2016 INTERNATIONAL YEAR OF PULSES



वार्षिक प्रतिवेदन
Annual Report
2015-16

ISO 9001-2008

भा.कृ.अनु.प.–भारतीय दलहन अनुसंधान संस्थान

कानपुर - 208 024

ICAR-Indian Institute of Pulses Research

Kanpur 208 024

With best compliments from



Dr. N.P. Singh
Director

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Kanpur 208 024

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
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Preface

It gives me immense pleasure to present the Institute's Annual report for the year 2015-16. The common man's *Dal* was back in limelight during this year, particularly due to declaration of 2016 as 'International Year of Pulses' by FAO. The present Annual Report of the Institute highlights the significant achievements made under different research programmes. During the period under report, three high yielding varieties of pulses including IPC 2006-77 in chickpea, IPM 410-3 (Shikha) in mungbean and IPFD 12-2 in fieldpea were identified for different zones. Lentil biofortified variety IPL 220 with high Fe and Zn has been recommended for identification. To identify high protein content in chickpea, two potential chickpea lines T 39-1 and T 1-A were identified with high seed protein content (28-30%) which will be used as promising donors for quality breeding programmes. In addition, several entries were identified for mechanical harvesting in chickpea. Five fieldpea genotypes *viz*., P 729, 637, 1297-35-1, 2016 and P 706 were found tolerant against post-emergence herbicide metribuzin. Seed priming with polyethylene glycol @ -0.5 MPa was found effective in improving field emergence (60-62%) over control (49%) in extra large seeded *kabuli* chickpea cv. Kripa. Pigeonpea hybrid IPH 15-3 showed high fertility and yield advantage (38%) over check Pusa 992. Under All India Coordinated Research Projects several varieties were identified for different agro-ecological zones: GNG 2171, GNG 2144, IPC 2006-7 (*Desi)* and NBeG 119 (*Kabuli)* in chickpea*;* DGGV2, BGS 9, Shalimar Mung 2, DGGS 4, DBGV 5 in mungbean; Vallabh Urd, MDU 1, KPU 405 in urdbean; RVL 31, Shalimar Masoor 2, KLB 2008-4 (Kranti), KLS 09-3 (Krish) in lentil, RFP 2009-1, IPFD 11-5 , Shalimar Pea 1 in fieldpea and CRHG 22 in horsegram.

For development of climate resilient pulses, 18 mungbean genotypes were identified as heat tolerant, while 6 urdbean genotypes were identified for both heat and drought tolerance. Heat tolerant lentil genotypes *viz*., IG 3330, IG 3973 and IG 4258 showed *in situ* pollen germination over stigma at high temperature. Pigeonpea genotypes *viz*., JKM 7, JSA 59, RVK 275, Bennur Local, BDN 2008-12, JKM 189 and VKS-11-24-2 were identified as drought tolerant based on osmotic adjustment. Wild pigeonpea *Cajanas scarabaeoides* line ICP 15671 was identified as heat tolerant based upon pod setting at 47^0C. During the period, total 3066 germplasm accessions of chickpea, rajmash, fieldpea, lentil, urdbean and mungbean were maintained /rejuvenated and characterized for agro-morphological traits, besides wild species and primitive and Mediterranean land races. Total 800 kg nucleus seed of 5 chickpea, 4 mungbean, 2 urdbean, 9 fieldpea, 6 lentil, 1 pigeonpea and 4 rajmash varieties was produced. Mutations were induced in lathyrus to create variability for low ODAP content. ICARDA grasspea nursery was evaluated for low ODAP, early and high biomass genotypes. To add more pulses for human consumption, research on minor pulses with high medicinal value besides protein content was initiated. Seventy five accessions of cowpea and 32 acc. of horsegram were collected, characterized and maintained at Dharwad Centre and will be further utilized for breeding purpose.

Significant success has been achieved in development of four transgenic events through GM technology and IPCa 2 and MP 9 for chickpea and IPCc 2 and SS 5 for pigeonpea were identified for event selection trial. Thirteen BC_3F_3 "*QTLs hotspot*" introgressed chickpea (DCP 92-3) lines were developed for drought tolerance. Two F_2 mapping populations derived from crosses Bahar x KPL 43 and Bahar x KPL 44 were developed for mapping and tagging of genes/QTLs linked to *Fusarium* wilt resistance in pigeonpea. Hydroponic techniques for screening of biotic (*Fusarium* spp.) and abiotic (salinity) stress tolerance were optimized.Three pod specific transcripts based on sequence analysis of chickpea genome were identified.

In long term agronomy trials, maize-wheat-mungbean system demonstrated highest pigeonpea equivalent yield (2801 kg/ha). Rice, wheat, chickpea and mungbean performed better under integrated nutrient management. Improvement in system productivity (7.06%) was recorded with residue incorporation. Highest system productivity in terms of chickpea equivalent yield was obtained in rice-chickpea-mungbean (5208 kg/ha). Foliar fertilization of zinc enhanced its concentration in different plant parts from 7 to 17% both in mungbean and urdbean. Optimum irrigation scheduling (OIS) with sprinkler irrigation in pigeonpea resulted in significantly higher grain yield (16%) with an increase of $\geq$ 29% water saving over flood irrigation. Sprinkler irrigation consumed 27% less water and benefitted with 67.1% higher water use efficiency. Topramezone and clodinafop propargyl+Na-acifluorfen has been recommended for controlling diverse weed flora particularly broad-leaf weeds in

chickpea. To make Imazethapyr safer for chickpea crop, the herbicide was converted to sustained release granular formulation with sodium alginate.

The Institute has developed suitable agro-techniques for pulses under rice fallows for better utilization of conserved moisture with minimum inputs. It was found that chickpea under rice fallows, maximum SMC in rooting zone was retained under unpuddled transplanted rice (UPR). In rainfed chickpea under rice fallows, NPK+FYM applied to rice crop conserved higher soil moisture over farmers' practice and led to higher chickpea yield. Incorporation of rice residue with suboptimal application of inorganic phosphorus along with PSB inoculation improved lentil crop growth.

During the year, several promising lines of chickpea (IC 83603, IPC 2005-18, IPC 2005-27, IPC 2005-37, IPC 2005-19 and IPC 2004-03) were found resistant to 4 races of wilt. Likewise, 4 genotypes of pigeonpea *viz*., ICP 8862, ICP 89049, ICP 8858 and BDN 1 were found resistant to all five races of *F. udum*. Thirteen medium duration pigeonpea lines were identified as resistant against *Phytophthora dreshleri* f. sp. *cajani*. Application of *Trichoderma harzianum* (Th 31 and Th11) inoculated FYM @ 100kg/ha reduced wilt incidence by 17-24%. Six genotypes of pigeonpea, 10 of chickpea, 6 of mungbean, 2 of urdbean, 2 of lentil and 3 of fieldpea were found resistant against *M. Javanica.* It was reported that root knot nematode gall index can be reduced if treated with carbofuran and neem cake.

Salicylic acid with supplemental foliar application of nitrogen was found effective in mitigating the adverse effect of drought and improved yield and biomass in chickpea. High nodule number/plant was recorded in six chickpea lines. Twelve lentil genotypes were identified for efficient nodulation. Bacterial endophytic strains such as NE-127, 173, 268, 138, 85, 142, 272, 77, 26 and NE-310 were identified for their plant growth promoting potential. P-fertilizer application alongwith inoculation with *M. ciceri* increased grain yield by 40% over control. Under low phosphorus availability in soil chickpea lines accumulated highest biomass at harvest.

Technology demonstration and promotion of pulses in tribal areas of Madhya Pradesh and Chhattisgarh was successfully conducted on pigeonpea and urdbean. Major impact of ISOPOM project was increasing the area of summer mungbean with adoption of good management practices. Yield increase in lentil variety IPL 81 was observed up to 251% over local variety under ICARDA project in Hamirpur. A home page for commodity profile for chickpea has been designed. Under the ICT, voice SMS based advisory service " *Dalhan Sandesh*" was initiated. E-books on weed, seed, pod borer, disease and insect pest management in pigeonpea, disease and insect management in urdbean and mungbean have been prepared. Nine training programmes and one farmers' fair was organised at the Institute wherein $\geq$ 2500 farmers participated.

Besides International collaboration with ICRISAT, ICARDA and World Vegetable Centre, the Institute is presently hosting a large number of externally funded projects on frontiers areas of pulses research from DBT, DST, ICAR National Fund, Bill and Melinda Gates Foundation, ACIAR, UPCAR and many others. The Institute has identified major R&D issues as per the recommendations of the RAC. These are being addressed with integration of conventional approaches with cutting edge technologies such as genomics, transgenics, molecular breeding, quality improvement, resource conservation, biotic and abiotic stress management. Accordingly new projects have been formulated as presented in this Annual Report.

The overall growth and development of the Institute has been possible with the able guidance, encouragement and continuous support received from Ex. DG, Dr. S. Ayyappan, present Director General and Secretary DARE, Dr. T. Mohapatra, Deputy Director General (Crop Science) Dr. J.S. Sandhu and ADG (O&P) Dr. B.B. Singh, ICAR which I duely acknowledge with sincere gratitude and respect.

I appreciate the efforts of all Project Coordinators Drs. Sanjeev Gupta, I.P. Singh, G.P. Dixit and Dr. Shiv Sevak and all Heads of Divisions Drs. Jagdish Singh, S.S. Singh, S.K. Chaturvedi, Krishna Kumar, Rajesh Kumar and K.R. Soren for research inputs and compiling the annual report of their respective divisions. I am thankful to the members of Publication Committee Drs. Krishna Kumar, P.S. Basu, Jitendra Kumar, Naimuddin, Alok Das and Chief Editor Mr. Diwakar Upadhyaya for their efforts in bringing out the Report in time.

