR-National Bureau of Plant Genetic Resources, New Delhi. (Aravnda K Konda)
- Virtual seminar on "How Do Pathogens Evolve Novel Virulence Activities?" hosted by the MPMI journal on January 24, 2022(Aravnda K Konda)

- Webinar on Intra-plant genetic diversity in cannabis: Clone not a clone?" held on 23rd June 2022, organized by ACSESS publication. (Shanmugavadivel PS)
- Webinar on "Chromium Single Cell CRISPR 5" held on 14th April 2022, organized by 10X Genomics. (Shanmugavadivel PS)
- DP Patel attended Webinar on "Sustaining growth in pulses" Organized by ISPRD Kanpur on the occasion of World Pulses Day, Feb. 10, 2022.
- Vijay Laxmi, Gurumurthy S, and Meena S.K. (2022) attended International Conference on Advances in Agriculture Technology and Allied Science. June 4-5, 2022. Odisha on Identification of Photosensitive lines in Urd bean and their characterization."
- Vaibhav Kumar attended Webinar on "Sustaining growth in pulses" Organized by ISPRD Kanpur on the occasion of World Pulses Day, Feb. 10, 2022.
- Kalpana Tewari attended Webinar on "Sustaining growth in pulses" Organized by ISPRD Kanpur on the occasion of World Pulses Day, Feb. 10, 2022.
- Namrata Laskar participated and presented a Poster in International Conference on "Advances in Agriculture & Food System towards Sustainable Development Goals" at University of Agricultural Sciences, Bangalore during 22-24 August, 2022.

Awards & Recognitions

- Jitendra Kumar received Fellowship of National Academy of Agriculture Sciences-2022, New Delhi, India
- AK Parihar got appreciation certificate from DM of Jalaun Smt. Priyanka Niranjan for developing high yielding varieties of fieldpea on the occasion of *Matar Mahotsav* on 05.01.2022.
- AK Parihar Editor in Current Agriculture, *International Journal of Agricultural and Allied Sciences* (ISSN 0254-1092).
- Young Scientist Award was conferred to Dr Antara Das on the occasion of IVth International Conference in hybrid mode on Innovation and Allied Sciences (ICAAAS-2022) from Society for Scientific Development in Agriculture and technology
- Young Scientist Award was conferred to Mr Sudhir Kumar by Hindustan Agricultural Research Welfare Society during National Conference 2022.
- Vaibhav Kumar was awarded best poster in the International Conference on Pulse Research (ICPR-2022) organized by Society for Plant and Agricultural Sciences on Feb, 10, 2022. Mondal, B, Kumar, V, Kumar, Y, Srivastava, AK, Jha, UC, Revanappa, B, Singh, A, Singh, N, Parween N, Chaturvedi SK, Singh F, Dixit, GP and Shivsewak (2022). Prebreeding for donor improvement for high protein content in chickpea.
- Vijay Laxmi awarded best poster presentation in "technical Session 1 on the occasion of 5th International Conference on Advances in Agriculture Technology and Allied Science.
- Narendra Kumar received International Travel Support Award by International Weed Science Society.
- Narendra Kumar received SERB-DST international travel grant award for attending 8th International Weed Science Congress on "*Weed Science in a Climate of Change*" (IWSC2022) at Thailand.
- Surendra Ghritlahre acted as external examiner for practical examination at Department of Agriculture, IES University on 03.07.2022.
- Dr. Archana Singh is nominated as member of Advisory group for KVK, CIAE, Bhopal and KVK, Sehore, M.P.
- Archana Singh acted as an Expert (New Biology) for 36th M.P. Young Scientist Award organized by MPCST, Bhopal and Mahatma Gandhi ChitrakootGramodaya Vishwavidyalaya, Chitrakoot during March 14 – 16, 2022
- Archana Singh has acted as a Member of Assessment committee of Category III-Technical Personnel (T6) under the functional group "Laboratory", nominated by ASRB, New Delhi at ICAR-IGFRI, Jhansi (U.P).
- The best poster presentation award was conferred 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. Poster presentation in National Web Conference on Sustaining Pulses Production for Self Sufficiency and Nutritional Security, Feb. 9-11, 2021, ICAR-Indian Institute of Pulses Research, Kanpur, U.P., India.
- Best Oral Presentation Award' for the presentation on the topic entitled 'Qualitative and quantitative losses by three bruchid species in pigeonpea' at International Conference – Global Perspectives in Crop Protection for Food Security (GPCP 2021), held during December 8-10, 2021 at TNAU, Coimbatore.
- Maximum *Hindi Lekhan* Award was given to Dr. R.K. Mishra during 2021-22 on the occasion of *Hindi Diwas* on 14th September, 2022.
- Member, Advisory Board, Academic Year (2022-23), Mahakaushal University, Jabalpur (Meenal Rathore)

On-going Research Projects

DIVISION OF CROP IMPROVEMENT (3)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
1.	**CRSCIIPRSIL 202000100156**	**Development of biotic and abiotic stress resistant superior varieties/hybrids through integrated conventional and modern breeding approach** **Dr. Aditya Pratap (*w.e.f.* 21.10.2022)** **Dr. P.K. Katiyar (*w.e.f.* 20.10.2022)** **(Dr. Farindra Singh till 30.06.2022)**			2020-2025
	SP 1	Genetic enhancement of *desi* chickpea for higher grain yield and wider adaptability	Dr. Yogesh Kumar	Dr. B. Mondal, Dr A.K. Srivastava Dr. U.C. Jha, Dr. Revanappa SB Dr. K.R. Soren, Dr. Manjunath L (till 30.06.2022) Dr Rishikesh Kumar (*w.e.f.* 01.07.2022)	
	SP 2	Breeding for high yielding chickpea with multiple biotic stress resistance	Dr. A.K. Srivastava	Dr. Yogesh Kumar, Dr. K.R. Soren, Dr. Manjunath L (till 30.06.2022) Dr Rishikesh Kumar (*w.e.f.* 01.07.2022)	
	SP 3	Genetic enhancement for grain quality and milling attributes in chickpea	Dr. B. Mondal	Dr. Prasoon Verma, Dr. Yogesh Kumar, Dr. Vaibhav Kumar	
	SP 4	Development of high yielding genotypes of chickpea having combined resistance against drought and heat stress	Dr. U.C. Jha	Dr Archana Singh (till 20.10.2022) Dr S.K. Ghritlehre (*w.e.f.* 21.10.2022) Dr. A.K. Srivastava, (*w.e.f.* 26.05.2022) Dr. D.P. Patel (*w.e.f.* 26.05.2022)	
	SP 5	Genetic enhancement of *kabuli* chickpea for higher productivity and wider adaptability and better quality	Dr Archana Singh (till 20.10.2022) Dr. Gitanjali Sahay (*w.e.f.* 21.10.2022)	Dr. Yogesh Kumar (till 20.10.2022) Dr. S.K. Ghritlehre (till 20.10.2022) Dr. Dibendu Datta (*w.e.f.* 21.10.2022) Dr Nidhi Kumari (*w.e.f.* 0.2022)	
	SP 6	Development of biotic and abiotic stress resistant superior varieties through integrated conventional and modern breeding approach in long duration pigeonpea	Dr. Satheesh Naik S.J.	Dr Dibendu Datta, Dr. Farindra Singh (till 30.06.2022) Dr R.K. Mishra Dr Abhishek Bohra (till 02.04.2022)	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 7	Development of biotic and abiotic stress resistant superior varieties through integrated conventional and modern breeding approach in medium duration pigeonpea	Dr. S.K. Ghritlehre	Dr. Farindra Singh (till 30.06.2022) Dr. R.K. Mishra (till 20.10.2022) Dr. Archana Singh (till 20.10.2022) Dr Dibendu Datta (*w.e.f.* 21.10.2022) Dr Nidhi Kumari (*w.e.f.* 21.10.2022)	
	SP 8	Development of biotic and abiotic stress resistant superior varieties through integrated conventional and modern breeding approach in short duration pigeonpea	Dr Abhishek Bohra (till 02.04.2022) Dr A.K. Singh (*w.e.f.* 03.04.2022)	Dr Dibendu Datta Dr. Satheesh Naik S.J. Dr. R.K. Mishra	
	SP 9	Harnessing CMS based hybrid technology for yield stability and stress tolerance in pigeonpea	Dr Abhishek Bohra (till 02.04.2022) Dr. Satheesh Naik S.J. (*w.e.f.* 03.04.2022)	Dr. Satheesh Naik S.J. (till 02.04.2022) Dr. S.K. Ghritlehre Dr U.C. Jha (*w.e.f.* 26.05.2022)	
	SP 10	Genetic enhancement of mungbean (*Vigna rediada* (L) Wilczek) 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 Dr. Monika Punia (*w.e.f.* 26.05.2022)	
	SP 11	Development of high yielding, drought and heat tolerant mungbean [*Vigna radiate*a (L.) R. Wilczek] genotypes for spring/summer season	Dr. Basavaraja. T	Dr. Aditya Pratap Dr. T N Tiwari	
	SP 12	Genetic enhancement of pulses for grain yield, quality and multiple stress resistance in urdbean	Dr. P.K. Katiyar (till 26.05.2022) Dr. Debjyoti Sen Gupta (*w.e.f.* 27.05.2022)	Dr. Debjyoti Sen Gupta (till 26.05.2022) Dr. Archana Singh , Dr. A.K. Singh, Dr. Manu B., Dr. P.R. Saabale, Dr. Anup Chandra	
	SP 13	Genetic enhancement of urdbean (*Vigna mungo* L. Hepper) for new niches of different agro-ecological conditions	Dr. A.K. Singh	Dr. P.K. Katiyar, Dr. Manu B., Dr. Vijaya Laxmi Dr. Kuldeep Kumar	
	SP 14	Biofortification in urdbean and mungbean for Fe and zinc concentration	Dr. Debjyoti Sen Gupta	Dr. Asik Datta, Dr. Aditya Pratap,	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 15	Development of biotic and abiotic stress resistant superior varieties through integrated conventional and modern breeding approach in lentil	Dr. Jitendra Kumar	Dr. Debjyoti Sen Gupta, Dr. Naimuddin, Dr. D.P. Patel, Dr. Kuldeep Kumar	
	SP 16	Development of biotic and abiotic stress resistant superior varieties through integrated conventional and modern breeding approach in fieldpea	Dr. A.K. Parihar	Dr. R.K. Mishra, Dr. Anup Chandra Dr Amrit Lamichaney (*w.e.f.* 27.05.2022)	
	SP 17	Genetic enhancement in arid pulses for abiotic and biotic stresses: Mothbean and cowpea	Mrs. Monika Punia	Dr. A.K. Parihar, Dr. Surendra Kumar Meena	
2.	**CRSCIIPRSIL 202000200157**	**PGR management and utilization** **Dr Dibendu Datta (till 20.10.2022)** **Dr. Jitendra Kumar (*w.e.f.* 21.10.2022)**			
	SP 1	Chickpea (IIPR)	Dr. Dibendu Datta	Dr. Yogesh Kumar, Dr. B. Mondal Dr. Amrit Lamichaney, Dr. Revanappa S.B.	
	SP 2	Chickpea (Bhopal)	Dr. Archana Singh (till 20.10.2022) Dr. D. Datta (*w.e.f.* 21.10.2022)	Dr. S.K. Ghritlehre (till 20.10.2022) Dr. Gitanjali Sahay (*w.e.f.* 21.10.2022) Dr. B. Mondal	
	SP 3	Pigeonpea (Kanpur)	Dr. Farindra Singh (till 30.06.22) Dr. Satheesh Naik SJ (w.e.f. 01.07.2022)	Dr Dibendu Datta Dr Abhishekh Bohra (till 02.04.22) Dr. Satheesh Naik (till 30.6.22), Dr Sujayanand GK Dr Revanasidda	
	SP 4	Pigeonpea (Bhopal)	Dr. S.K. Ghritlehre	Dr. Archana Singh (till 20.10.2022) Dr Dibendu Datta (*w.e.f.* 21.10.22)	
	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 (till 26.5.22) Dr P. K. Katiyar (*w.e.f.* 27.5.22)	Dr. Debjyoti Sen Gupta, Dr. P.K. Katiyar (till 26.5.22) Dr. B. Manu Dr. A.K. Singh (*w.e.f.* 27.5.22)	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 8	Fieldpea	Dr. A.K. Parihar	Dr. RK Mishra Dr. Anup Chandra (till 26.5.22) Dr Amrit Lamichaney (*w.e.f.* 27.5.22)	
	SP 9	Horsegram	Dr. Revanappa S. B.	Dr. Manu B., Dr. P.R. Saabale	
	SP 10	Cowpea (Dharwad)	Dr. B. Manu	Dr. Revanappa S.B. Dr. A.K. Parihar Dr. P.R. Saabale	
	SP 11	*Rajmash* (including genetic enhancement)	Dr. Basavaraja T.	Dr. Kalpana Tewari, Dr. Manjunatha (till 30.6.22), Dr. Rishikesh Kumar (*w.e.f.* 01.07.22) Dr. Mohar Singh (ICAR-NBPGR, Shimla) Dr. Aditya Pratap (*w.e.f.* 27.5.22)	
	SP 12	Cowpea (including genetic enhancement)	Dr. A.K. Parihar	Dr. B. Manu, Dr. Revanasidda, Dr. Monica Punia Dr A.K. Srivastava (*w.e.f.* 27.05.22)	
	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**	**Seed System Research**		**Dr. P. K. Katiyar**	2020-2025
	SP 1	Seed technological studies in pulses	Dr. Amrit Lamichaney	Dr. P.K. Katiyar Dr. D.S. Gupta	