(N.P. Singh)
Director

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Executive Summary

Crop Improvement

- Three high yielding varieties of pulses including IPC 2006-77 in chickpea, IPM 410-3 (Shikha) in mungbean and IPFD 12-2 in fieldpea have been identified for different zones.
- Lentil biofortified variety IPL 220 has been recommended for identification after one more year evaluation for Fe and Zn.
- Four varieties of pulses including two each of mungbean (IPM 205-7 and IPM 2K 14-9) and lentil (IPL 321 and IPL 315) have performed well over three years in UP state adaptive trials.
- In AICRP trials, a number of genotypes performed well and IPC 2010-62, IPC 2007-28, IPC 2010-134, IPCK 2009-165, IPCK 2009-165 and IPCK 2011-179 in chickpea, IPM 410-3, IPM 205-7 in mungbean, IPU 11-1 in urdbean, IPF 2014-16, IPF 2014-13, IPFD 2014-2 and IPFD 2014-11 in fieldpea and IPL 333, IPL 334, IPL 534 in lentil have been promoted to advanced breeding trials. IPA 2014-6 and IPA 2014-7A performed well over checks in pigeonpea.
- High seed protein content (28-30%) was recorded in chickpea lines T 39-1 and T 1-A and 32.7% protein content was recorded in IG 72569 accession of wild species *L. ervoides* in lentil.
- Several entries were identified for amenability to mechanical harvesting in chickpea and highest plant height (77.29 cm) and highest point of podding from soil surface was in genotype HC 5 (33.71 cm).
- Genetics of *Fusarium* wilt showed that resistance is recessive monogenic trait in pigeonpea.
- Based on visual observation and toxicity on plants, five fieldpea genotypes *viz*., P-729, P-637, P-1297-35-1, P-2016 and P-706 were found highly tolerant against post-emergence herbicide metribuzin @ 500 g/ha, while 21 genotypes showed tolerance.
- Screening of munbean germplasm for pre-harvest sprouting (PHS) tolerance in laboratory resulted in identification of CHAMU-4, DOPOLE, IC-52061, CHAMAH-1, BGG-1 and Pusa Ratna genotypes as PHS tolerant with <10 % seed germination in pods.
- Seed priming with 10% lantana extract for 12h and polyethylene glycol @ -0.5 MPa improved field emergence (60-62%) over control (49%) in extra large seeded *kabuli* chickpea cv. Kripa,
- Eight lines of chickpea *viz*., ICC 16690, ICC 11452, ICC 5445, ICC 12362, ICC 12354, ICC 6490, ICC 11505 and ICC 15040) were identified for salnity tolerance under field conditions having mean pH 8.5 and EC equivalent to 6 dS/cm on the basis of good population stand and high plot yield.
- Pigeonpea hybrid IPH 15-1, IPH 15-2, IPH 15-3, and IPH 15-4 exhibited more than 90% fertility in initial hybrid trial (IHT) and IPH 15-3 showed considerably high yield (38%) over the best check Pusa 992.
- Fertility restoration in A_2-CMS was identified under the control of a single dominant gene in two populations *i.e.*, F_2 (ICP 88039 A × AK 261322 R) and BC_1F_1 [ICPL 88039 A × (ICPL 88039 × AK 261322 R)].
- Total 25 SSR markers showed polymorphism between ICP 88039 A and AK 261322 R parental lines in pigeonpea.
- Eighteen mungbean genotypes were identified as heat tolerant based on in-field and controlled studies in polyhouse. Top 10 genotypes included IPM 02-1, IPM 02-16, IPM 2-14, PDM 139, IPM 9-43-K, PDM 288, IPM 5-3-22, IPM 9901-10, IPM 409-4 and IPM 02-3.
- UG 14-14, PLU 96-6, NPU 240 and PDU 1 genotypes of urdbean were found tolerant for heat and drought stress on the basis of total plot yield and related morphological traits for heat and drought.
- Interspecific cross involving IPC 2006-88 (cultivated) and ILWC 179 (*C. echinospermum*) resulted in release of tremendous variability for number of seeds/pod with mean value of 2.4 seeds/pod.
- Molecular diversity analysis of 57 accessions of lentil with 61 polymorphic SSR markers resulted in amplification of 112 loci that generated 545 alleles ranging 2–26 loci per marker and association mapping analysis showed significant association ($p < 0.05$) of 9 SSR markers with flowering time.
- Significant genetic variability was observed among a number of genotypes in lentil for Fe and Zn concentration and genotype × year interactions explained a large proportion of total

phenotypic variation.

- No signification effect of any cropping system including mono-, mix- and inter-cropping was observed on Fe and Zn concentration in the seeds of 10 lentil genotypes.
- Heat tolerant lentil genotypes IG 3330, IG 3973 and IG 4258 had *in situ* pollen germination over stigma, while maximum pollen viability and membrane stability was observed in IG 4258 and FLIP 2009-55L genotypes, respectively, at higher temperature .
- Mapping populations for dry root rot in chickpea, seed size, earliness, root traits, early vigour and *Fusarium* wilt in lentil, and rust resistant in fieldpea have been maintained and advanced to next generation.
- Advanced backcross mapping populations for yield traits and early vigour in lentil and photo-thermo-insensitivity in mungbean have been advanced to next generation.
- Total 515 germplasm accessions of chickpea, 330 of rajmah, 400 of fieldpea, 746 of lentil, 300 of urdbean and 775 accessions of mungbean were maintained/rejuvenated and characterized for agro-morphological traits. Besides, 92 accessions of six wild species and 179 primitive land races in chickpea, 339 accessions of 6 wild species and 90 Mediterranean land races in lentil and 98 accessions of 18 different species in mungbean were maintained and characterized.
- Total 800 kg nucleus seed of five chickpea varieties (DCP 92-3, IPC 97-67/SCS 3, Ujjawal, Shubhra and Karnal Chana 1), 420 kg of four mungbean varieties (IPM 99-125, Samrat, IPM 2-3 and IPM 2-14), 75 kg of two urdbean varieties (IPU 2-43 and IPU 94-1), 909 kg of 8 fieldpea varieties (Adarsh, Aman,Vikas, Prakash, IPFD 10-12, IPF 4-9, IPFD 11-5 and IPFD 12-2), 168 kg of 6 lentil varieties (IPL 81, IPL 406, DPL15, DPL 62, IPL 316 and IPL 526), 101 kg of 4 rajmah varieties (PDR 14, Arun, Utkarsh and Amber) and 150 kg of one pigeonpea variety (IPA 203) was produced.

Plant Biotechnology

- Ten insect resistant (IR) transgenic events, five each of chickpea and pigeonpea were identified for event selection trial.
- Phenotyping of agronomically important traits was done in 3000 global chickpea accessions to establish specific genome regions through genome wide association studies.
- Thirteen BC_3F_3 "*QTLs hotspot*" introgressed chickpea (DCP 92-3) lines were developed for drought tolerance by employing linked flanking SSR markers (NCPGR21, TR11 and ICCM0246).
- Three F_1s were developed by crossing transgenic chickpea line BS6L (*cry*2Aa) with *desi* chickpea genotypes *viz*., JG 11 and DCP 92-3 for insect resistance breeding programme.
- Transcriptomics of herbicide (imidazolin) tolerance in chickpea indicated 4979 differential expressed gene (DEG) regulated by miRNAs, transcription factors, Hub proteins *etc*. Further, additional markers were generated *i.e.*, SSR-FDM, SNP and InDels based on transcriptomic data that could be used in breeding programme.
- Developed two F_2 mapping populations derived from crosses (Bahar x KPL 43 and Bahar x KPL 44) for mapping and tagging of genes/QTLs linked to *Fusarium* wilt resistance in pigeonpea.
- Nucleotide polymorphism of the alleles CcCDP (Acc. No. GU 444041.1) and CcHyPRP (Acc. No.GU 444042.1) and CaCAP2 gene (homolog of the DREB 2A gene; Acc. No. DQ 321719.1) were documented in chickpea and pigeonpea genotypes and submitted to EMBL (LN 873257 to LN 873410).
- Hydroponic techniques for screening of biotic (*Fusarium* spp.) and abiotic (salinity) stress tolerance were optimized.
- Three pod specific transcripts based on sequence analysis of chickpea genome were identified.
- Identified a multiple stress inducible chickpea WRKY transcription factor and developed structure model of the protein.

Crop Production

- Among different cropping systems, maize-wheat-mungbean system fetched highest pigeonpea equivalent yield (2801 kg/ha), while for *bajra* based systems, highest PEY was recorded under *bajra*-wheat-mungbean (2688 kg/ha). Recommended fertilization (NPKSBZn) resulted in higher PEY under different nutrient management practices, followed by INM.
- In rice based system under long term study, all component crops *viz*., rice, wheat, chickpea and mungbean performed better under integrated nutrient management (INM). Highest system productivity in terms of chickpea equivalent yield was recorded in INM (3894 kg/ha). Further, system productivity was highest in rice-wheat-mungbean (4479 kg/ha). Significantly

higher SOC and available NPK were recorded in INM and rice-wheat-mungbean as compared to other cropping systems.

- In resource conservation, improvement in system productivity (7.06%) was recorded with residue incorporation. In cropping systems, highest system productivity in terms of chickpea equivalent yield (CEY) was obtained in rice-chickpea-mungbean (5208 kg/ha).
- Foliar fertilization of zinc enhanced its concentration in different plant parts (leaves, stem and grain) from 7 to 17% both in mungbean and urdbean. Seed coating with zinc was found superior over zinc sulphate.
- Sowing of early pigeonpea on 5th June gave higher yield (15.93 q/ha), followed by 25th May (14.62 q/ha) and 15th June (13.34 q/ha). Sowing at 50×15 cm recorded highest grain yield (16.84 q/ha), followed by 60×15 cm (14.43 q/ha) and 40×15cm (12.63 q/ha).
- Sowing of early pigeonpea hybrid at 70×20 cm recorded highest grain yield (17.96 q/ha), followed by 60×20 cm (17.21 q/ha) and 50×20 cm (16.99 q/ha). Further, variable sowing dates had marked influence on productivity.
- Micro-irrigation (sprinkler) influenced crop productivity and input use efficiency in chickpea. Optimum irrigation scheduling (OIS) with sprinkler irrigation applied at branch and pod development resulted in significantly higher grain yield (16.1%), biomass yield (9%), harvest index (5.7%), net return (22.4%), BCR (22.8%) and productivity per day (16.4%) over that at branching stage only.
- There was increase in water saving (29.4%), WUE (30.7%) and WP (20.8%) following optimum irrigation scheduling at branch and pod development through sprinkler over flood irrigation at both stages to realize the same yield levels (2.65 t/ha).
- Row spacing of 22.5 cm on an average produced 173-230 kg additional grain yield over farmers' practices of 30 cm row spacing.
- Sprinkler irrigation consumed on an average 27% less water that was further benefitted with 67.1 % higher water use efficiency, 67.3 % higher WP, increased net return of Rs. 9083 and elevated BCR by 0.13 over flood irrigation applied by farmers at 30 cm row spacing in mungbean.
- Maximum grain yield was recorded in *kharif* mungbean in weed free (927 kg/ha), followed by pendimethalin *fb* imazethapyr (864 kg/ha), pendimethalin *fb* clodinafop-propargyl @ 150 g/ha (780 kg/ha) and there was no effect on soil microbial parameters at 30 days after application of above herbicides.
- Topramezone and clodinafop propargyl+ Na-acifluorfen could be a option for controlling diverse weed flora particularly broad-leaf weeds in chickpea.
- Significantly higher total productivity was recorded with soybean+pigeonpea-lentil, followed by soybean+urdbean-lentil in Central Zone.
- In rainfed chickpea under rice fallows, maximum SMC in rooting zone (0-40 cm) was retained under unpuddled transplanted rice (UPR) and direct seeded rice (DSR) and minimum under puddle transplanted rice (PTR). At flowering and pod filling stages (60 and 90 DAS), foliar nutrition of 2% urea and micronutrients enhanced nodulation in chickpea. Maximum grain yield was recorded in UPR (1498 kg/ha), followed by DSR (1468 kg/ha). In foliar nutrition, maximum chickpea yield was recorded in micronutrients (1512 kg/ha), followed by 2% urea (1434 kg/ha).
- In rainfed chickpea under rice fallows, NPK+FYM applied to rice crop conserved higher soil moisture over farmers' practice at all crop growth stages of chickpea. This resulted in higher chickpea yield under NPK+FYM (57.4%). Increase in grain yield of chickpea was also recorded due to life saving irrigation (16.3%) and foliar application of micronutrients (8.93%) over rainfed.
- Incorporation of rice residue and suboptimal application of inorganic phosphorus along with PSB inoculation improved lentil crop growth. Performance of lentil crop was better under DSR than that of SRI and PTR.

Crop Protection

- Out of 125 NBPGR lines including *kabuli* and *desi* types, 21 (EC 223519, -267154, -267308, -267437, -440552, -441805, -498818, 489919, -489991, IC 83523,-83530, -83538, -83539, - 83542, -83556, -83558, -83748, -83750, -83751, -83570 and IC 83757) were found resistant, 15 (EC 267293, -267511, -441725, -489845, -489905, IC 83519, -83523, -83526, -83527, -83529, -83534, -83535, -83541, -83551 and IC 83569) were moderately resistant and remaining 89 were susceptible against *Fusarium oxysporum* f. sp. *ciceris*.

- Out of 75 stable elite breeding lines consisting of *kabuli* and *desi* types, 31 were resistant and 18 lines were found moderately resistant for more than 2 years.
- Two *kabuli* entries *viz*., IPCK 2015-235 and -264 and 75 *desi* entries were found resistant to wilt.
- Twenty five NBPGR and elite breeding lines were screened in race specific tanks. Six lines (IC 83603, IPC 2005-18, IPC 2005-27, IPC 2005-37, IPC 2005-19 and IPC 2004-03) were found resistant to 4 races, one line (IPC 2005-34) was resistant to 3 races, 8 lines (IC-83559, IC-83560, IC-83587, IC-83614, IPC2005-35, IPC2004-08, IPC2005-26, IPC2005-15) were resistant to 2 races and 8 lines were resistant to single race.
- Out of 31 ICRISAT pigeonpea genotypes, five (ICPL 99044, ICPL 20095, ICPL 87051, ICPL 99009 and ICPL 99055) were found resistant.
- Out of 84 AICRP genotypes of pigeonpea, 10 (BWR 133, GRG 140, GRG 160, GRG 177, DRG 107, KDVP 935, LRG 15, TRG 59, WRGE 90 and RVSA 07-31) were found resistant, whereas BRG 3, BRG 4, BRG 5, BSMR 736, BSMR 853, IPA 204, KPL43 and Mahabeej 105 showed moderately resistant reaction against *Fusarium udum*.
- Twenty nine genotypes of pigeonpea (KPL 44, ICP 8862, KPL 49, IPA 38A, IPA 38B, GPS 33, BSMR 736, BSMR 853, KPBR 80-2-1, PI 397430, KPL 43, IPA 40, Sujatha, ICP 8858, IC8859, Banda Palera, BWR 377, ICP 89046, ICP93812, ICP 89048, ICP89049, ICP14722, ICP9174, ICP93011, AWR74/15, JAW5-6A, BDN1, BDN2 and ICP 8863) used as donors continued to show wilt resistant reaction in wilt sick plot.
- Out of 92 short and medium duration pigeonpea lines, 13 (IPAC 3-2, IPAC 42, IPAC 79, IPAPB 7-2-1-7, KPBR 80-2-1, IPAC 66-7, IPAC 66-9, WDBCU 1, WDBCE 5-4, IPA 14-4, IPA 38A, PH 1063 and WD 5-4) were identified as resistant against *Phytophthora dreshleri* f. sp. *cajani*.
- Thirty isolates of *Trichoderma* species isolated from soil on trichoderma selective medium (TSM), revealed presence of four species, *T. harzianum, T. viride, T. virens* and *T. pseudokoningii*.
- Application of *Trichoderma harzianum* (Th 31 and Th 11) inoculated FYM @ 100kg/ha reduced wilt incidence by 17-24%.
- Out of 17 promising genotypes of pigeonpea screened against five races of *F. udum*, 4 genotypes *viz*., ICP 8862, ICP 89049, ICP 8858 and BDN 1 appeared to be resistant to all variants.
- Six pigeonpea genotypes *viz.,* BDN 2004-1, BDN 2011-1, RVSA 07-10, Pusa 84, TJT 501 and Manak were found resistant against *Meloidogyne javanica*.
- Six mungbean lines *viz*., GM 04-02, HUM 1, HUM 27, KM 2342, RMG 1028 and RMG 1030 and two urdbean lines *viz*., MU 44 and NUL 205 were found resistant against *M. javanica*.
- Two lines of lentil L 4076 and DPL 15 and three lines of fieldpea *viz*., IPF 13-14, Adarsh (IPFD 99-25) and IPFD-12-2 were found resistant against *M. Javanica.*
- Ten lines of chickpea *viz*., GJG 1209, Phule G 0611, GAG 1107, IPC 14-73, IPC 14-143, IPC 14-05, IPC 14-137, IPC 14-107, IPC 14-146 and IPC 10-72 were found resistant against *M. javanica*.
- *Heterodera cajani* multiplied more in medium texture soil than light textured soil and the damage threshold level was low in medium textured soil and light textured soil.
- *H. cajani* @ 8 cysts/100 cc soil reduced plants growth, biomass, pod length, number of seeds/pod and caused 78.9% reduction in grain yield of urdbean variety Uttara.
- Root knot nematode gall index was minimum (1.9) in plots treated with carbofuran (1 kg a.i./ha), followed by 2.5 in plots treated with neem cake (500 kg/ha), whereas grain yield was maximum (536 kg/ha) in neem cake treated plots, followed by carbofuran treated plots (518 kg/ha).
- Sequences of mitochondrial small subunit (SSU) ribosomal DNA (rDNA) of 16 isolates of *Fusarium oxysporum* f. sp. *ciceri* and 15 of *Fusarium udum* were studied and were found to have genetic variation ranging from 0.47 to 15.6% and 247 sites were informative showing intergenic variation in SSU sequences of *F. oxysporum* f. sp. *ciceri* and *F. udum*.

Basic Science

- Evaluation for combined tolerance to drought and heat was done in advanced breeding lines from the crosses derived from Tyson x Kaniva. Breeding line C 16 expressed high root biomass as well as heat tolerance, confirming both heat and drought tolerance.
- Salicylic acid alone could mitigate the adverse effect of drought and improved yield and biomass significantly, however supplementing nitrogen application had additional advantage towards further yield increase.