DIVISION OF PLANT BIOTECHNOLOGY (1)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
4.	**CRSCIIPRSIL 202000400159**	**Genomics, Genetic Engineering and New Breeding Technologies for Pulses Improvement.**		**Dr. Meenal Rathore**	2020-25
		Theme I. Genomics for Pulses 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, Dr. B Mondal Dr. Archana Singh (till 20.10.2022) Dr Dibendu Datta (*w.e.f.* 21.10.2022) Dr Revanappa	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	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 (till 20.10.2022) Dr Gitanjali Sahay (*w.e.f.* 21.10.2022) Dr. Surendra Kr. Meena Dr. Revanappa Dr. U.C. 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. (till 30.06.22) Dr Rishikesh Kumar (*w.e.f.* 01.07.22)	
	SP 4	Molecular dissection of loci for Powdery Mildew (PM) resistance and Photo-thermo insensitivity (PTI) in *Vigna mungo* (Urdbean)	Mr. Sudhir Kumar	Dr Kuldeep Kumar Dr.Debjyoti Sen Gupta Dr. P.R. Saabale	
	SP 5	Identification of genes/QTLs for salinity tolerance in urdbean and earliness in lentil	Mr. Kuldeep Kumar	Dr. Awnindra Kr. Singh, Dr. Manu B. Dr. Jitendra Kumar	Oct. 2020 to Sept. 2025
		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 Sudhir Kumar Dr. Meenal Rathore	
	SP 7	Molecular approaches for improving the nutritional quality of grasspea (*Lathyrus sativus*) and fieldpea (*Pisum sativum*)	Dr. Neetu Singh Kushwah	Dr. Meenal Rathore Dr. Alok Das Dr. Archana Singh Dr Ashok K. Parihar Dr Kalpana Tewari	
	SP 8	Transforming *Vigna* for tolerance to whitefly (*Bemisia tabaci*)	Dr. Meenal Rathore	Dr. Neetu Singh Kushwah Dr. Alok Das Dr Aditya Pratap	
	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
5.	CRSCIIPRSIL 202000500160	**Development of resource use efficient agro-technologies involving pulses and its cropping systems under diversified agro-ecologies: Dr. Narendra Kumar (from 01.10.2021), Dr. C.S. Praharaj (till 30.09.2021)**			2020-25
	SP 1	Long-term effect of pulses in rice-wheat cropping systems on soil health and crop productivity under Gangetic plains	Dr. Narendra Kumar (from 01.10.2021), Dr. C.S. Praharaj (till 30.09.2021)	Dr. Narendra Kumar (till 30.09.2021) Mr. K.K. Hazra Dr. C.P. Nath Mr. Krishnashis Das Mr. Asik Dutta Dr Raghavendra Singh (*w.e.f.* 27.05.2022) Ms. Mrunalini Kancheti (*w.e.f.* 27.05.2022)	
	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	Dr. Raghavendra Singh (from 01.10.2021), Dr. C.S. Praharaj (till 30.09.2021)	Mr. Asik Dutta Dr Man Mohan Deo (*w.e.f.* 27.05.2022)	
	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 Dr Lalit Kr. Rolania Dr Banwari Lal	
	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 Dr Namrata Laskar (*w.e.f.* 27.05.22)	
	SP 7	Enhancing input use efficiency and productivity of pulses production system in central India	Dr. Sandeep Kumar	Dr Narendra Kumar, Dr Pramod Jha, IISS, Bhopal Dr R Elanchezhian, IISS, Bhopal	
	SP 8	Enhancing input use efficiency and productivity of pulses in arid ecosystem	Dr. Ram Lal Jat	Dr. Narendra Kumar (till 26.05.22) Dr. S.K. Meena Dr. Lalit Kr. Rolaniya Dr. N.D. Yadav (CAZRI RS, Bikaner)	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	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 (till 26.05.2022) Dr S.L. Patil	
	SP 10	Sustainable intensification of rice-fallows with inc lusion of pulses in Eastern India	Dr. Raghavendra Singh	Dr. Narendra Kumar (from 01.10.2021 to 26.05.2022), Dr. C.S. Praharaj (till 30.09.2021) Mr. K.K. Hazra, Dr. P.K. Panda (ICAR-IIWM) Dr. Sunil Sunani (*w.e.f.* 27.05.22)	
	SP 11	Farm mechanization suitable for pulses and its cropping system in Gangetic plains	Dr. Man Mohan Deo	Dr. Prasoon Verma Dr. Narendra Kumar (from 01.10.2021), Dr. C.S. Praharaj (till 30.09.2021)	
	SP 12	Organic farming in pulses and its cropping system with technological interventions in Gangetic plains	Dr. Raghavendra Singh (from 01.10.2021) Dr. C S Praharaj (till 30.09.2021)	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	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. Banwari Lal Dr. S.K. Meena Dr. Narendra Kumar (till 26.05.2022)	
	SP 15	Effect of integrated nutrient management in pulse based cropping system on soil properties, crop productivity and economics in Vertisols of semi - arid Tropics of South India	Dr. S. L. Patil	Dr. M. Venkatesh, Dr. B. Manu, Dr. Miland Poddar (UAS, Dharwad) Dr. Ravi K.N. (IISWC RC, Bellari)	
	SP 16	Enhancing productivity and resource use efficiency of pulses through agronomic management in arid region	Dr. Banwari Lal	Dr. L.K. Rolaniya, Dr. S.K. Meena, Dr. Narendra Kumar (till 26.05.2022)	
	SP 17	Development of novel coated P-fertilizers for increasing PUE and system productivity under cereal-pulse cropping system in an Inceptisol	Mr. Asik Dutta	Ms. Namrata Laskar	2022-25

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 18	Adoption, refinement and development of farm machineries for pulses for small and marginal farmers	Dr Man Mohan Deo	Dr Prasoon Verma Dr Narendra Kumar	2022-25
	SP 19	Development of pulse based natural farming system for enhancing the sustainability of ecosystem	Dr. Raghavendra Singh	Dr Narendra Kumar Dr. C.P. Nath Mr. Asik Dutta	2022-25
	SP 20	Enhancing nitrogen use efficiency, productivity and profitability through Nano-urea in pulses	Dr Mohammad Hasim	Dr K.K. Hazra Mr. Asik Dutta	2022-25
6.	**CRSCIIPRSIL 202000600161**	**Post harvest management of pulses, value addition and by-product utilization: Dr. Prasoon Verma**			**2020-25**
	SP 1	Evaluation of existing pre -milling treatments and development of improved pre-milling treatments for ease of pulse milling.	Dr. Prasoon Verma	Dr. Man Mohan Deo	
	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 Dr. Revanasidda	

DIVISION OF CROP PROTECTION (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
7.	**CRSCIIPRSIL 202000700162**	**Biotic stresses management through bio-intensive and novel eco-friendly approaches in pulse crops: Dr. Bansa Singh**			**2020-25**
	SP 1	Root-knot nematode management in pulse cropping system using bio -fumigation and trap crops	Dr. Bansa Singh	Dr. Jagadeeswaran Dr Devindrappa (*w.e.f.* 11.10.2022)	
	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. (till 30.06.2022) Dr. Arvind Kr. Konda	
	SP 3	Development of consortium of nematode biocontrol agents for the management of phyto -nematodes in pulses	Dr. Jagadeeswaran, R.	Dr Devindrappa	
	SP 4	Management of major sucking insect-pests in greengram and blackgram	Dr. Anup Chandra	Dr. Mohd. Akram Dr. M.H. Kodandaram	
	SP 5	Management of major soil borne diseases of chickpea through bio and chemo priming	Dr. Manjunatha, L. (till 30.06.22) Dr R.K. Mishra (w.e.f. 01.07.22)	Dr. R.K. Mishra (till 30.06.22) Dr. Amrit Lamichaney Dr. Rishikesh Kumar (*w.e.f.* 01.07.2022	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
	SP 6	Management of Ascochyta blight, Botrytis gray mold and rust disease of chickpea through host resistance, defense inducers and new fungicide molecules	Dr. Manjunatha, L. (till 30.06.22) Dr. Rishikesh Kumar (*w.e.f.* 01.07.22)	Dr. Rishikesh Kumar (till 30.06.22) Dr Saabale P. R.	
	SP 7	Insect pest dynamics and their management in long duration pigeonpea	Dr. Sanjay M. Bandi	Mr. Revanasidda	
	SP 8	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 9	Pre and post-harvest management of bruchids in cowpea, mungbean and pigeonpea	Dr. Revanasidda	Dr. Sanjay M. Bandi Dr. Prasoon Verma	
	SP 10	Eco-friendly 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	Dr. Sunil Sunani (*w.e.f.* 27.05.22)	
	SP 12	Development and validation of BIPM module for chickpea	Dr. Sujayanand G.K.	Dr. Anup Chandra Dr. Rishikesh Kumar Dr. Jagadeeswaran R Dr.Jitendra Singh (NCIPM)	2022-25
	SP 13	Seasonal abundance of major pests and diseases in pigeonpea and their correlation with the weather parameters	Dr. Asish Kumar Rout	Mr. Sunil Sunani Dr. Anup Chandra	2022-25
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**
	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. (till 30.06.22) Dr. Khela Ram Soren	
	SP 2	Epidemiology of major fungal pathogens of pigeonpea	Dr. RK Mishra	Dr. Naimuddin	
	SP 3	Molecular epidemiology of yellow mosaic disease in mungbean and urdbean and diagnostics for seed borne viruses	Dr. M. Akram	Dr. Anup Chandra, Dr. Naimuddin, Dr. P.R. 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
	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. Anup Chandra	Dr. Hemant Kumar Dr. M.H. Kodandaram (*w.e.f.* 27.06.22) Dr. Man Mohan Deo (*w.e.f.* 27.06.22) Dr. Sanjay M Bandi (*w.e.f.* 27.06.22) Dr. Sujayanand GK (*w.e.f.* 10.10.2022) Dr. Asish Kumar Rout (*w.e.f.* 10.10.2022)	
	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 (till 10.10.2022) Dr Devindrappa (w.e.f. 11.10.2022)	Dr. Jagadeeswaran, R. Dr. Bansa Singh (*w.e.f.* 11.10.2022)	
	SP 8	Seasonal dynamics of major pest and diseases in peninsular India	Dr. P R Saabale	Dr. M H Kodandaram Dr. Sunil Sunani (*w.e.f.* 27.05.22)	
	SP 9	Epidemiology of major diseases of mungbean and urdbean, and search for their resistance	Mr. Sunil Kumar Sunani	Dr. Mohd. Akram Dr. R.K. Mishra Dr. P.R. Saabale	
	SP 10	Identification of resistant sources in pulses against three bruchids species	Dr. Revanasidda	Dr. Sanjay M. Bandi	2022-25