- Urdbean genotype PGRU 95016 was identified as photo-thermo-insensitive and thermo-tolerant based on flowering at 10 and 16 h photoperiod as well as flowering at both 25/15 and 36/20°C max/min temp and pollen germination at 43°C.
- Pigeonpea genotypes JKM 7, JSA 59, RVK 275, Bennur Local, BDN 2008-12, JKM 189 and VKS 11-24-2 were identified as drought tolerant based on osmotic adjustment.
- Wild pigeonpea *Cajanas scarabaeoides* lines were identified which are able to set pods even at 47°C.
- Pigeonpea genotypes IPAC 79 and MAL 9 were identified as water logging tolerant based on mortality, Chlorophyll retention and arenchyma cells.
- Pigeonpea lines IPAC 80, IPAC 75 and ICP 7035 were identified tolerant against frost/chilling.
- Mungbean genotypes *viz*., PDM 54, PDM 288, IPM 02-3, IPM 2-14 and IPM 03-3 were identified as photo-insensitive.
- Six contrasting chickpea genotypes were identified for drought induced leaf senescence. Faster senescence genotypes included Pusa 372, RVG 203, GG 3, H 82 2, Digvijay and WR 315, and delayed senescence genotypes were CSJ 515, PDG 5, HC 3, Radhey, RSG 888 and ICCV 1205. Under rainfed conditions, delayed senescence genotypes showed higher biomass, yield and harvest index, whereas faster senescence genotypes showed higher reduction in biomass, yield and harvest index.
- Comparatively less per cent reduction (6.16-11.36%) in biomass was recorded over non-saline condition in genotypes *viz*., IC 21001, IPU 2-43, IPU 99-123, MS 131, NODAI Urd, RTM 10, LBG 645, STY 2801, Bara Nabada and UH 85-3, whereas, more biomass reduction (28-41%) was recorded in WBU 108, TU 91-22, TU 17-4, LBG 685, KUG 365, Co 5, TU 40 and SPS 39.
- Carbohydrate content in pigeonpea genotypes ranged from 46 to 68.6 % and it was 36.7 to 76.7% in urdbean. In pigeonpea D-glucose concentration ranged from 1.37 to 2.02, sucrose from 1.65 to 7.04 and oligosacchardies 4.49 to 7.95 mMoles/100g, whereas in urdbean genotypes it ranged from 1.27 to 1.49, 1.32 to 4.53 and 2.61 to 5.21 mMoles/100g, respectively. Total dietary fibre ranged from 13.7 to 36.4% in pigeonpea and 10.8 to 33.5% in urdbean genotypes.
- In pigeonpea, Fe content ranged from 53.57 to 77.04 ppm, whereas Zn content varied from 16.72 to 34.82. Comparatively higher Fe (71.02 to 100.20 ppm) and Zn content (18.93 to 60.58 ppm) was recorded in urdbean genotypes. In general the Fe content of genotypes remained stable over the years and did not vary significantly from one year to other.
- Anti-nutrients like phytic acid, trypsin inhibitor activity and phenol content was estimated for two years which ranged from 0.14 to 0.86 %, 1.35 to 6.95 TIU/mg protein and 0.6 to 5.6 mg GAE/g respectively in pigeonpea. In urdbean it ranged from 0.07 to 0.0.37 g/100g, 0.57 to 10.9 TIU/mg protein, 4.6 to 9.3 mg GAE/g, respectively.
- Mean antioxidant activity (AOA) in pigeonpea ranged from 0.45 to 3.25 µmolesTEA/g, whereas in urdbean it ranged from 12-26 µmolesTEA/g.
- Based on antioxidative enzyme assay, chickpea genotypes *viz*., PG 5, ICC 1205, ICC 8950 and ICC 15614 were identified as heat tolerant.
- In pots filled with phosphorus deficient soil, nodulation in chickpea mini-core accessions ranged from 0 to 50 ±7.48 with mean value of 19/plant. In field, nodule number/plant was less and ranged from 2.0 to 25 with mean value of 11.0 nodules/plant.
- Low number of nodules was observed in ICC 16207, ICC 3512, IG 10309 and ICC13628, while highest nodule number/plant was recorded in ICC 12537, ICC 10945, ICC 4567, ICC 15264, ICC 14799 and ICC 15610.
- P-fertilizer application along with inoculation with *M. ciceri* increased grain yield by 40% over control.
- Under low phosphorus availability in soil, three chickpea lines *viz*., ICC 9137, ICC 2580 and ICC 12968 accumulated highest biomass at harvest.
- Bacterial endophytic strains such as NE-127, NE-173, NE-268, NE-138, NE-85, Ne-142, NE-272, NE 77, NE-26 and NE-310 were identified for their plant growth promoting potential.
- 16S rDNA sequence of ACC deaminase producing bacteria indicated that strain IIPR-ACC-3 belongs to *B subtilis,* while IIPR-ACC-79 belongs to *Pseudomonas stutzeri.*
- In screening for high biological nitrogen fixation, lentil genotypes *viz*., IC-428610, IC-429151, IC-429159, IC-429195, IC-418150, IC-428229, IC-428249, IC-428999, IC-429081, IC-429092, IC-429094, and DPL 15 were identified for efficient nodulation and high plant biomass production.
- Persistence and degradation studies of Imazethapyr herbicide conducted in field

revealed residue level in range of 0.0044 - 0.0032 mg/g of soil at intervals ranging from 2 hr to a maximum period of 45th day. These residual values are far below than its prescribed MRL value of 0.1mg/g.

- To make herbicide safer for chickpea crop, the herbicide was converted to sustained release granular formulation with sodium alginate.

Social Science

- Tribal Sub-programme (TSP) was implemented in tribal areas of Madhya Pradesh and Chhattisgarh in collaboration with 10 KVKs. Demonstrations were conducted on pigeonpea and urdbean during *kharif* season in 262.5 acres and on chickpea, lentil and fieldpea in *rabi* season in 1100 acres.
- Major impact of ISOPOM project was seen as increasing the area of summer mungbean with adoption of good management practices.
- Yield increase in lentil variety IPL 81 was observed up to 251% over local variety under ICARDA project in Hamirpur, followed by 181.25% yield increase in DPL 62.
- Village Seodhari near Ghatmapur in Kanpur Nagar was selected for pulse model village development. Rapport build-up with farmers, linkages strengthened with various agencies, diagnostic survey on various pulses were carried out and activities were initiated.
- Analytical modules were developed for row-column and augmented split plot design.
- District level analysis of major chickpea growing states revealed that Churu (Rajsthan) has largest area, Kurnool (Andhra Pradesh) has highest production and Chindwara (Madhya Pradesh) has highest productivity.
- Contents on crop statistics, MSP, crop calendar, FLDs, BSPs and mandi prices were collected and analysed. A user-friendly structure has been created for digital platform. A home page for commodity profile for chickpea has been designed.
- Total 113 package demonstrations of improved pulse production technologies were conducted in about 52 ha area in four project villages of Kanpur Dehat and Jalaun districts and two registered seed societies were formed in one project village each in Kanpur Dehat and Jalaun districts. In addition, 7 number of capacity building programmes were organized for pulse producing farmers, youth and farm women.
- Under traditional extension services component, total 50 need based participatory demonstrations on recommended varieties of major pulse crops were conducted in 21 ha area in Jalaun and Fatehpur districts of Uttar Pradesh. Under the ICT mediated disseminated component of the project, voice SMS based advisory service "*Dalhan Sandesh*" was initiated wherein about 2300 farmers from 7 districts of UP have been linked.
- The structure of knowledge platform is completed for e-books on weed management in pulse crops, seed management, pod borer management, disease and insect pest management in pigeonpea, disease and insect management in urdbean and mungbean.
- Nine training programmes were organized for different stakeholders. *Jai Kisan Jai Vigyan* week was celebrated. Besides, one farmers fair was organised at the Institute wherein 2500 farmers participated.

Regional Station, Phanda, Bhopal

- Four station trails on genetic improvement for plant type and grain yield and suitability for mechanical harvesting in chickpea were conducted and promising genotypes were identified.
- Trials were conducted for development of chickpea genotypes to mitigate terminal heat and drought stress for enhancing productivity. The breeding materials were advanced. Potential donors for heat tolerance were identified. Genetic analysis of heat stress tolerance in chickpea was also done.
- Genetic material was advanced for genetic improvement for yield and disease resistance in medium duration pigeonpea. Wild derivatives were also generated involving *Cajanus scarabeoides* and breeding material was advanced. Mutations were induced in lathyrus to create variability for low ODAP content. ICARDA grasspea nursery was evaluated for low ODAP content, early maturity and high biomass.
- Total 430 germplasm accessions of chickpea were rejuvenated. Screening of 125 germplasm lines was done for wilt resistance. Total 452 germplasm of lathyrus were evaluated for agro-economic traits besides, purification of genotypes and single plant selection. Besides this, 1005 chickpea germplasm received from NBPGR were evaluated for pod borer tolerance

and 600 chickpea genotypes were characterized. In pigeonpea, 600 germplasm received from NBPGR were characterized for various characters. Twenty genotypes of pigeonpea were evaluated for drought tolerance under NICRA programme.

- Soybean based cropping systems were evaluated and soybean+pigeonpea – lentil was found highly productive and remunerative. IPM module for management of borer complex in central India was evaluated.

Regional Centre *cum* Off-season Nursery, Dharwad

- Collection, characterization and maintenance of genetic resources of cowpea (75 acc.) and horsegram (32 acc.) was done and large genetic variation for yield and yield components was observed. Further, 150 acc. each of mungbean and urdbean were also maintained, besides three wild *Vigna* species (*Vigna trilobata*, *Vigna stipulacea* and *Vigna aconitifolia*) were maintained for their utilization in breeding programmes.
- During off-season, chickpea breeding material form 8 AICRP centres and chickpea, lentil and fieldpea breeding material generated at IIPR was advanced.
- Total 960 kg breeder seed of different pulse crops and 250 kg truthful labeled seeds of *desi* chickpea was produced.
- Two promising entries of mungbean (IPM 205-9 and IPM 410-3) and two of *kabuli* chickpea (IPCK 2002-29 and IPCK 2004-29) are being evaluated in state multi-location trials to assess their suitability for cultivation in Karnataka.
- Chickpea (IPC 2014-28, IPC 2012-24, IPC 2006-127, IPC 2014-28), mungbean (IPM 406-1, IPM 104-3, IPM 9901-8, IPM 312-134-135K and IPM 312-66K-1) and urdbean (IPU 11-2, IPU 12-30) genotypes were found promising for cultivation in southern India.
- Maize-chickpea system recorded highest chickpea equivalent yield of 3867 kg/ha under rainfed condition. There was increase by 13% CEY due to mulching in different cropping systems.

All India Coordinated Research Projects

Under All India Coordinated Research Projects following varieties were identified for different agro-ecological zones:

Crop	Variety	States
Chickpea	GNG 2171 *Desi*	Punjab, Haryana, Western U.P., Jammu & Kashmir, Delhi, Northern Rajasthan, Himachal Pradesh and Uttarakhand
	GNG 2144 *Desi*	Punjab, Haryana, Delhi, Northern Rajasthan and Uttarakhand
	IPC 2006-77 *Desi*	Madhya Pradesh, Chhattisgarh, Maharashtra, and Southern Rajasthan
	NBeG 119 *Kabuli*	Karnataka, Andhra Pradesh and Tamil Nadu
Mungbean	DGGV 2	Karnataka
	BGS 9	Gujarat
	Shalimar Mung 2	Jammu and Kashmir
	DGGS 4	Tripura, Manipur and Arunachal Pradesh
	DBGV 5	Karnataka
Urdbean	Vallabh Urd	Western Uttar Pradesh, Punjab, Haryana Rajasthan and Uttarakhand
	MDU 1	Tamilnadu
	KPU 405	Western Uttar Pradesh, Punjab, Haryana Rajasthan and Uttarakhand.
Lentil	RVL 31	Madhya Pradesh
	Shalimar Masoor 2	Kashmir Valley
	KLB 2008-4 (Kranti)	Uttar Pradesh
	KLS 09-3 (Krish)	Uttar Pradesh
Fieldpea	RFP 2009-1	Chhattisgarh and Bihar
	IPFD 11-5	Madhya Pradesh, Chhatisgarh, Bundelkhand region of U.P. and Gujarat
	Shalimar Pea 1	Jammu and Kashmir
Horsegram	CRHG 22	Andhra Pradesh, Tamil Nadu, Telangana, Karnataka and Kerala

About the Institute

Pulses continue to be an important ingredient of human diet specially, 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 of 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 become 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. During this year, All India Network Project on Arid Legumes has also been shifted to this Institute from Jodhpur (Raj.) The main focus of the project is on cowpea, horsegram, clusterbean and mothbean. Since then, the Institute is playing a key role in strengthening the nutritional security and sustenance of soil health. Besides generating basic knowledge and material, other activities of the Institute include development of appropriate crop production and protection technologies, production and supply of nucleus and breeder seeds of improved varieties, demonstration and transfer of technologies, and strategic coordination of pulses research through wide network of testing centers across the country.

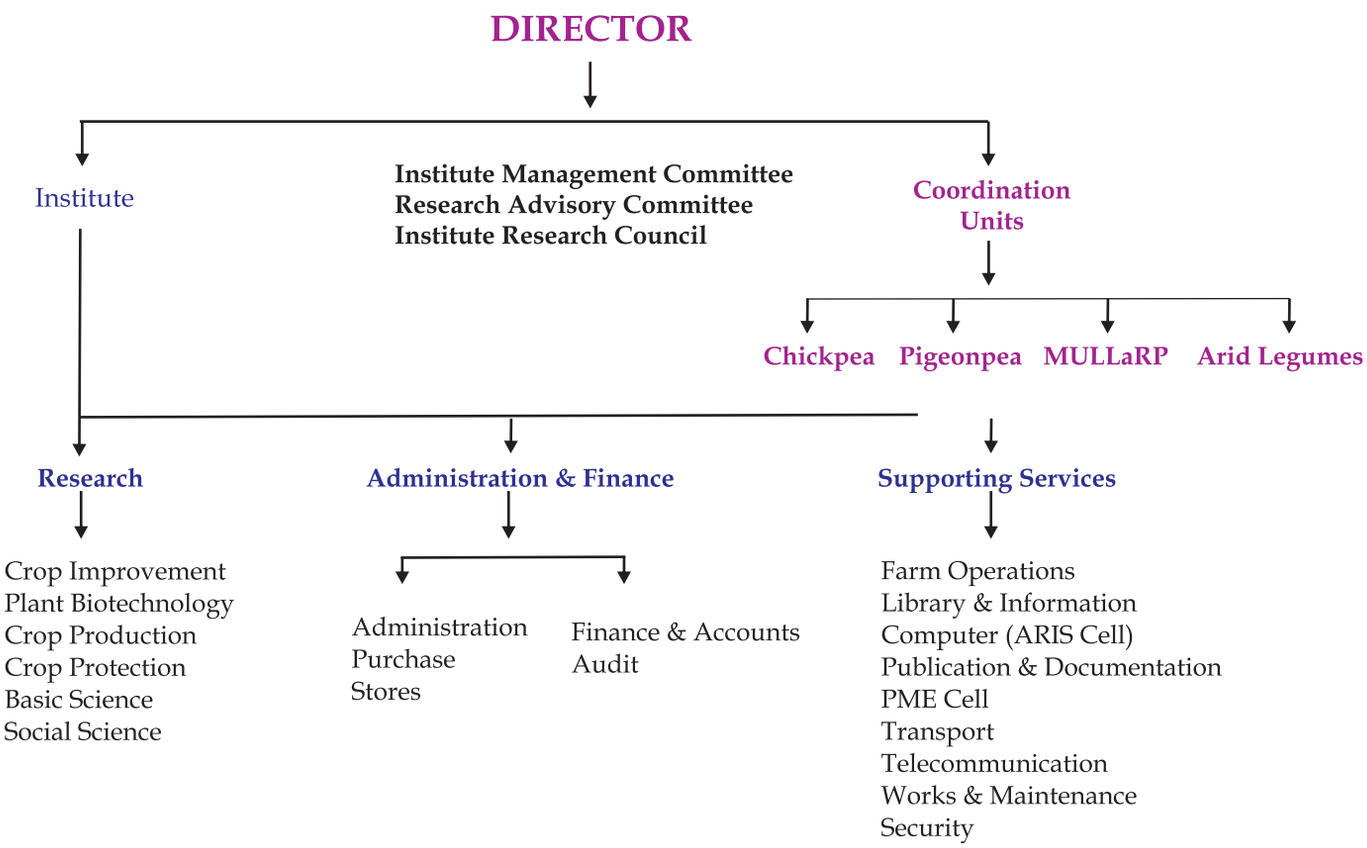
The Institute is located at Kanpur, Uttar Pradesh at $26^0 27'$N latitude, $80^0 14'$E longitude and 152.4 meter above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central Railway Station towards New Delhi.

The overall climate varies from semi-arid to arid. The summers are very hot and winters are cool and dry. The monthly weather data for the year 2015-16 revealed that the mean monthly maximum temperature varied from 22.7°C in January to 41.2°C in April and the minimum temperature from 6.5°C in January to 25.3°C in July. The relative humidity varied from 21.36% in May to 94.65% in August. During the year 2015, total 591.4 mm rainfall was received which was below normal. The monsoon rains withdrew by the mid of September. During winter season, no rainfall was received from November, 2015 to February, 2016.

Multi-disciplinary research of both applied and basic nature is conducted under six divisions namely, Crop Improvement, Plant Biotechnology, Crop Production, Crop Protection, Basic Science and Social Science. For region specific and strategic research, the Institute has one Regional Centre *cum* Off-season Nursery at Dharwad in Karnataka and one Regional Station at Bhopal in Madhya Pradesh. To cater to the needs of the Institute's activities and mandate, service units such as Farm Management, Library & Informatics, ARIS Cell, Hindi Cell, Art & Reprography and Publication & Documentation are in place.

The Institute has a well developed 84 ha research farm at its headquarter, Kanpur. Physical Containment Facility has been created for advancing generation of the transgenic plants and further validation of the transgenic lines. A post-entry quarantine facility is also in place to intercept seed borne virus from imported seeds. 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 data base 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 88 scientists, 66 technical, 27 administrative and 56 supporting personnel.