DIVISION OF BASIC SCIENCE (2)

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
9.	**CRSCIIPRSIL 202000900164**	**Physio-biochemical intervention for improving climate resilience and nutrition enriched pulses:**	**Dr. D. P. Patel**		**2020-25**
	SP 1	Deciphering the physiological mechanisms of heat tolerance in lentil (*Lens culinaris* Medik.)	Dr. D P Patel	Dr. J. Kumar	
	SP 2	Physiological characterization of pigeonpea genotypes for water logging tolerance	Dr. TN Tiwari	Dr. D. Datta Dr. Kalpana Tewari Dr. Vijay Laxmi (*w.e.f.* 27.05.22)	
	SP 3	Identification and physiological characterization of urdbean genotypes for heat tolerance	Dr. Vijay Laxmi	Dr. A.K. Singh Dr. T.N. Tiwari (*w.e.f.* 27.05.22)	

S No.	IIPR Code	Mega Project/Sub Project	PI	Co-PI	Period
9.	CRSCIIPRSIL 202000900164	**Physio-biochemical intervention for improving climate resilience and nutrition enriched pulses. Dr. D. P. Patel**			2020-25
	SP 4	Biochemical responses of chickpea to heat stress and identifying key factors limiting its productivity	Dr. Vaibhav Kumar	Dr. Kalpana Tewari Dr. Shanmugavadivel PS, Ms. Namrata Laskar	
	SP 5	Exploring common bean (*Phaseolus vulgaris)* genotypes for bioactive components associated with health promoting properties and flatulence	Dr. Kalpana Tewari	Dr. Vaibhav Kumar	
	SP 6	Identification of donors and physiological traits for drought and heat tolerance in *Kharif* legumes (mothbean, mungbean, and pigeonpea) under arid environments	Dr. S K Meena	Dr. Ram Lal Jat (till 26.05.22) Dr. N.S. Nathawat Dr. Banwari Lal (*w.e.f.* 27.05.22) Mrs. Monika Punia (*w.e.f.* 27.05.22)	
	SP 7	Dynamics of imazethapyr and glyphosate residues in soil-plant system	Ms. Namrata Laskar	Ms. Mrunalini Kancheti Dr. Krishnasish Das	
10.	CRSCIIPRSIL 202001000165	**Establishment of effective symbiotic nitrogen fixation in pulses Dr. Senthilkumar M.**			2020-25
	SP 1	Unravelling of molecular basis for variations in nodulation and symbiotic efficiency of chickpea	Dr. M. Senthil Kumar	Dr. Shanmugavadivel PS Dr. Kalpana Tewari	
	SP 2	Deciphering the root signals for effective nodulation of rajmash	Dr. Kris hnashis Das	Dr. Senthilkumar M. Dr. Vaibhav Kumar , Ms. Namrata Laskar	

DIVISION OF SOCIAL SCIENCES (2)

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period
11.	CRSCIIPRSIL 202001100166	**Innovative extension approaches for livelihood and nutritional security through pulse production technology in India: Dr. Uma Sah**			2020-25
	SP 1	Development of model pulses village through integrated technological interventions for livelihood and nutritional security in selected agro-ecological regions	Dr. Uma Sah	Dr. Archana Singh (till 20.10.2022), Dr Dibendu Datta (w.e.f 21.10.2022), Dr. Kodandaram, MH Dr. Ram Lal Jat, Dr. C.P. Nath	

S No.	IIPR Code	Mega Project/ Sub Project	PI	Co-PI	Period
	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 (30.11.2020)	
	SP 3	Impact assessment of pulses varieties developed by ICAR-IIPR, Kanpur	Dr Rekha Rani	Dr. Uma Sah Dr. Hemant Kumar	Dec-21 to Dec-24
12.	**CRSCIIPRSIL 202001200167**	**IT enabled data management in pulses for policy support system.** **Dr. Devraj**			**2020-25**
	SP 1	Development of 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. Shiv Sewak (till 31.03.2022)	
	SP 3	Digitalization of quality seed production and germplasm database for pulses	Dr. Devraj	Dr. P.K. Katiyar Dr. Amrit Lamichaney	

Externally Funded Projects

Crop Improvement Division (12)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
1	Seed Production in Agricultural Crops (SPAC).	DA & FW	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	2005-06 to March 2022	Plan Scheme of ICAR
2	ICAR (NSP) crops	DA & FW	Dr. P.K. Katiyar	Dr. Amrit Lamichaney	April 2007 to March 2022	Plan Scheme of ICAR
3	CRP on molecular breeding for improvement of tolerance to biotic and abiotic stresses, yield and quality traits in crops-chickpea	ICAR	Dr. Aditya Pratap	Dr. K.R. Soren	2015 To Dec 2023	28.80
4	CRP on hybrid technology in pigeonpea	ICAR	Dr.Abhishak Bohra (till 02.04.2022) Dr. Satheesh Naik S.J. (w.e.f. 03.04.2022)	Dr. Satheesh Naik S.J. (till 02.04.2022) Dr. Alok Kumar	2015-16 to 2022-23	88.00
5	International Mungbean Improvement Network Phase-2	ACIAR/ AVRDC	**Prog. Coordinator :** Dr. Bansa Singh PI: Dr. Aditya Pratap	Dr. Sanjeev Gupta Dr. Mohd. Akram	June 2022-27	105.75
6	CRP on Agro-biodiversity 1. Pigeonpea	ICAR	Dr. I.P. Singh	Dr. Archana Singh (till 20.10.2022) Dr Dibendu Datta (w.e.f 21.10.2022)	2014 - 17	47.35
	2. Chickpea		Dr. G.P. Dixit	Dr Manjunath L (till 30.06.2022) Dr Rishikesh Kumar (01.07.2022)	2017 - 21	40.90

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
7	Application of Next Generation Breeding, Genotyping and Digitalization Approaches for Improving the Genetic Gain in India Staple Crops (TL III)	ICAR-Bill and Melinda Gates Foundation Project	Dr. G.P. Dixit	**AICRP-**Dr. A. K. Srivastava **Institute-Pigeonpea CC-PI:** Dr. Abhishek Bohra (till 02.04.2022) Dr Satheesh Naik S. J. (w.e.f. 03.04.2022) Dr. Archana Singh **Chickpea CC-PI:** Dr. B. Mondal Dr. Archana Singh	2018-2022 (Extended till Oct.2023)	-
8	Institute Technology Management Unit: **Component I:** Intellectual Property Management and Transfer/ Commercialization of Agricultural Technologies **Component II :** Agri-business Incubation Centres in institutions developing agricultural technologies Incubation Fund (ABI)	ICAR (NAIF)	**Component I:** Dr. Aditya Pratap **Component II :** Dr. Uma Sah	Dr. Aditya Pratap Dr. P.K. Katiyar Dr. R.K. Mishra Dr. Prasoon Verma Dr. Senthil Kumar M	2016- Plan Scheme till date 2019- Plan Scheme till date	Plan Scheme of ICAR
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
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	-

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
11	Genetic enhancement to Stemphylium blight resistance in lentil through induced mutation	BRNS, Mumbai	Dr. Jitendra Kumar	Dr. Naimuddin, Dr. Debjyoti Sen Gupta	2022-25	26.14
12	Biodiversity for opportunities, livelihood and development (BOLD): Augmenting and up-scaling CWR-derived grasspea elites for climate resilience in farmers' fields (AUGER)	ICARDA	Dr. Bansa Singh, Director ICAR-IIPR	Dr. Gitanjali Sahay	01.03.2022 to 31.12.2024	USD 48,800

Division of Plant Biotechnology (3)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹. in lakh)
13	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	26.35
14	Development of early flowering chickpea genotype using CRISPR/Cas9 technology	SERB (DST)	Dr. Alok Das	Dr. Biswajit Mondal	2021-24	33.529
15	CRISPER Crop Network: Targeted improvement of stress tolerance, nutritional quality and yield of crops by using genome editing	NASF (ICAR)	Dr Alok Das	Dr. Satish Naik S.J.	2022-2025	47.3025

Crop Production Division (1)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate/Co-PI	Period	Budget (₹ in lakh)
16	Integrated management of fieldpea (*Pisum sativum* L) through conservation tillage and sprinkler irrigation under limited resources.	CST, UP (DST, Govt. of Uttar Pradesh)	Dr. Raghavendra Singh	Dr. C.P. Nath	2021-2023	7.80

Crop Protection Division (2)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
17	Innovative and contextual agromet advisory services for climate smart agriculture.	IITM (Indian Instt. of Tropical Metro-logy)	Dr. R.K. Mishra	Dr. Sanjay M. Bandi, Dr. Uma Sah	2018-2022	80.7984
18	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)
19	CRISPER Crop Network: Targeted improvement of stress tolerance, nutritional quality and yield of crops by using genome editing	NASF (ICAR)	Dr. M. Senthilkumar	Dr. Alok Das Dr. Shanmugavadivel PS	2022-2025	738.7633

Social Science (2)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
20	Integrated approaches for food, nutrition and livelihood security for rural household in Fatehpur district of Uttar Pradesh. **(Farmers FIRST)**	ICAR	Dr. Uma Sah	1. Dr. C.P. Nath (from May 18) 2. Dr. Subhash Chandra (CSAUAT) 3. Dr. M.P. S. Yadav (CSAUAT) 4. Dr. R.K. Mishra, Pr. Scientist (PP.), CO-PI 5. Dr. A.K.Parihar, Sr. Scientist (PB), CO-PI 6. Dr. Sujayanand, G.K., Scientist (Agril. Entomology), CO-PI Dr. Rekha Rani, Scientist (Agril. Economics)	2016-23	256.67

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
21	Production Systems, Agri-business and Institutions Component I: Impact Assessment of Agricultural Technologies	ICAR-NIAP, New Delhi	Dr. Rekha Rani	Dr Uma Sah (CC Co-PI) Dr Rajesh Bishnoi	2022-23	0.75

Institute Mega- Projects (8)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
22	Implementation of PVP legislation, DUS test.	Chickpea AICRP	Dr. G.P. Dixit	Dr. A.K. Srivastava	2007 to Continued Project)	PPV & FRA Budget
23	Implementation of PVP legislation, DUS test.	Pigeon-pea AICRP	Dr. I.P. Singh	Dr. Satheesh Naik	2007 to Continued Project)	PPV & FRA Budget
24	Implementation of PVP legislation, DUS test	MULLaRP AICRP	Dr. I.P. Singh	Dr. A.K. Parihar	2007 to Continued Project)	PPV & FRA Budget
25	Creation of Seed hubs for increasing indigenous production of pulses in India	ICAR & DAC (NFSM)	**National Coordinator :** Dr. P. K. Katiyar	**Kanpur:** Dr. A.K. Singh **Bhopal:** Dr. Archana Singh (till 20.10.2022) Dr Gitanjali Sahay (w.e.f. 21.10.2022) **Bhubneswer:** Dr. Raghavendra Singh	2016-2020 (Continued Project from revolving fund)	22531.08
26	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 (till 20.10.2022) Dr Dibendu datta (w.e.f 21.10.2022)	2016-2020 (Continued Project from revolving fund)	2039