Organizational Set-up



Staff Strength

As on 31.3.2016

Category	Sanctioned	In position	Vacant
RMP	1	1	-
Scientist	88	66	22
Technical	66	54	12
Administrative	27	22	5
Supporting	56	43	13

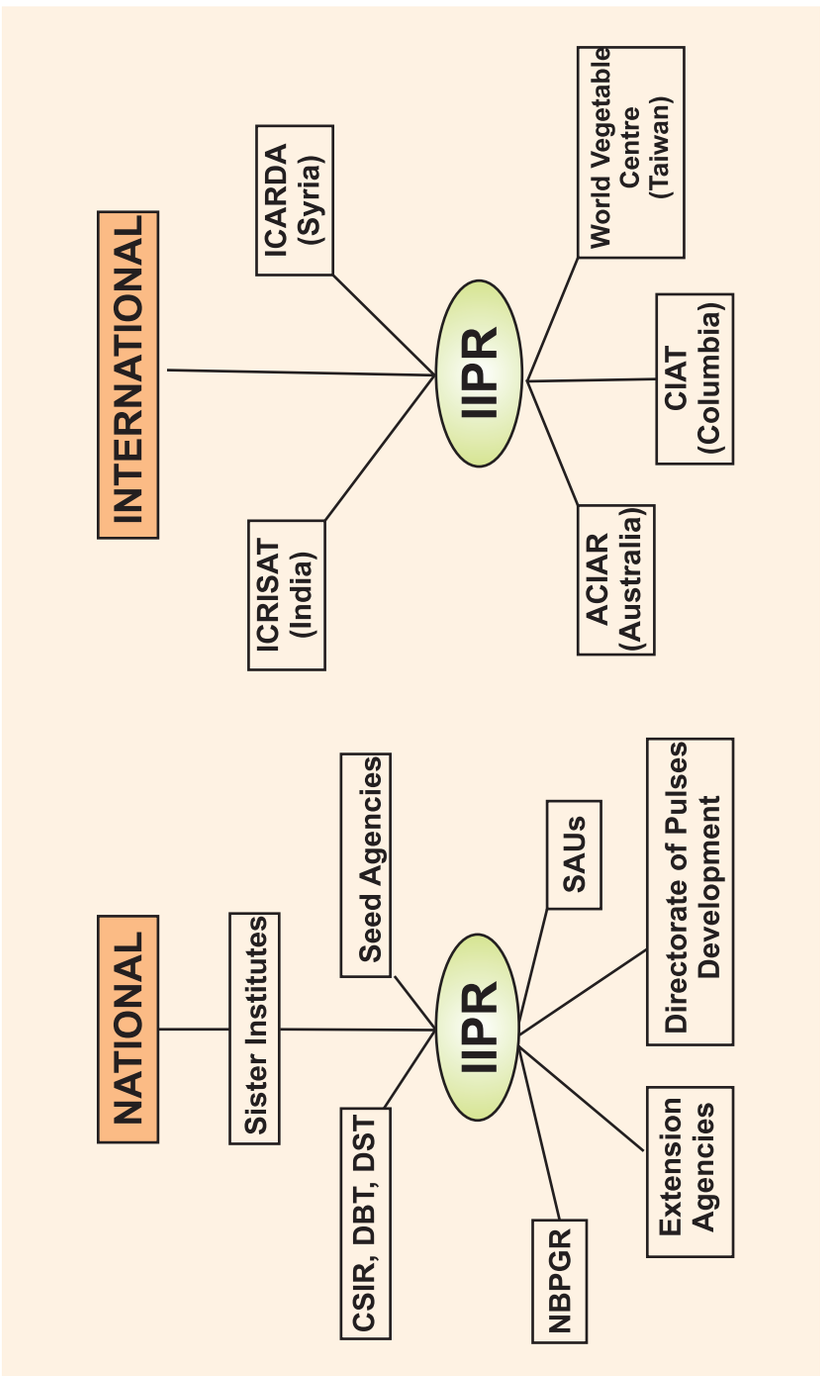
Mandate

- 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 2015-16

		Rs. in lakhs
A.	**Receipt**	180.44
B.	**Expenditure**	
	Non-Plan	2210.71
	Plan	849.29
C.	**Pension and other retirement benefits**	243.71
D.	**AICRP**	
	Chickpea	
	a. Coordination Unit	12.16
	b. Grant-in-aid	1146.75
	Pigeonpea	
	a. Coordination Unit	11.28
	b Grant-in-aid	1057.61
	MULLaRP	
	a. Coordination Unit	34.62
	b. Grant-in-aid	1357.38
	AINPAL	
	a. Coordination Unit	6.21
	b. Grant-in-aid	305.5

Status of Implementation of XII Five Year Plan (Upto 31.03.2016)

(Rs. in lakh)

Head	Approvd outlay	Expenditure 2015-16
A. Recurring		
Pay & Allowances/Wages	0.00	0.00
TA	78.80	14.86
HRD	26.50	4.95
Contingency	1075.50	291.52
Total	**1180.80**	311.33
B. Non-Recurring		
Equipment	673.60	21.86
Works	1800.01	460.00
Library	164.23	18.11
Total	**2637.84**	**499.97**
C. TSP	**200.00**	**37.99**
D. Total (A+B+C)	**4018.64**	**849.29**

Crop Improvement

Genetic Enhancement for Yield and Multiple Diseases Resistance in Chickpea

Variety developed

IPC 2006-77: This high yielding (2065 kg/ha), early maturing (112-115 days) and medium small seeded (16.5 g/100 seed weight) *desi* chickpea variety developed through hybridization (DCP 92-3 x T 39-1) has been identified for late sown conditions in Central Zone comprising of Madhya Pradesh, Chhattisgarh, Maharashtra, Gujarat, southern parts of Rajasthan and Bundelkhand tracts of Uttar Pradesh. It exhibited yield superiority by 22.7% and 13.5% over national check BG 372 (1683 kg/ha) and zonal check JG 14 (1819 kg/ha) during last 4 years of evaluation.

Performance of breeding lines in AICRP trials

Following elite breeding lines performed well under multilocation evaluation in different AICRP trials :

Genotype	Trial	Zone	Yield (kg/ha)
IPC 2010-62	AVT 2 (Late sown)	North East Plain Zone	1855
IPC 2007-28	AVT 1 (Late sown)	North East Plain Zone	1684
IPC 2010-134	AVT 1 (Late sown)	East Central Zone	1921
IPCK 2009-165	AVT 1 (*Kabuli*)	West Central Zone	1494
IPCK 2009-165	AVT 1 (*Kabuli*)	North West Plain Zone	1626
IPCK 2011-179	AVT 1 (*Kabuli*)	North West Plain Zone	1312

Generation of breeding material

Total 17 new crosses were made using genetically diverse parents to generate breeding material.

Generation advancement

F_2 seeds were harvested from 17 crosses. Total 2074 single plant selection (SPS) were made from 38 F_2 (383 SPS), 39 F_3 (588 SPS), 74 F_4 (706 SPS), 50 F_5 (334 SPS) and 16 F_6 (63 SPS) for further advancement and selection of desirable types. Similarly, 239 progeny bulks (*desi* and *kabuli*) from different generations were selected for further evaluation. Eight F_1s were advanced and 5 new crosses (DCP 92-3 x ICC 4958, JG 16 x ICC 4958, JG 16 x T 39-1, T 39-1 x ICC 4958 and DCP 92-3 x T 39-1) were made during off-season at Regional Center-*cum*- Off-season Nursary, Dharwad and grown at IIPR Main Farm and single plant selections were made from segregating populations.

Evaluation of elite breeding lines

More than 170 elite breeding lines of *desi* and *kabuli* chickpea were evaluated under irrigated and late sown conditions. In addition to these, 28 elite breeding lines were grown along with 4 checks at Bhopal and Dharwad to evaluate performance in central and southern India. In addition, one set of 30 elite breeding lines along with 3 checks was also evaluated at Bhopal centre.

Normal sown condition

Station Trial 1: Total 30 elite breeding lines were evaluated along with three check varieties (DCP 92-3, JG 16, HC 5). Five genotypes *viz*., IPC 2007-56 (2519 kg/ha: 20.8 g 100 seed wt.), followed by IPC 2009-21 (2472 kg/ha: 19.24 g/100 seed wt.), IPC 2007-28 (2467 kg/ha: 15.79 g/100 seed wt.), IPC 2008-11 (2450 kg/ha, 19.42 g/100 seed wt.) and IPC 2010-181: 2416 kg/ha, 16.72 g/100 seed wt.) out yielded best check DCP 92-3 (2275 kg/ha: 14.8 g/100 seed wt.) by more than 5%. Other promising genotypes *viz*., IPC 2010-40 (2397 kg/ha: 2113 g/100 seed wt.), IPC 2010-160 (2372 kg/ha: 21.68 g/100 seed wt.), IPC 206-127 (2311 kg/ha: 22.16 g/100 seed wt.), IPC 2010-216 (2308 kg/ha, 19.04 g/100 seed wt.) and IPC 2010-217 (2284 kg/ha: 14.97 g/100 seed wt.) also performed better than check variety DCP 92-3. Further, two genotypes (IPC 2011-28 and IPC 2008-83) having more than 60 cm plant height performed well for two consecutive years over tall variety HC 5.

Station Trial 2: Total 30 elite breeding lines (IPC 2015 series) were evaluated along with three checks (DCP 92-3, GNG 469 and HC 5). Genotypes IPC 2015-183 (2664 kg/ha: 18.96 g/100 seed wt.) and IPC 2015-213 (2599 kg/ha: 20.73 g/100 seed wt.) out yielded best check DCP 92-3 (2552 kg/ha: 15.8 g/100 seed wt.).

Late sown condition

Station Trial 1: Total 23 promising elite breeding lines of *desi* chickpea along with three checks (JG 14, Pusa 372 and DCP 92-3) were grown to assess for yield and maturity period. Genotypes *viz*., IPC 2010-30 (1914 kg/ha: 17.04 g/100 seed wt.), IPC 2012-98 (1761 kg/ha: 16.73 g/100 seed wt.) and IPC 2006-126 (2328 kg/ha: 13.49 g/100 seed wt.) out yielded check DCP 92-3 (1742 kg/ha) and Pusa 372 (1650 kg/ha). All genotypes are with small seeds and matured in less than 110 days when sown on 17-12-2015.