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
27	Genetic enhancement of miner pulses: characterization, evaluation, genetic enhancement and generation of genomic resources for accelerated utilization and improvement of minor pulses- **Sub Proj. 4: Genetic enhancement of minor pulse**	DBT (Min of Science & Technology)	National Coordinator : Dr. Aditya Pratap	Dr. Mohd. Akram, Dr. Meenal Rathore Dr. A.K. Singh Dr. Naimuddin Dr. A.K. Parihar Dr. Debjyoti Sen Gupta Dr. Sudhir Kumar Dr. Revannasidda Dr. P.R. Sabaale Dr. Revanappa B	2018-2023	441
28	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 Archana Singh	Dr. G.P. Dixit Dr. Surendra K. Ghritlahre	2020-2025	718.725
29	Intervention of Improved Agricultural Technologies for Transforming Agriculture in Uttar Pradesh for enhancing farmer's income in Fatehpur and Sonbhadra districts of Uttar Pradesh	UPCAR, Lucknow	**Project leader:** Dr. Shiv Sewak **PI:** Dr. Uma Sah	Dr. P.K. Katiyar Dr. R.K. Mishra Dr. Yogesh Kumar Dr. Prasoon Verma Dr. Hemant Kumar Dr. Anup Chandra Dr. C.P. Nath Dr. Rekha Rani	2021-2025	**318.675** (Fatehpur: 159.60 & Sonbhadra: 159.075)

Young Scientist Project (1)

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate	Period	Budget (₹ in lakh)
30	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 31.12.2022)

Dr. Bansa Singh 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 31.12.2022)

Dr. P.M. Salimath Ex. Vice-Chancellor University of Agricultural Sciences, Raichur (Karnataka)	Chairman
Dr. Sanjeev Gupta ADG (OP), ICAR, New Delhi	Member
Dr. P. Ananda Kumar, Ex. Project Director NRCPB, New Delhi	Member
Dr. (Mrs.) Om Gupta Director of Extension, JNKVV, Jabalpur	Member
Dr. Masood Ali Ex. Director IIPR, Kanpur	Member
Dr. R.P.S. Rattan Ex. Director Extension BAU, Ranchi	Member
Director ICAR-IIPR, Kanpur	Member
Dr. B.B. Singh, Ex ADG (O&P), ICAR, Krishi Bhawan, New Delhi	Member
Mr. Rakesh Shukla 303, Tower-F, Amarpali, Noida, U.P.	Member
Mr. Ch. Gulbir Singh Vilage Hirnoti, Po. Digsara, Aligarh, U.P.	Member
Dr. Mohd. Akram Principal Scientist	Member Secretary

Institute Research Council

(As on 31.12.2022)

Dr. Bansa Singh Director ICAR-Indian Institute of Pulses Research, Kanpur	Chairman
Assistant Director General (O&P), ICAR, Krishi Bhavan, New Delhi	Member
All Scientists of the Institute	Member
Dr. Jitendra Kumar Principal Scientist, Division of Crop Improvement, ICAR-IIPR, Kanpur	Member Secretary

Important Committees of the Institute

(As on 31.12.2022)

1.	Monthly Review Committee (MRC)	**Chairman**	:	Director
		Members	:	All Project Coordinators, All Heads 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, Pr. Scientist
2.	Farm Advisory Committee (FAC)	**Chairman**	:	Dr. Narendra Kumar, PS and HoD (I/c), CPD
		Members	:	All HoDs, I/c Farms, I/c Security, & Dr. Mohd. Akram, Dr. (Er.) Manmohan Deo, Dr. P.K. Katiyar, Nodal Officer (Seed)
		Member Secretary	:	Dr. A.K. Singh, Principal Scientist
3.	Estate Management Committee	**Chairman**	:	Director
		Co-Chairman	:	Er. Prasoon Verma
		Members	:	Dr. Narendra Kumar, Dr. A.K. Singh, Dr. Mohd. Akram, Dibendu Datta, Sr. Administrative Officer, Sr. F.&A.O., Mr. S.K. Garg, Mr. R.M. Pal
		Member Secretary	:	Sh. S. Mahto, AAO(W) : I/c work
4.	Seed Advisory Committee	**Chairman**	:	Dr. G.P. Dixit, Principal Scientist & I/c Project Co-ordinator (Chickpea)
		Members	:	Dr. Archana Singh, (Bhopal), Dr. Banwari Lal, (Bikaner), Dr. Raghavendra Singh (Khordha) Dr. A.K. Singh (Kanpur), Dr. Revanappa Biradar (Dharwad) Dr. Amrit Lamichaney
		Member Secretary	:	Dr. P.K. Katiyar, Nodal Officer (Seed)
5.	Publication Committee (English)	**Chairman**	:	Director
		Co. Chairman	:	Dr. (Mrs.) Meenal Rathore
		Members	:	Dr. Uday Jha, Dr. Sanjay M. Bandi, Dr. K.K. Hazra, Dr. Alok Das
		Member Secretary	:	Dr. Rajesh Kumar Srivastava, ACTO
6.	Publication Committee (Hindi)	**Chairman**	:	Director
		Co. Chairman	:	Dr. Jitendra Kumar
		Members	:	Dr. R.K. Mishra, Dr. T.N. Tiwari, Dr. Prasoon Verma, Dr. Kanhaiya Lal, Ms. Meenakshi Varshney
		Member Secretary	:	Dr. Rajesh Kumar Srivastava, ACTO
7.	Purchase Advisory Committee (PAC)	**Chairman**	:	Dr. Farindra Singh, Principal Scientist & Head
		Members	:	Dr. Dibendu Datta, Dr. Uma Sah, Dr. T.N. Tiwari, Dr. Mohd. Akram, Dr. K.R. Soren, Sr. AO. and SF & AO.
		Member Secretary	:	AAO (S)

8. Results Framework Document Committee	**Chairman**	:	Director
	Members	:	Dr. Farindra Singh Dr. Narendra Kumar, Dr. Meenal Rathore, Dr. D.P. Patel, Dr. Uma Sah, Sr. AO and Sr. F&AO
	Nodal Officer	:	Dr. Naimuddin
	Co-Nodal Officer	:	Dr. Meenal Rathore
9. Institute Technology Management Committee	**Chairman**	:	Director
	Members	:	Dr. Farindra Singh, Dr. D.P. Patel, Dr. Uma Sah, Dr. Meenal Rathore, Dr. Naimuddin, Sr. AO and Sr. F&AO
	Member Secretary	:	Dr. Aditya Pratap
10. Institute Technology Management Unit (ITMU)	**Incharge**	:	Dr. Aditya Pratap
	Members	:	Dr. R.K. Mishra, Dr. (Er.) Prasoon Verma, Dr. Devraj, Dr. Basavaraja, T.
	Member Secretary	:	Dr. Aditya Pratap
11. Resource Generation and Farm Produce Price Fixation Committee	**Chairman**	:	Dr. Raghvendra Singh
	Members	:	Dr. Yogesh Tiwar, Dr. Rekha Rani, Dr. K.K. Hazra, Sr. Administrative Officer, Sr. Finance & Accounts Officer
	Member Secretary	:	Dr. A.K. Singh, Pr. Scientist
12. Prioritization Monitoring and Evaluation Cell (PME Cell)	**Chairman**	:	Director
	Members	:	Dr. Uma Sah, Dr. C.P. Nath, Dr. Alok Das, Dr. Krishnashis Das, Dr. R.K. Mishra
	Member Secretary	:	Dr. Aditya Pratap
13. Library Committee	**Chairman**	:	Director
	Members	:	All HoDs, Sr. AO and Sr. F&AO
	Member Secretary	:	Dr. Mohd. Akram
14. Institutional Bio-safety Committee	**Chairman**	:	Director
	Members	:	Dr. (Mrs.) Meenal Rathore, Dr. Mohd. Akram Dr. Neetu Singh Kushwah, Dr. Jonaki Sen, IIT, Kanpur Dr. Sanjeeb Kumar, IISR, Lucknow Dr. P.K. Singh, Govt. Medical College, Ambedkar Nagar
	Member Secretary	:	Dr. Alok Das, Sr. Scientist
15. Germplasm & Genotype Identification Committee	**Chairman**	:	Director
	Co-Chairman	:	Dr. I.P. Singh
	Members	:	Dr. D. Datta, Dr. Sujayanand G.K., Dr. Shanmugavadivel, Dr. Naimuddin, Dr. Amrit Lamichaney
	Member Secretary	:	Dr. Aditya Pratap, PS
16. Academic and HRD Committee	**Chairperson**	:	Dr. Yogesh Tiwari, Pr. Scientist
	Members	:	Dr. R.K. Mishra, Dr. Hemant Kumar, Dr. Debjyoti Sen Gupta, Dr. C.P. Nath, Dr. Neetu Kushwaha, Dr. Kalpana Tiwari

	Member Secretary	:	Dr. Alok Das, Sr. Scientist
17. Grievance Cell	**Chairman**	:	Dr. I.P. Singh, Pr. Scientist & I/c Project Coordinator (Pigeonpea)
	Members	:	Dr. A.K. Srivastava, Dr. (Mrs.) Archana singh (RS Bhopal) Dr. (Mrs.) Vijay Laxmi, Dr. P.S. Saable (Dharwad), Dr. Lalit Kumar Ralaniya (Bikaner) & Dr. Satheesh Naik S.J., Sh. Akhil Kumar Gangal, Secy. (Staff), IJSC Ms. Meenakshi Varshney
	Member Secretary	:	Sh. R.K. Nigam, AAO
18. Computer/ ARIS Cell & Instrumentation Committee	**Chairman**	:	Dr. Naimuddin, Pr. Scientist
	Members	:	Dr. Prasoon Verma, Dr. Hemant Kumar, Dr. Asik Datta, Dr. Biswajit Mondal, Sh. Kunal Kalra, Sr. F & AO
	Member Secretary	:	Dr. Devraj, Pr. Scientist
19. IIPR, website and social Media maintenance and updation committee	**Chairman**	:	Dr. Uma Sah
	Members	:	Mr. Revanasidda, Dr. B. Mondal, Mr. Sudhir Kumar, Ms. Mrunalini Kancheti
	Member Secretary	:	Dr. Devraj
20. Consultancy Processing Cell	**Chairman**	:	Dr. P.K. Katiyar, Pr. Scientist
	Members	:	Dr. T.N. Tiwari, Dr. Amrit Lamichaney, Dr. Anup Chandra, Dr. Konda Aravind Kumar, Dr. Rekha Rani
	Member Secretary	:	Dr. Raghavendra Singh, Pr. Scientist
21. Guest House Management Committee	**Chairman**	:	Dr. Awnindra Kumar, Principal Scientist
	Members	:	Dr. Dibendu Datta, Dr. Naimuddin, Dr. K.R. Soren, Sr. A.O. & Sr. F & AO
	Member Secretary	:	Mr. Sukhdeo Mahto, AAO & I/c Guest House
22 House allotment Committee	**Chairman**	:	Dr. D.P. Patel
	Members	:	Dr. D. Sengupta, Sr. A.O., Mr. Sukadeo Mahto AAO, Mr. R.M. Pal, Mr. Akhil Kumar Gangal IJSC Members
	Member Secretary	:	Mr. Rajendra Kumar Nigam, AAO
23. Vehicle Maintenance Committee	**Chairman**	:	Dr. T.N. Tiwari, Pr. Scientist
	Members	:	Dr. Satheesh Naik S.J. Dr. Manu B. (R S, Dharwad), Dr. Ram Lal Jat (Bikaner), Dr. Surendra Ghritlahre (RC, Bhopal), Sr. A.O., Sr. F & AO
	Member Secretary	:	Mr. Rajendra Kumar Nigam, AAO

24. Sports Committee	**Chairman**	:	Dr. A.K. Parihar, Scientist
	Members	:	Dr. (Mrs.) Vijay Laxmi, Dr. Amrit Lamichaney, Dr. Jagadeeswaran, Dr. G.K. Srivastava, Dr. Akhil Kumar Gangal, Secretary IJSC
	Member Secretary	:	Dr. K.R. Soren, Sr. Scientist
25. *Rajbhasha* Implementation Committee	**Chairman**	:	Director
	Members	:	All HoDs, Dr. Mohd. Akram, Dr. Aditya Pratap, Dr. Rishikesh Kumar
	Member Secretary	:	Dr. Rajesh Kumar Srivastava
26. Technical Advisory & Proprietary Committee	**Chairman**	:	Dr. Jitendra Kumar, Pr. Scientist
	Members	:	Dr. Naimuddin, Dr. Devraj, Dr. Jagadeeswaran, Dr. Vaibhav Kumar, Dr. (Er.) Manmohan Deo
	Member Secretary	:	Dr. Alok Das
27. Local Purchase Committee	**Chairman**	:	Dr. A.K. Srivastava, Pr. Scientist
	Members	:	Dr. Satheesh Naik SJ, Mr. Sudhir Kumar, Dr. Asik Dutta, Dr. Anup Chandra and Sr. F & AO or his representative
	Member Secretary	:	AAO (S)
28. Women Cell	**Chairperson**	:	Dr. (Mrs) Vijay Laxmi, Sr. Scientist
	Member	:	Dr. (Mrs) Archana Singh, RS, (Bhopal), Dr. (Mrs) Kalpana Tiwari, Ms. Namrata Laskar, Mrs. Monika Punia (Bikaner) Mrs. Reeta Mishra,
	Member Secretary	:	Sh. Rajendra Nigam, A.A.O
29. Standing Weeding out Committee	**Chairman**	:	Dr. T.N. Tiwari
	Members	:	AAO (E), Sh. S. Mahto
	Member Finance	:	Sr. F & AO/Nominee
	Member Secretary	:	AAO (S): Sh. R.K. Nigam
30. Standing Committee E-Governance Cell & Parliamentary Affairs	**Chairman**	:	Sr. AO & Head of Office
	Members	:	Sr. F&AO, AAO (S)
	Member Secretary : AAO (E)		
31. CPIO	Dr. D.P. Patel		
32. In-charges	Sr. Administrative Officer, Head of Office Dr. Aditya Pratap, I/c PMEC & Member Secretary, QRT Dr. Jitendra Kumar, PS – Member Secretary, IRC Dr. Mohd. Akram, PS - Member Secretary, RAC Dr. P.K. Katiyar PS- I/c Seed Dr. A.K. Singh, PS I/c Farm, (Main Campus) Dr. Dibendu Datta I/c (NRF), Kanpur Dr. Dev Raj, I/c Computer under ARIS Cell Dr. Amrit Lamichane, I/c, Gene Bank Including Cold Module Under Supervision of HoD (CI)		

	Dr. Mohd. Akram, PS and I/c Library & Convener Seminar Sh. S. Mahto, AAO (Works) I/c Works & Custodian 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 and I/c, Security (Interim Arrangement) Dr. Omkar Nath, CTO, Farm Manager, (NRF) Shri Krishna Autar, STO Seed Production (NRF) Shri R.K. Singh STO Farm Manager, (Main Farm) & I/c Horticulture Under Supervision of Dr. A.K. Singh Shri Rajendra Kumar Nigam, AAO, I/c Vehicle Shri Shiv Saran Singh, Assistant, I/c Sanitation under supervision of Sr. A.O. Shri Yaduvir Singh, I/c EPABX and other electronic facilities under supervision of Dr. (Er.) Prasoon Verma, Sr. Sci.
33. Nodal Officer/Link Officer/ Liaison Officer	Dr. G.P. Dixit: Link Officer, IIPR RC, Dharwad (Karnataka) Dr. Raghavendra Singh: Nodal Officer, IIPR RRS, Khordha (Odisha) Dr. P.K. Katiyar: Link Officer, IIPR RS, Phanda, Bhopal (M.P) Dr. Narendra Kumar: Nodal Officer, IIPR RS, Bikaner (Rajasthan) Dr. Aditya Pratap: Nodal Officer, Off Season Nursery (H.P.)

ICAR - IIPR Regional Research Centre, Dharwad

1.	Farm Produce Auction & Purchase Committee	**Chairman**	: Dr. M.H. Kodandaram, PS & In-Charge
		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.	Farm Development Committee	**Chairman**	: Dr. S.L. Patil, PS (Agronomy)
		Members	: Dr. Manu B., 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	
5.	I/c Security	Dr. M.H. Kodandaram	

ICAR - IIPR Regional Research Station, Phanda, Bhopal

1.	Local 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
			:	Sh. Priyank Shrivastava
2.	Seed/Grain Auction Committee	**Member Secretary**	:	Mr. Chandra Mauli Sharma, AAO
		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.	Local Purchase Committee	**Chairperson**	:	Dr. Ram Lal Jat
		Members	:	Dr. Deepak Kumar Sarolia Principal Scientist, CIAH, Bikaner
			:	Dr. Surendrea Kumar Meena
			:	Mrs. Monika Punia
		Member Secretary	:	Sh. M.M. Vanvi, AAO
2.	I/c Seed and Farm			Dr. Banwari Lal
3.	I/c Campus and Experimental Farm			Dr. Ram Lal Jat
4.	I/c Lab, Gardening and land scape			Dr. Surendra Kumar Meena
5.	I/c Vehicle and Farm implements			Dr. Lalit Kumar Rolaniaya

IIPR, Regional Research Centre, Khordha	: Dr. Raghavendra Singh, Principal Scientist, Officer-in-charge Dr. Sunil Kumar Sunani, I/c Farm and other campus activities+Vehicle
Off-season nursery Lahul and Spiti (HP)	: Dr. Aditya Pratap, Officer-in-charge

Panorama

Brainstorming Webinar organized on Sustaining Growth in Pulses

World Pulses Day was celebrated at ICAR-IIPR on February 10, 2022. On this auspicious occasion, a Brainstorming Webinar was organized jointly by ICAR-Indian Institute of Pulses Research, Kanpur and Indian Society of Pulses Research and Development. The theme was "Sustaining growth in pulses" and it attracted an impressive participation of more than 220 scientists, researchers and research managers from across the country and abroad. Hon'ble Secretary, DARE-cum-DG, ICAR, Dr. Trilochan Mohapatra was Chief Guest of the occasion. The programme was chaired by Dr. T.R. Sharma, DDG (Crop Sciences), ICAR while Dr. Sanjeev Gupta, ADG (Oilseeds and Pulses), ICAR was the Guest of Honour. The Webinar was organized on four major themes including genetic gain through conventional and modern breeding tools, conservation agriculture and natural farming,

crop resilience to climate change, mechanization and value addition and each session was represented by one lead speaker and 6-8 eminent researchers as panelists. Dr. S.K. Sharma, Former VC, CSK HPKV, Palampur was moderator of the Webinar. Lead speakers included Dr. N. Nadarajan, Former Director, ICAR-IIPR, Kanpur; Dr. Shanti K. Sharma, Director Research, MPUAT, Udaipur; Dr. P.S. Basu,

Former PS, ICAR-IIPR, Kanpur and Dr. C.R. Mehta, ICAR-CIAE, Bhopal. Among the panelists, Dr. B.B. Singh, Dr. P.M. Gaur, Dr. Rajeev Varshney, Dr. A.K. Shasany, Dr. Shiv Kumar, Dr. Ramakrishnan Madhavan Nair, Dr. Masood Ali, Dr. Ch. Srinivasa Rao, Dr. V.K. Singh, Dr. A.N. Ganeshmurthy, Dr. S.S. Singh, Dr. H.C. Sharma, Dr. (Mrs.) M. Maheshwari, Dr. S.C. Dubey, Dr. S.K. Chaturvedi, Dr. Bansa Singh, Dr. R.K. Vishwakarma, Dr. Jagan Mohan, Dr. B.K. Tiwari, Dr. Prasoon Verma and Dr. Narendra Kumar were notable. From the industry side, Mr. Mithilesh Gupta, President, Kanpur Pulse Millers Association; Mr. Anurag Gupta, MD, Ashok Masala Co., Kanpur and Mr. Adarsh Aggarwal, Mung Miller took active part. The day-long deliberations focused on formulating strategies to sustain growth in pulses in the country and recommendations were made on ways to be adopted to increase pulses productivity, promote vertical expansion, increase nutrition content, mitigate climate change, reduce storage and post-harvest losses and increase milling recovery. Dr. Shiv Sewak, Director, ICAR-IIPR, Kanpur was the Organizing Chairman of the webinar, while Dr. I.P. Singh, President, ISPRD was the convener. Dr. Aditya Pratap and Dr. (Mrs.) Meenal Rathore were the Organizing Secretaries.

Annual Group Meet on *Kharif* Pulses-2022

The Annual *Kharif* Pulses Group Meet of AICRPs on Pigeonpea, MULLaRP and AINP on Arid Legumes was organized at CSK HPKV, Palampur on May 10-11, 2022. The group meet was inaugurated by Prof. H.K. Chaudhary, Vice-Chancellor of the University; accompanied by Dr. T.R. Sharma, DDG (Crop Science), ICAR and Dr. Sanjeev Gupta, ADG (O&P), ICAR, New Delhi. At the outset, Dr S.P. Dixit, Director of Research, CSKHPKV, Palampur, welcomed the dignitaries and delegates that was followed by deliberations of introductory remarks by Dr Sanjeev Gupta, ADG (O&P), ICAR. He appreciated the efforts of the researchers and farming community for achieving an all-time high

production of 27.00 million tonnes of pulses (2nd advanced estimate, 2022, DAC, GoI). He said that the current yield level in pulses was record high in the history of growth jump across crops. Dr. Gupta suggested that pulses production and protection technologies should be incorporated in package of practices of respective states so that it reaches the farming community.

Dr. I.P. Singh, Project Coordinator, AICRPs on Pigeonpea and MULLaRP apprised about the major achievements and constraints in pigeonpea, mungbean and urdbean crops. He elaborated the ongoing efforts on pre-breeding, transfer of traits for crop adaptation, genetic enhancement in yield & quality, development of new plant types, identification of appropriate post- emergence herbicides, productive cropping systems, management of prevailing diseases, development of IPM modules, *etc*. On a similar note, Dr Farindra Singh, Nodal Officer of AINP on Arid Legumes apprised the significant achievements made in Arid legumes including development of varieties, germplasm maintenance & its utilization, breeder seed production and dissemination of technologies through FLDs at farmers' field. Dr. Bansa Singh, Director, ICAR-IIPR, Kanpur deliberated about the on-going pulses research and development activities and the future road map for enhancing pulses production. He emphasized the need of pre-breeding in major pulse crops in order to create new variability for desired traits and appreciated the efforts taken by ICAR-IIPR, Kanpur in this context.

The chief guest of the occasion, the Vice-Chancellor of CSKHPKV, Prof. H.K. Chaudhary acknowledged the AICRP system in playing an important role in sustaining food grain self-sufficiency of the nation and furthermore, highlighted various avenues for pulses improvement including rigorous selection from the existing genetic variability in order to exploit available germplasm pool using biotechnological tools. He laid special emphasis on exploration of Himalayan states (Himachal Pradesh and Uttarakhand) for *rajmash*, urdbean, horsegram and lentil crops. Prof. Chaudhary also said that the next generation extension approaches, including machine learning and farmer to farmer extension, should be used for effective dissemination of our technologies to the farmers.

The chairman, Dr. T.R. Sharma, DDG (CS), ICAR emphasized the need of intensifying pre-breeding activities and breeding for bio-fortification and climate resilience traits. He suggested that breeding programmes of AICRPs should focus on achieving "Precisely-defined product profiles" in different pulse crops.