Station Trial 2: Total 23 chickpea genotypes along with three checks (JG 14, Pusa 372 and DCP 92-3) were grown to assess for yield and maturity period. Genotype IPC 2013-21 (2063 kg/ha: 16.4 g/100 seed wt.) out yielded all entries and checks and matured in 106 days. Other promising entries were IPC 2014-69 (1969 kg/ha: 18.4 g/100 seed wt.), IPC 2013-33 (1933 kg/ha), IPC 2014-156 (1814 kg/ha) and IPC 2014-109 (1766 kg/ha). Best check variety JG 14 gave 1602

kg/ha yield and took 109 days to mature. All genotypes had more than 50 cm plant height, whereas JG 14 attained 43.5 cm height only.

Preliminary yield trials

Out of 142 elite breeding lines evaluated in preliminary yield trails, 48 exhibited higher grain yield than the best check varieties. IPC 2012-31, IPC 2014-51, -56, -120, -169, IPC 2015-11, -24, -34, -37, -63, -85, -105, -120, -144, -146, -148, -196 and IPC 2015-220 out yielded best check varieties in yield trials.

***Kabuli* chickpea:** Total 25 *kabuli* breeding lines were evaluated along with 3 checks (Shubhra, Pusa 1053 and KAK 2). Among semi-erect breeding lines, IPC 2012-129 (3362 kg/ha: 73.3 cm., 27.0 g/100 seed wt.), followed by IPCK 2012-144 (3055 kg/ha: 59.3 cm., 27.6 g/100 seed wt.), IPCK 2012-264 (2972 kg/ha: 61.2 cm., 26.5 g/100 seed wt.) and IPCK 2011-44 (2945 kg/ha: 69.4 cm., 25.8 g/100 seed wt.) out yielded best check variety Shubhra (2858 kg/ha: 72.3 cm., 32.0 g/100 seed wt.).

Station trials at Bhopal

Station Trial 1: Total 28 elite breeding lines of *desi* chickpea along with 4 checks (JG 16, RVG 203, JG 11 and DCP 92-3) were evaluated under normal sown condition. IPC 2010-181 (1193 kg/ha) out yielded best check variety JG 11 (1037 kg/ha). Other promising breeding lines were IPC 2008-92, IPC 2013-21, IPC 2011-28, IPC 2013-03, IPC 2011-30 and IPC 2011-54.

Station Trial 2: Total 30 elite breeding lines of *desi* chickpea along with 3 checks (RVG 203, JG 14 and BG 372) were evaluated under normal sown condition. IPC 2014-15 (959 kg/ha) out yielded best check variety JG 14 (738 kg/ha). Several other breeding lines *viz*., IPC 2013-33, IPC 2013-21, IPC 2013-74, IPC 2010-134, IPC 2010-142, IPC 2013-55 and IPC 2013-78 also out yielded the best check.

Station trial at Dharwad

Total 28 elite breeding lines of *desi* chickpea along with 4 check varieties were evaluated under normal sown condition. Small seeded (16.27 g/100 seed weight) and earliest maturing (89 days) line IPC 2014-28 registered maximum grain yield (980 kg/ha), followed by IPC 2007-13 (952 kg/ha: 16.79 g/100 seed wt.), IPC 2012-24 (932 kg/ha: 14.28 g/100 seed wt.), IPC 2011-30 (860 kg/ha: 25.93 g/100 seed wt.), IPC 2006-126 (785 kg/ha: 16.20 g/100 seed wt.) against best check variety JG 11 (775 kg/ha: 19.58 g/100 seed wt.). Check JG 11 flowered in 46 days and matured in 95 days.

Genotype IPC 2011-30 performed well at Bhopal and Dharwad, hence will be entered in AICRP trial.

Besides these trials, ICVT-*Desi* (18 entries), ICVT-*Kabuli* (18 entries) of ICRISAT and two trials (ICEN and CAT) of ICARDA materials were also conducted.

Screening against biotic stresses

Wilt resistance: Out of 248 IPC 2015 series lines (228 *desi* and 20 *kabuli*) screened against *Fusarium* wilt, 42 lines (*desi*: 39, *kabuli*: 3) exhibited resistance, whereas 69 lines (*desi*: 65, *kabuli*: 4) showed moderate resistance to *Fusarium* wilt in sick plot which is predominantly developed for race 2. The resistant/moderately resistant *kabuli* genotypes were IPCK 2015-211, -235, -239, -241, -261, -264, -266 and *desi* genotypes were IPC 2015-6, -10, -11, -34, -35, -65, -71, -72, -75, -77, -82, -85, -90, -92, -99, -115, -120, -125-147, -148, -151, -154, -155, -156, -158, -165, -170, -171, -176, -188, -194, -201, -205, -207, -208, -230, -251, - 273 and IPC 2015- 281.

Out of 67 promising entries selected from previous screening, 26 were resistant (IPC 2005-18, -19, -26, -44, IPC 2007-48, -50, -51, -56, -98, IPC 2009-153, IPC 2010-05, -71-120, -123, -146, -173, IPC 2011-94, IPC 2012-198, IPC 2014-19, -35, -77, -78, -119, -123, -112 and IPC 2014-136) and 18 lines were moderately resistant (IPC 2005-41A, -41B, -52, -59, -62, IPC 2008-10, IPC 2010-61, -185, IPC 2011-28, -76, -99, IPC 2013-37, IPC 2014-124, -160, -133, -158, -129 and IPC 2014-156) for more than 2 years.

Following genotypes exhibited resistance/ moderate resistance against major diseases:

Fusarium wilt : IPC 2010-112, IPC 2007-28, IPC 2010-134, IPCK 2010-124, IPCK 2009-165, IPCK 2005-74, IPC 2008-103, IPC 2004-68, IPCK 2004-29, IPC 2008-11, IPCK 2006-56, IPC 2008-69

Dry root rot: IPCK 2006-78, IPC 2005-28

Collar rot: IPC 2010-134

***Ascochyta* blight**: IPCK 2010-92, IPCK 2009-165

Stunt: IPC 2004-52 and IPC 2000-6 (confirmed resistance over 4 years)

Donors recommended

Genotypes IPC 2007-28 and IPC 2010-134 were recommended as donors against combined resistance to wilt and dry root rot, while IPC 2010-10 for combined field resistance against wilt, dry root and collar rot.

Abiotic stresses tolerance

Total 440 recombinant inbred lines segregating for response to heat stress were sown under late sown (21 January) condition. Variations amongst RIL population with respect to pod and seed development were observed. Similarly, out of 229

elite breeding lines grown under late sown on 21st January, 37 lines exhibited heat tolerance and performed well over best check (JG 14), therefore have been selected for further evaluation.

Nucleus seed production

Nucleus seed (894 kg) of chickpea varieties *viz*., DCP 92-3 (18 kg), Shubhra (38 kg), Ujjawal (252 kg), IPC 2006-77 (281 kg), IPC 2004-1 (150 kg), IPC 2005-62 (115 kg), IPC 2004-98 (38 kg) and IPC 97-67 (2 kg) was produced.

Enhancing Protein Content in Chickpea

Total seed protein content of 5 germplasm lines, which were reported with high and low seed protein content, was determined by Kjeldahl method. T 39-1 and T 1-A were recorded with high seed protein content (~30%), followed by P 3318 (~28%). Entries NEC 755 and P 3719 had low seed protein content (<19%). Crosses were attempted between contrasting lines which had high (>28%) seed protein content. F_1 generations were raised for crosses DCP 92-3×T 39-1, DCP 92-3×IPC 2005-62, T 39-1×ICC 4958 and ICC 4958 × T 39-1 attempted during off-season. Three F_2 (IPC 2004-98×T 39-1, DCP 92-3×T 39-1 and JG 130 ×T 39-1) were advanced to next generation. F_1 generation of DCP 92-3×T 39-1 was subjected to three way crossing to utilize diverse parental lines like JG 130 and IPC 2004-98.

Combining *Fusarium* Wilt and Dry Root-rot Resistance in Chickpea by Integrated Breeding Approach

Generation of breeding material

Fifteen new crosses involving parents possessing stable resistance against dry root rot and *Fusarium* wilt *viz*., JG 16, GNG 1958, GNG 2226, JG 35, JG 37, JG 315, IPC 2005-28, IPC 2007-28, IPC 2008-103, IPC 2010-134, JG 14, JSC 37, DKG 964, Phule G 06102, IPCK 2006-78 and IPCK 2002-29 were attempted. F_2 seeds were harvested from 7 crosses *viz*., JG 16 x BG 212, JG 16 x JG 3-14-16, JG 16 x IPC 2005-64, JG 16 x IPC 2005-28, IPCK 4-29 x IPCK 12-258, IPC 11-28 x JG 16 and JAKI 9218 x IPC 2005-24. Nine crosses in F_2 to F_4 involving JG 3-14-16 as dry root rot resistant donors were advanced through single seed descent method for developing mapping population. Similarly 18 advanced lines in F_5 and 25 advanced lines in F_6 involving WR 315 and JG 3-14-16 as one of the parents were selected for further screening for dry root rot and *Fusarium* wilt resistance.

Development of Chickpea Varieties Tolerant to Heat Stress

Generation of breeding material

Six crosses *viz*., KWR 108 x JG11, JG 315 x ICC92944, KWR 108 x ICC1205, JG11 x ICC1205, JG 130 X ICC1205 and KWR 108 X JG 315 were made for developing heat tolerant varieties by transferring heat tolerance traits. Two genotypes ICC 1205 and JG 315 grown under heat and normal conditions were characterized physiologically on the basis of pollen germination, pollen fertility and cell membrane injury. Seven F_3 (ICC 92944 x ILC 3279, DCP 92-3 x ILWC 142, JG 16 x ICC 4958, FLIP 03-100 x ICC 92944, JG 11 x ICC 4958, JGK 1 x ICC 4958, JG 11 x ICC 4958, two F_5 (IPC 06-11 x ICC 96030 , T 39-1 x ICC 96030) and one F_6 cross (IPC 09-50 x BPM) were advanced to next generation.