27th Annual Pigeonpea (Long duration) Group Meet organized

The Annual Group Meet of AICRP on Pigeonpea (Long duration) was organized on 10th June, 2022 at ICAR-IIPR, Kanpur in hybrid mode and chaired by Dr. Sanjeev Gupta, ADG (O&P), ICAR, New Delhi. The invited subject experts namely Dr. B.B. Singh, Former ADG (O&P), ICAR; Dr. Masood Ali, Former Director, ICAR-IIPR, Kanpur and Dr. Suhas Yelehetty, Ex. Professor, ZARS, Kalaburagi participated in the meeting for improvement of the programme. Dr. Gupta reviewed the annual progress and stressed upon accelerating variety development, especially for climate resilient traits. such as terminal heat tolerance in long duration pigeonpea. Co-Chairman Dr. Bansa Singh suggested exploring novel traits suitable for mechanical harvesting, intensifying research on intercropping systems for sustaining the area of long duration pigeonpea in NEPZ and sharing of breeding materials, particularly for pre-breeding, on regular basis for accelerating genetic gain in long duration pigeonpea. The meeting was attended by Dr. I.P. Singh, Project Co-ordinator, AICRP-Pigeonpea and all principal investigators from concerned AICRP centres, participants from NEPZ of the country involved in research on long duration pigeonpea through video conferencing.

ICAR-IIPR, Kanpur signed MoU with CSJM University, Kanpur and CSKHPAU, Palampur

ICAR-IIPR, Kanpur and CSJM University, Kanpur signed MoU for research and academic collaboration in areas of life sciences and biotechnology on June 15, 2022. The MoU was signed by Dr Bansa Singh, Director, ICAR-IIPR, Kanpur and Dr Vinay Kumar Pathak, Vice Chancellor, CSJM University, Kanpur on behalf of their respective organizations. ICAR-IIPR, Kanpur has also signed an MoU with CSKHPAU, Palampur for training and post-graduate research on May 11, 2022. On behalf of the Institute, the MoU was signed by Dr Bansa Singh, Director, ICAR-IIPR, Kanpur and Dr H.K. Chaudhury, Vice Chancellor, CSKHPAU, Palampur.

Speaking on the occasion, Dr. Bansa Singh stressed upon the need of quality research in agriculture and assured the support of scientists of the Institute to both the organizations in research and developments on subjects of common interests. The Vice-Chancellors of both the universities highlighted the need of quality research and collaborations for the benefit of society at a large.

Successful introduction of new high yielding wheat varieties in project villages under Farmer FIRST Project

DBW-187 (*Karan Vandana*) and DBW 222 (*Karan Narendra*) are recently released high yielding varieties of wheat that are recommended for cultivation in the North Eastern Plain Zone of India. These multiple disease resistant varieties were introduced for the first time in Delemau, Khadra, Karchalpur, Merai, Shahpur villages of Fatehpur district under Farmer FIRST Project in *rabi* season 2021-22. A total of 76 farmers actively participated in these interventions on wheat varieties DBW 187 (56 farmers) and DBW 222 (20 farmers) covering 20 ha area. These varieties were sown in first fortnight of November 2021. To support farmers with the improved production technologies of the introduced wheat varieties, a collaborative online training programme was also organised. Participating farmers obtained average grain yield of 46.29 q/ha from wheat variety DBW 187 and 50.74 q/ha from DBW 222, which was about 29.5% and 42% higher than the grain yield from existing wheat variety (35.75 q/ha), respectively. Further, the farmers also fetched higher straw yield by 12.3 q/ha (18.2%) from DBW 187 and 6.15 q/ha (9.1%) from DBW 222. This resulted in higher gross returns to participating farmers from the introduced wheat varieties at prevailing market price for grain (₹ 2025/q) and straw (₹ 417/q). Farmers received gross return of ₹1,27,068/ha and 1,33,523/ha from wheat varieties DBW 187 and DBW 222, respectively which was about 26.31% and 32.72% higher as compared to the gross returns from existing wheat variety. Farmers were satisfied with the performance of the introduced wheat varieties and were eager to enhance the area coverages.

Celebration of Foundation Day at IIPR

ICAR-Indian Institute of Pulses Research, Kanpur celebrated its 29th Foundation Day on 05th September, 2022 following its establishment in 1993. Dr T.R. Sharma, Deputy Director General (CS), ICAR was the Chief Guest and Dr Sanjeev Gupta, Asstt Director General (O&P), ICAR was the Guest of Honour of the function. On this occasion, issues related to pulses cropping/ production remained in discussion keeping in view the current scenario of pulses research. Eminent scientists, research scholars and farmers from different areas of pulses research were invited to participate and discuss on the research activities and advancements in achieving self sufficiency and nutritional security in pulses in the country.

The chief guest of the occasion, Deputy Director General (CS), ICAR delivered the Foundation Day lecture and expressed his concern over the activities going on in the Institute and warmly praised the achievements of the Institute under the able guidance of Dr Bansa Singh, Director, IIPR. He congratulated all the pulse scientists for achieving record production of 27.69 million tonnes of pulses. Keeping in view the present circumstances, he urged the scientists to work hard for the allround benefit of the farmers and stressed on minimizing production cost of pulses farming. He said that farmers ought to be partners in various research based programmes and this research, if applied on their fields, should surely give better results. He urged the scientific community to work sincerely in order to achieve the target of 32 million tonnes of pulses by the year 2030.

Dr Sanjeev Gupta, Asstt. Director General (O&P), ICAR widely applauded the research works and efforts made by IIPR scientists in allround development of the Institute. He added that as though pulses are at good stage, yet, there is still a lot to be done in respect of their production and productivity. He also said that farmers are the soul of the nation and being the owner of his land, they should be self-sustained and should not be in distress so that our country may remain self-sufficient in pulse crops.

While delivering his remarks, Dr Bansa Singh, Director, IIPR stressed on the importance of pulses and related future plannings and strategies to the current scenario. Dr Singh discussed the research activities and advancements in achieving self-sufficiency and nutritional security in pulses in the country. He briefed on the research activities going on in the Institute and stressed on the importance of pulses as a building block for sustaining both crop and human/animal life on a long-term basis. He stressed on the fact that research and development activities of the Institute have been further strengthened towards increasing production of pulses which have resulted in continuous high production and productivity. In the last few years, he informed that the various projects under National programmes have been successful and added that research and development activities of the Institute are heading towards bringing a remarkable pulse revolution in the country in time to come.

In addition, three bulletins and one folder were released on the occasion. The chief guest also laid the Foundation Stone of the Speed Breeding Facility at IIPR campus. He also launched the high protein & fiber rich biscuits named Delomeo prepared in collaboration with Mahodya Agro.

During the function, Dr. Narendra Kumar, Principal Scientist was awarded with the Best Scientist Award 2022 (Senior Category) and Dr. A.K. Parihar, Sr Scientist was awarded the Best Scientist Award 2022 (Young Category). Dr. Kanhaiya Lal was awarded as the Best Technical Officer. Mr. Shiv Sharan, AAO was awarded as the Best Worker in Administrative Category and Mr Rama Shanker was awarded as the Best Worker in supporting staff category and Best Team Award was given to Dr Aditya Pratap, Dr Mohd. Akram, Dr Revenappa Birader, Dr Basavraj, Dr A. Ravanasidda, Dr Meenal Rathore and Dr Sanjeev Gupta for Research & Development activities during 2022.

Dr. I.P. Singh, Project Coordinator (Pigeonpea) offered vote of thanks to all the esteemed guests and participants. The programme was conducted by Dr. Aditya Pratap and Dr (Smt) Meenal Rathore, Principal Scientists.

Launch of *Delomeo* brand of protein and fibre handmade cookies by ABI incubatee- Mahodhya Agriworks

Agribusiness Incubation Unit (ABI) of ICAR-Indian Institute of Pulses Research, Kanpur is working continuously to promote the pulse based agribusiness. The ABI unit signed Memorandum of Agreement (MoA) with Mahodhya Agriworks for incubation support for preparing "High fibre and protein rich biscuits from pulse byproducts" on 29th July 2022. On the occasion of Institute Foundation Day on 05th September 2022, these high fiber and protein rich pulse biscuits prepared by Mahodhya Agriworks with the brand *Delomeo* was launched by Hon'ble Deputy Director General (Crop Science), Dr. T.R. Sharma, in the presence of Dr. Sanjeev Gupta, Assistant Director General (Oilseeds and Pulses) ICAR and Dr. Bansa Singh, Director, IIPR, Kanpur. The Director congratulated concerned team ABI, Dr. Uma Sah, Dr. Prasoon Verma, Mr. Jitendra Ojha and Mr. Mohit Katiyar and Mr. Mohit Garg of Mahodhya Agriworks for the efforts made for the launch. The biscuits are available in two variants-*Delomeo Original Classic Elaichi* and *Delomeo Classic Salted*. Pigeonpea milling byproducts with whole wheat flour have been used as primary ingredients to optimize the protein content of these handmade cookies. High fiber and protein rich pulses cookies are attracting health conscious peoples. These cookies are available for sale at the sale counter of ABI Unit "*Dalhan haat*" located at the main gate of the Institute. The incubatee could generate about ₹ 21,560 as revenue till 30th Sept. 2022 (within 25 days of launch) from the sale of these handmade biscuits. The launched biscuits are finding quick acceptance among consumers for their taste, feel, flavour and nutrient composition.

Crispier biscuits prepared by using pulse milling byproducts

Pulses are mostly consumed in form of dehusked splits, *i.e.*, *dal* that are dehusked in commercial mills using abrasive emery rollers in multiple passes that causes scouring of peripheral region of cotyledons leading to lesser *dal* recovery. About 10-15% cotyledon powder gets mixed with husk in milling byproduct. In the project funded "Utilization of Pulse Milling Byproduct for Edible Use" funded by Ministry of Food Processing, the bioactive compounds, *viz.*, proteins, phenols, antioxidants, fibers *etc.*, were evaluated for pulse milling byproduct of different pulses. It was observed that the milling byproduct and its fractions are nutritionally rich and can be utilized for edible purposes.

The milling byproducts obtained from milling of pigeonpea and lentil were separated into husk and powder fractions with the help of Electro-magnetic Sieve Shaker. Whole milling byproduct, husk and powder fractions were used to prepare protein and fiber rich biscuits. Instead of white flour (*Maida*), whole wheat flour was used as base material. Three types of biscuits, *viz.*, i) whole milling byproduct, ii) husk fraction and iii) powder fraction each for pigeonpea and lentil were prepared. Textural properties of these biscuits were evaluated using texture analyzer (TexVol TVT-300XP) in terms of hardness. The hardness was also compared with the commercially available wheat fibre rich biscuits (Digestive). The hardness of the biscuits indicates that biscuits with pulse milling byproduct are more crispy than wheat fiber biscuits. Among the biscuits, pigeonpea byproduct biscuits were crispier than the lentil byproduct biscuits for all three combinations.

Parthenium Awareness Week

'*Parthenium* Awareness Week' programme was organized at ICAR-IIPR, Kanpur on August 22, 2022. The programme was chaired by Dr. Bansa Singh, Director, ICAR-IIPR, Kanpur; Dr. G.P. Dixit, Project Co-ordinator (Chickpea) and Dr. Narendra Kumar, Head (Division of Crop Production). Dr. C.P. Nath Scientist (Agronomy) was convener of the programme. Programme was attended by all the Heads of Divisions, scientists, technical officers, skilled & supporting staff, and projects staffs of ICAR-IIPR. Dr. Narendra Kumar briefed about *Parthenium* and highlighted its control measures. Dr. G.P. Dixit highlighted the obnoxious nature of this

weed and severity in different ecologies. Dr.Bansa Singh mentioned the harmful impacts of *Parthenium* on society and ecosystem. He also highlighted to create mass awareness to eliminate this weed. This programme was also organized in different farms of ICAR-IIPR, Kanpur and its regional centres/stations.

World Soil Day organized at ICAR-IIPR

The **'World Soil Day'** was organized at ICAR-IIPR, Kanpur on 5th December, 2022. The programme was chaired by Dr. Bansa Singh, Director, ICAR-IIPR. Dr. K.N. Tiwari, Ex-Director, IPNI, (India Programme) was Chief Guest of the programme. The programme was organized by Dr. Raghavendra Singh, Principal Scientist, Crop Production Division. Mr. Asik Dutta, Scientist (Soil Science) was the Convenor. This programme was attended by Scientists from ICAR-IIPR and farmers from Fatehpur, UP. At the outset, Dr. R. Singh, PS, Crop Production Division welcomed the delegates and highlighted the importance of Soil Health and 'World Soil Day'.

He also highlighted the role of soil in securing the food system for all the living entities. This was followed by the remarks of Dr. B. Singh, Director; ICAR-IIPR, Kanpur. He elaborately discussed and sensitized farmers on balanced nutrition on soil health and importance of the day. Dr. K.N. Tiwari, Chief Guest elaborately discussed on "Balanced fertilization and soil health". He also covered different aspects of soil nutrition such as importance of potassium in soil health and farm productivity,

importance of field management for N-nutrition, water management, conservation tillage, crop residue burning, judicial use of inorganic inputs (herbicide, pesticide and fertiliser), importance of compost preparation and utilisation of rural wastes, cropping systems and inclusion of pulses in the existing cropping systems and lastly improving profitability in the village level *via* value addition. He urged farmers to buy the microbial formulations and bio-fertilizers from authentic sources for better efficacy.

किसान–वैज्ञानिक परिचर्चा आयोजित

फार्मर फर्स्ट परियोजना के अन्तर्गत 27 मार्च 2022 को ग्राम खदरा, फतेहपुर में "दाल प्रसंस्करण और मूल्य संवर्धन" पर किसान–वैज्ञानिक परिचर्चा का आयोजन किया गया। निदेशक, आईसीएआर–आईआईपीआर सहित चार वैज्ञानिकों ने खदरा, डेलेमाऊ, होलापुर, करचलपुर में "नमामि गंगे महिला कृषि उद्योग समिति" के अन्तर्गत पंजीकृत 50 किसानों ने इस महत्वपूर्ण परिचर्चा में भाग लिया। इस दौरान दलहन प्रसंस्करण, दलहन मूल्य संवर्धन, दलहन विपणन, मिनी दाल मिल के उपयोग और ग्रीष्मकालीन दलहन के कीट जैसे महत्वपूर्ण विषयों पर बातचीत हुई। निदेशक महोदय ने दाल उत्पादन के विपणन के लिए शुद्धता और विश्वास निर्माण की आवश्यकता पर बल दिया और इस गांव में किसानों द्वारा मूल्य संवर्धन और दाल के प्रसंस्करण के माध्यम से आय सृजन और उपलब्ध अवसरों का मूल्यांकन किया। निदेशक, भाकृअनुप–आईआईपीआर ने खदरा गांव में स्थापित आईआईपीआर मिनी दाल मिल का भी उद्घाटन किया।

भाकृअनुप–आईआईपीआर में एबीआई इकाई का बिक्री काउंटर "दलहन हॉट" प्रारंभ

विश्व दलहन दिवस 2022 के अवसर पर, भाकृअनुप–भा.द.अनु.सं. कानपुर संस्थान के गेट पर एबीआई इकाई का "*दलहन हाट*" बिक्री काउंटर कार्यरत हो गया। संस्थान के गेट पर ही गुणवत्तायुक्त एवँ प्रसंस्कृत सभी प्रकार की दालें, बेसन आदि छोटे–बड़े पैकटों में उचित दर पर उपलब्ध करायी जा रही हैं और यह बिक्री काउंटर संस्थान

की *एबीआई* इकाई के *इनक्यूबेटी* के साथ–साथ *फार्मर फर्स्ट* परियोजना के अन्तर्गत खदरा गांव से दाल मूल्यवर्धन में लगी कृषि महिलाओं की पंजीकृत *सोसायटी* के लिए एक विपणन मंच प्रदान करता है। इस बिक्री *काउंटर* के खुलने से ग्राहकों में काफी उत्साह देखा गया और लोग *काउंटर* से गुणवत्तायुक्त दालें क्रय कर रहे है।

फार्मर फर्स्ट प्रोजेक्ट
चना की प्रजाति जीएनजी 2207 से अधिक उपज की प्राप्ति

देसी चने की उन्नत प्रजाति जीएनजी 2207, जिसे अवध के नाम से भी जाना जाता है, को रबी 2021–22 के दौरान *फार्मर फर्स्ट प्रोजेक्ट* के अन्तर्गत फतेहपुर जिले के खदरा, देलेमऊ, शाहपुर, मिराई और करचलपुर गाँवों में सफलतापूर्वक बोया

गया। यह प्रजाति देश के उत्तर पूर्वी मैदानी क्षेत्र के लिए, समय पर बुवाई की स्थिति के लिए उपयुक्त है। इस किस्म का बीज आकार मध्यम होता है और यह *फ्यूजेरियम* उकठा रोग के प्रति सहनशील होती है। परियोजना के गाँवों के कुल 60 किसानों ने 9.10 हेक्टेयर क्षेत्र में इस प्रजाति की बुवाई की और इसकी खेती धान–चना और मक्का–चना की फसल के फसल–क्रम में की गई थी। शुरू की इस प्रजाति से किसानों ने उपलब्ध स्थानीय गैर–वर्णित चना की किस्मों से 12.02 क्विंटल के मुकाबले 16.76 क्विंटल/हेक्टेयर की औसत उपज प्राप्त की, जिसमें 39 प्रतिशत का उपज लाभ दर्ज किया गया। परियोजना गाँवों के भाग लेने वाले किसानों ने ₹ 26,000/हेक्टेयर से अधिक की आय प्राप्त की। उपज में वृद्धि के अलावा, किसानों ने बड़ा बीज, बीज रंग, पौधे की शक्ति और उकठा के प्रतिरोध के लिए इस प्रजाति को प्राथमिकता दी। जीएनजी 2207 प्रजाति की विशेषताओं से किसानों का उत्साहवर्धन हुआ है तथा आने वाले वर्षों में और अच्छे परिणामों की आशा की जा रही है।

दलहन व गेहूं प्रसंस्कृत उत्पाद द्वारा द्वारा महिला कृषक समूह की आय में वृद्धि

भारतीय दलहन अनुसंधान संस्थान, कानपुर द्वारा *फार्मर फर्स्ट* परियोजना का क्रियान्वयन फतेहपुर जनपद के देवमई प्रखण्ड के गाँव में किया जा रहा है। महिला कृषकों की उद्यमिता विकास तथा अतिरिक्त आय अर्जित करने के उद्देश्य से दिनांक 04 अक्टूबर, 2020 को परियोजना ग्राम खदरा के 11 सदस्य की पंजीकृत नमामि गंगे महिला कृषि उद्योग समिति का गठन किया गया था। दलहन प्रसंस्करण एवं मूल्य संवर्धन द्वारा आय बढ़ाने के प्रयासों के अंतर्गत परियोजना ग्राम में इन महिला कृषकों को आई.आई.पी.आर. मिनी दाल मिल उपलब्ध करायी गयी, जो महिला कृषक समूह को दलहन प्रसंस्करण के माध्यम से अतिरिक्त आय अर्जित करने में मददगार साबित हो रही है।

संस्थान के स्थापना दिवस के अवसर पर महिला कृषि उद्योग समिति द्वारा संस्थान के मुख्य द्वार पर कृषि व्यवसाय ऊष्मायन इकाई के विक्रय केंद्र 'दलहन हाट' पर समूह द्वारा निर्मित उत्पादों का प्रदर्शन स्टॉल लगाया गया। महिला कृषक समूह द्वारा गेहूँ की *बायोफॉर्टीफाइड* प्रजाति डी.बी. डब्लू. 187 के 50 कि.ग्रा. आटा तथा अन्य प्रसंस्कृत उत्पाद जैसे मूंग दाल, उर्द दाल, चना दाल तथा बेसन आदि का प्रदर्शन एवं विक्रय किया गया। डी.बी.डब्लू. 187 प्रजाति उच्च प्रोटीन तथा आयरन से युक्त प्रजाति है। इस सफल अनुभव से नमामि गंगे महिला कृषि उद्योग समिति के सदस्य उत्साहित हैं और दलहन प्रसंस्करण एवं मूल्य संवर्धन के क्षेत्र में दलहन उद्यम को बड़े स्तर पर करने के लिए उत्सुक है।

संस्थान में हिंदी दिवस मनाया गया

भाकृअनुप–भारतीय दलहन अनुसंधान संस्थान में दिनांक 14 सितम्बर, 2022 को हिन्दी दिवस समारोहपूर्वक मनाया गया। लोकप्रिय कवि, लेखक एवं शिक्षाविद्, डॉ सुरेश अवस्थी इस समारोह के मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक डॉ. बन्सा सिंह ने की। हर्षोल्लास के साथ आयोजित उक्त समारोह में संस्थान के सभी वैज्ञानिक, तकनीकी, प्रशासनिक एवं सहायक वर्ग के कर्मचारियों ने भाग लिया।

मुख्य अतिथि, डॉ सुरेश अवस्थी ने अपने उद्बोधन में कहा कि आज विकास की गति में हमारी राजभाषा हिन्दी एक मजबूत सूत्रधार का कार्य कर रही है अतएव 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 संकल्पबद्ध रूप से प्रयासरत हैं।

अध्यक्षीय उद्बोधन में संस्थान के निदेशक ने कहा कि हिन्दी एक समृद्ध भाषा है और इसकी सम्प्रेष्णीयता भी उच्च कोटि की है। हिन्दी को हमारे संविधान में राजभाषा के रूप में घोषित किया गया 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। 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। उक्त अवसर पर हिंदी में अधिकाधिक काम करने हेतु श्री मयंक मिश्रा, श्रीमती मीनाक्षी वार्ष्णेय, श्रीमती रीता मिश्रा, श्री संजय शर्मा, श्री अनिल सोनकर, श्री हरगोविंद राठौर, मोहम्मद शब्बीर, श्री देवी प्रसाद, श्री यशवंत को नकद

पुरस्कार एवं प्रशस्ति–पत्र से सम्मानित किया गया। हिंदी में सर्वाधिक प्रकाशित लेखन हेतु डॉ राजकुमार मिश्रा, प्रधान वैज्ञानिक; डॉ मनमोहन देव, वैज्ञानिक और डॉ पी. के. कटियार, प्रधान वैज्ञानिक को नकद पुरस्कार एवं प्रशस्ति–पत्र से सम्मानित किया गया। अधिकारी वर्ग में हिंदी में सर्वाधिक कार्य हेतु वरिष्ठ वित्त एवं लेखा अधिकारी श्री कुनाल कालरा, प्रशासनिक अधिकारी, श्री शुकदेव महतो, सहायक प्रशासनिक अधिकारी श्री राजेंद्र निगम, श्री गुलाब चन्द्र शर्मा और श्री शिव शरण सिंह, को नकद पुरस्कार एवं प्रशस्ति–पत्र से सम्मानित किया गया। डॉ. इंद्र प्रकाश सिंह, परियोजना समन्वयक (अरहर) ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन डॉ. राजेश कुमार श्रीवास्तव, सचिव, ने किया।

Personnel

A. Research Management

1.	Dr. Bansa Singh	Director (From 01.04.2022)
	Dr. Shiv Sewak	Director (Upto 31.03.2022)

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. I.P. Singh	Project Coordinator (In-charge)

E. AINP-Arid Legumes

5.	Dr. Bansa Singh	Nodal Officer, AINPAL

F. Scientific

Crop Improvement			
6.	Dr. P.K. Katiyar	Genetics & Plant Breeding	PS & Head (In-charge)
7.	Dr. Jitendra Kumar	Genetics & Plant Breeding	Principal Scientist
8.	Dr. Aditya Pratap	Genetics & Plant Breeding	Principal Scientist
9.	Dr Dibendu Datta	Genetics & Plant Breeding	Principal Scientist
10.	Dr Awnindra Kumar Singh	Genetics & Plant Breeding	Principal Scientist
11.	Dr Yogesh Kumar	Genetics & Plant Breeding	Principal Scientist
12.	Dr. A.K. Srivastava	Genetics & Plant Breeding	Senior Scientist
13.	Dr. Udai Chand Jha	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
14.	Dr. Debjyoti Sen Gupta	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
15.	Dr. Abhishek Bohra	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
16.	Dr. Ashok Kumar Parihar	Genetics & Plant Breeding	Sr. Scientist (Sr. Scale)
17.	Dr. Biswajit Mondal	Genetics & Plant Breeding	Scientist (Sr. Scale)
18.	Dr. Amrit Lamichaney	Seed Science & Technology	Scientist
19.	Dr. Satheesh Naik S.J.	Genetics & Plant Breeding	Scientist
20.	Dr. Basavaraja T.	Genetics & Plant Breeding	Scientist
Plant Biotechnology			
21.	Dr. (Mrs.) Meenal Rathore	Biotechnology	PS & Head (In-charge)
22.	Dr. Khela Ram Soren	Biotechnology	Senior Scientist
23.	Dr. Alok Das	Biotechnology	Senior Scientist
24.	Dr. P.S. Shanmugavadivel	Biotechnology	Scientist (Sr. Scale)
25.	Dr. Neetu Singh Kushwah	Biotechnology	Scientist (Sr. Scale)
26.	Dr. Arvind Kumar Konda	Biotechnology	Scientist
27.	Dr. Sudhir Kumar	Biotechnology	Scientist
28.	Dr. Kuldeep Kumar	Biotechnology	Scientist

Crop Production		
29. Dr. Narendra Kumar	Agronomy	PS & Head (In-charge)
30. Dr. Raghavendra Singh	Agronomy	Principal Scientist
31. Dr. Prasoon Verma	ASPE	Senior Scientist
32. Dr. Kali Krishna Hazra	Agronomy	Scientist
33. Dr. Chaitanya Prasad Nath	Agronomy	Scientist
34. Dr. Man Mohan Deo	FMP	Scientist
35. Mr. Asik Dutta	Soil Science	Scientist
36. Ms. Kancheti Mrunalini	Agronomy	Scientist
Crop Protection		
37. Dr. Mohd. Akram	Plant Pathology	PS & Head (In-charge)
38. Dr. Bansa Singh	Nematology	Principal Scientist
39. Dr. Naimuddin	Plant Pathology	Principal Scientist
40. Dr. R.K. Mishra	Plant Pathology	Principal Scientist
41. Dr. Sujyanand G.K.	Entomology	Sr. Scientist
42. Dr. Anup Chandra	Entomology	Sr. Scientist
43. Dr. R. Jagdeeswaran	Nematology	Scientist
44. Dr. Bandi Sanjay Maruti	Entomology	Scientist
45. Mr. Devindrappa	Nematology	Scientist
46. Dr. Manjunatha L.	Plant Pathology	Scientist
47. Dr. Revanasidda	Entomology	Scientist
48. Dr. Rishikesh Kumar	Plant Pathology	Scientist
Basic Science		
49. Dr. D.P. Patel	Plant Physiology	PS & Head (In-charge)
50. Dr. M. Senthilkumar	Microbiology	Principal Scientist
51. Dr. T.N.Tiwari	Plant Physiology	Principal Scientist
52. Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
53. Dr. Kalpana Tiwari	Biochemistry	Scientist
54. Dr. Vaibhav Kumar	Biochemistry	Scientist
55. Mr. Krishnashis Das	Microbiology	Scientist
56. Ms. Namrata Lashkar	Agril. Chemicals	Scientist
Social Science		
57. Dr. (Mrs.) Uma Sah	Agril. Extension	PS & Head (In-charge)
58. Dr. Rajesh Kumar	Agril. Extension	Principal Scientist
59. Dr. Dev Raj Mishra	Computer Application	Principal Scientist
60. Dr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)
61. Dr. (Mrs.) Rekha Rani	Agril. Economics	Scientist
G. Regional Station-cum-Off-Season Nursery, Dharwad (Karnataka)		
62. Dr. M.H. Kodandaram	Entomology	Principal Scientist & Station In-charge
63. Dr. M.S. Venkatesh	Soil Science	Principal Scientist
64. Dr. Revanappa	Plant Breeding	Sr. Scientist
65. Dr. P.R. Saabale	Plant Pathology	Sr. Scientist
66. Dr. Manu B.	Genetics & Plant Breeding	Scientist

H. Regional Centre, Bhopal (Madhya Pradesh)		
67. Dr. (Mrs.) Archana Singh	Eco. Botany & P.G.R.	Principal Scientist & Station In-charge
68. Dr. Surendra Kumar Ghritlahre	Genetics & Plant Breeding	Scientist
69. Mr. Alok Kumar	Seed Science & Technology	Scientist (Study Leave)
70. Dr. Sandeep Kumar	Agronomy	Scientist
71. Sh. Chandra Mouli Sharma	—	AAO (on deputation)

I. Regional Centre, Bikaner (Rajasthan)		
72. Dr. Banwari Lal	Agronomy	Sr. Scientist & I/c Farm
73. Dr. Ram Lal Jat	Agronomy	Scientist
74. Dr. Surendra Kumar Meena	Plant Physiology	Scientist
75. Dr. Lalit Kumar Rolaniya	Agronomy	Scientist
76. Dr. (Mrs.) Monika Punia	Genetics & Plant Breeding	Scientist
77. Sh. M. V. Vanvi	—	AAO (on deputation)

J. Regional Station, Khordha (Odisha)		
78. Sh. Sunil Kumar Sunani	Plant Pathology	Scientist

K. Technical	
79. Mr. R.S. Mathur	Chief Technical Officer (T-9)
80. Dr. G.K. Srivastava	Chief Technical Officer (T-9)
81. Dr. Omkar Nath	Chief Technical Officer (T-9)
82. Mr. S.K. Garg	Chief Technical Officer (T-9)
83. Mr. Radha Krishan	Chief Technical Officer
84. Mr. A.P. Singh	Assistant Chief Technical Officer (T 7-8)
85. Mrs. Rashmi Yadav	Assistant Chief Technical Officer (T 7-8)
86. Dr. Rajesh Kumar Srivastava	Assistant Chief Technical Officer (T 7-8)
87. Mr. Krishna Autar	Senior Technical Officer (T-6)
88. Mr. Lakhan Verma	Senior Technical Officer (T-6)
89. Mr. R.K.S. Yadav	Technical Officer (T-6)
90. Mr. R.K. Singh	Senior Technical Officer (T-6)
91. Mr. Rakesh	Senior Technical Officer (T-6)
92. Dr. Kanhaiya Lal	Senior Technical Officer (T-6)
93. Mr. Malkhan Singh	Senior Technical Officer (T-6)
94. Mr. Ashraf Khan	Senior Technical Officer (T-6)
95. Mr. Arvind Singh Yadav	Senior Technical Officer (T-6)
96. Mr. H.N. Maurya	Technical Officer (T-5)
97. Mr. K.S. Meena	Technical Officer (Driver) (T-5)
98. Mr. Arvind Kumar	Technical Officer (T-5)
99. Mr. Hasmat Ali	Technical Officer (T-5)
100. Mr. Satish Kumar Singh	Technical Officer (Driver) (T-5)

L. Administrative	
101. Mr. Sujeet Kumar Verma	Senior Administrative Officer
102. Mr. Kunal Kalra	Senior Finance & Accounts Officer
103. Mr. Sukhdeo Mahto	Administrative Officer
104. Mr. Rajendra Kumar Nigam	Assistant Administrative Officer
105. Mr. G.C. Sharma	Assistant Administrative Officer
106. Mr. Shiv Sharan	Assistant Administrative Officer
107. Mr. Brij Kishore	Principal Private Secretary to Director

Appointment, Transfer, Promotion, *etc.*

Promotions

(*All results declared in 2022*)

Name and designation	Promoted to	w.e.f.
Dr. P.R. Sabale, Scientist	Sr. Scientist	15/09/2020
Dr. Uday Chand Jha, Scientist	Sr. Scientist	15/12/2019
Dr. Debjyoti Sen Gupta, Scientist	Sr. Scientist	03/05/2020
Dr. Ashok Kumar Parihar, Scientist	Sr. Scientist	01/09/2019
Dr. Revanappa, Scientist	Sr. Scientist	23/01/2021
Dr. Sujay Anand G.K., Scientist	Sr. Scientist	02/07/2021
Dr. Anup Chandra, Scientist	Sr. Scientist	27/04/2020
Dr. Banwari Lal, Scientist	Sr. Scientist	28/09/2019
Sh. Brij Kishore, Private Secretary	Principal Private Secretary	03/08/2022.
Sh. Shukdeo Mahto, AAO	Administrative Officer	20/05/2022
Sh. Alok Kumar Saxena, Asstt.	Asstt. Administrative officer	11/08/2022
Sh. Gulab Chandra Sharma, Asstt.	Asstt. Administrative officer	02/08/2022
Sh. Shiv Sharan Singh, Asstt.	Asstt. Administrative officer	24/08/2022
Sh. R.M. Pal, Tech. Officer (T-5)	Sr. Tech. Officer (T-6)	28.02.2022

Transfers

Name	Designation	From	To	w.e.f.
Sh. A.P. Singh	ACTO	ICAR-IIPR, Kanpur	ICAR-IISR, Lucknow	23/03/2022
Smt. Shruti Srivastava	Assistant	ICAR-IIPR, Kanpur	ICAR-IISR-KVK, Lucknow	26/03/2022
Sh. Kumar Vivek	Sr. Admn. Officer	ICAR-IIPR, Kanpur	ICAR-IGFRI, Jhansi	12/08/2022
Sh. Sujeet Kumar Verma	Sr. Admn. Officer	ICAR-CISH, Lucknow	ICAR-IIPR, Kanpur	09/09/2022
Dr. Gitanjali Sahay	Pr. Scientist (Genetics & PB)	ICAR-IGFRI, Jhansi	ICAR-IIPR-RS, Bhopal	27/09/2022
Dr. Manjunatha. L.	Scientist (Plant Pathology)	ICAR-IIPR, Kanpur	ICAR-IIHR, Bengaluru	01/07/2022
Dr. Krishnasis Das	Scientist (Agril. Microbiology)	ICAR-IIPR, Kanpur	ICAR-IARI, New Delhi	20/08/2022
Dr. S.K. Meena	Scientist (Plant Physiology)	ICAR-IIPR-RC, Bikaner	ICAR-IGFRI, Jhansi	17/09/2022
Dr. Mohd. Hashim	Scientist (Agronomy)	ICAR-IARI-RC, Samastipur	ICAR-IIPR, Kanpur	18/08/2022
Antara Das	Scientist	ICAR-CISH, Lucknow	ICAR-IIPR, Kanpur	19/09/2022
Dr. Asish Kumar Rout	Scientist (Agril. Entomology)	ICAR-IINRG, Namkum, Ranchi	IIPR-RS, Khordha	01/09/2022
Nidhi Kumari	Scientist	ICAR-CISH, Lucknow	ICAR-IIPR, RS Bhopal	13/10/2022

Retirements

Name	Post held	Date of retirement
Dr. N.P. Singh	Director	31/01/2022
Sh. Rajendra Kumar	AAO	31/01/2022
Sh. Ram Sajeevan	SSS	31/01/2022
Sh. Ramesh Chandra	SSS	31/01/2022
Smt. Shyam Kumari	SSS	28/02/2022
Dr. Shiv Sewak	Director (Acting)	31/03/2022
Dr. Farindra Singh	Principal Scientist	30/06/2022
Sh. Radha Krishna	Chief Technical Officer	30/06/2022
Sh. Alok Kumar Saxena	AAO	31/08/2022
Sh. Indra Bahadur	Sr. Technician (T-2)	30/09/2022
Sh. R.M. Pal	Senior Technical Officer	31/10/2022
Dr. G.K. Srivastava	Chief Technical Officer	31/12/2022

स्वच्छ भारत

एक कदम स्वच्छता की ओर

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भाकृअनुप-भारतीय दलहन अनुसंधान संस्थान, कानपुर, 208 024

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