Maintenance of germplasm

Total 300 accessions of chickpea lines including mini-core for heat tolerance were maintained.

Development of Chickpea Genotypes to Mitigate Terminal Heat and Drought Stress for Enhancing Productivity

Out of 29 genotypes evaluated under timely and late sown conditions, four genotypes *viz*., Pusa 547 (121days), RAU 52 (121days), Gujarat Gram 2 (122 days) and JG 130 (125 days) expressed combined tolerance to heat and drought and early maturity.

Breeding for Enhanced Yield Potential and *Phytophthora* Stem Blight Resistance in Short Duration Pigeonpea

Evaluation of early maturing lines

Eight entries (IPA 15-01 to 15-08) were evaluated using three checks *i.e*., Pusa 992, UPAS 120 and PAU 881. Seven entris showed significant yield advantage [12% in IPA 15-08 (1467 kg/ha) to 31% in IPA 15-2 (1707 kg/ha)] over the best check *i.e*., Pusa 992 (1300 kg/ha). Days to maturity varied from 141 (IPA 15-1) to 164 (IPA 15-7) days.

Generation of breeding material

Total 70 new crosses were attempted and 16 F_1s were advanced to F_2. Single plant selections were made in 7 F_2 (44 SPS), 4 F_3 (31 SPS), 3F_4 (30 SPS), 3F_5 (28 SPS) and 14 F_6 (107 SPS).

Molecular Mapping of Resistance Genes against Variant 1 and Variant 2 of Pigeonpea Wilt

Pot screening for wilt resistance

Screening of 200 F_2 individual plants against *Fusarium* wilt in pots showed 140 susceptible and 60 resistant plants. Chi-square analysis ($\chi 2$ value: 2.66; df=1) supports the view that pigeonpea susceptibility to *Fusarium* wilt is dominant monogenic in nature.

Parental screening and population genotyping

F_1s generated by crossing Type 7 × ICP 8863 were tested using polymorphic markers. Parental screening with 72 markers provided 19 polymorphic SSRs. Marker genotyping pattern of one random set of this F_2 population with two markers *viz*. CcGM-13944 and CcGM-14064 corroborated with the segregating nature of the population.



Screening of an F_2 population derived from Type 7 × ICP 8863 cross

Genetic Improvement for Yield and Disease Resistance in Long Duration Pigeonpea

Performance of entries in AICRP trials

Two entries *viz*., IPA 2014-6 (21.19 q/ha) and IPA 2014-7A (21.06 q/ha) performed well over check varieties Bahar (18.09 q/ha), NA 1 (19.18 q/ha) and IPA 203 (17.09 q/ha) with resistance to *Fusarium* wilt.

Performance of entries in State Adoptive Trials

Two entries *viz*., IPA 9-1 and IPA 206 were tested in Uttar Pradesh State Adaptive Trials and entry IPA 206 out yielded the check variety Bahar over two years. Three new entries *viz*., IPA 13-1, IPA 2014-6 and IPA 2014-7 have also been submitted for multilocation evaluation.

Generation of breeding material

Total 43 new cross combinations were generated involving 23 parents (UPAS 120, Dholi Dwarf, Ranchi Local, Asha, IPA 6-1, Azad, IPA 203, DA 11, KPL 44, Pusa 9, KPL 43, T 7, Mutant 3, IPA 409, Kudrat, Maruti, IPA 7-1, NDA 2, Bahar, IPA 209, Banda Phulera, ICP 89049, MAL 13, NDA 1, PH 1063, ICP 7045, MAL 16, PH 4816, ICPL 20124, IPA 2014-4A, ICPL 9908, KPBR 80-2-1, IPA 38b, Bahar and DPPA 85-12). Fifteen genotypes were identified for vegetable type and cross JBP 13×IPA 203 was made from the identified parents. Single plants were selected from 13 F_8 (27 SPS), 8F_7 (23 SPS), 4 F_6 (22 SPS), 30 F_5 (91 SPS), 40 F_4 (159 SPS), 29 F_3 (94 SPS). In addition to this, 6 F_2 populations and 18 F_1s were advanced to next generation. BC_2F_1 seeds were harvested from three crosses aiming to develop wilt resistance [(T 7 × Bahar) × KPL 43, (NA 1 × Dholi dwarf) × KPL 43, (Bahar × IPA 6-1) × KPL 43] and 25 single plants were selected from 8 BC_1F_4.

Maintenance breeding

Genetic purity of 61 parents was maintained through selfing of single plants and nucleus seed of IPA 203 was produced.

Genetic Improvement of Mungbean for Yield Enhancement and Resistance to Multiple Stresses

Varieties developed

IPM 410-3 (Shikha): IPM 410-3 (IPM 03-1 x NM1) was identified for spring cultivation in North-West Plain Zone (Punjab, Haryana, western U.P., Delhi, northern Rajasthan, Himachal Pradesh and Uttarakhand) and Central Zone (Madhya Pradesh, Chhattisgarh, Maharashtra and southern Rajasthan). Its average grain yield is 1197 kg/ha in NWPZ and 1171 kg/ha in CZ with a yield superiority >10.5% over the best check variety IPM 02-3 in NWPZ and 6.56% over the best check variety Pusa 953 in CZ. It is highly resistant to MYMV and powdery mildew and moderately resistant to *Cercospora* leaf spot. It matures in 60-65 days and has green, shining, attractive and medium large seeds.



IPM 410-3

IPM 205-7: This extra early genotype performed consistently better than the best check in UP State Adaptive Trials over past three years and its proposal has been invited by the State Department of Agriculture for identification and release.



IPM 205-7

IPM 2K 14-9: This genotype was tested in U.P. State Adaptive Trials for 3 years and yielded better (574 kg/ha) than the best check IPM 99-125 (515 kg/ha). Its identification and release proposal has been invited by the State Department of Agriculture.

Performance of breeding lines in AICRP trials

Ten advanced genotypes *viz*., IPM 410-3, IPM 312-19, IPM312-20, IPM 9901-8, IPM 205-7, IPM 409-4, IPM 302-2, IPM 306-6, IPM 2K 14-9 and IPM 5-17 were evaluated at multiple locations. IPM 410-3 was outstanding across zones and seasons and was observed largely photo- and thermo- insensitive. This variety, already identified for spring season in NWPZ and CZ, was promoted to AVT 2 in NHZ for *kharif* season. It also performed better in Karnataka State MLT. IPM 205-7 was also retained at AVT 1 in extra early summer trials. Two new genotypes, IPM 312-19 and IPM 312-20 were nominated for multilocation evaluation for all seasons and locations. IPM 9901-8 was nominated for evaluation under extra early trials. Five new genotypes *viz*., IPM 409-4, IPM 2K 14-9, IPM 302-2, IPM 5-17 and IPM 306-6 are currently under evaluation in the U.P. State Adaptive Trials. These have already been tested for one or two seasons and have been found better than the best check.

Evaluation of breeding material

One demonstration of 12 entries, 1 station trial of 24 entries including 5 checks and 1 preliminary yield trial of 48 entries including 5 checks were conducted. The entries IPM 312-20 (879 kg/ha), IPM 03-1 x NM 1 (877 kg/h), IPM 2K 08-1-1 (874 kg/h), IPM 512-1 (853 kg/ha) and IPM 6-15-1 (843 kg/ha) were found better than the best check Pusa Vishal (738 kg/ha). In PYT, entries IPM 14-13 (875 kg/ha), IPM 14-12-3 (868 kg/ha), IPM 312-394-3 (847 kg/ha), IPM 312-394-1 (833 kg/ha) and IPM 14-5-7 (820 kg/ha) out yielded the best check Pusa Vishal (750 kg/ha). During summer, one demonstration and 2 station trials were conducted. In Station trial comprising of 24 entries including 5 checks, genotype IPM 410-3 (1087 kg/ha) out yielded the best check IPM 02-3 (984 kg/ha). During spring season, one demonstration and one station trial were conducted, and entries IPM 410-3, IPM 545-1, and IPM 2K 14-7 were found promising.

One preliminary yield trial comprising 48 entries including 5 checks was also conducted at Regional Center *cum* Off-season nursery at Dharwad. Entries *viz*., IPM 14-28 (1907 kg/ha) and IPM 14-34-2 (1879 kg/ha) were significantly better than the best check IPM 99-125 (1676 kg/ha). Other promising entries were IPM 14-37 (1768 kg/ha) and IPM 14-37 (1699 kg/ha).

Generation of breeding material

Total 11 new cross combinations *viz*., PDM 139 x VBG 04-008, PDM 139 x VBG 04-003, PDM 139 x MH 805, PDM 139 x DGG 5, IPM 02-3 x VBG 04-008, IPM 02-3 x MH 2-15, IPM 02-3 x MH 805, IPM 02-3 x DGG 5, IPM 2-14 x MH 805, IPM 2-14 x MH 2-15 and IPM 2-14 x DGG 5 were attempted involving 6 mungbean parental lines (IPM 2-3, IPM 2-14, PDM 139, MH 2-15, MH 805, DGG 5) and 2 urdbean lines (VBG 04-003 and VBG 04-008). In advanced breeding material (F_7-F_9), 54 outstanding bulks were isolated. Besides this 426 single plants were selected from different segregating generations in mungbean x mungbean and mungbean x urdbean crosses. These include 30 SPS from F_9, 14 SPS from F_8, 5 SPS from F_7, 109 SPS from F_6, 74 SPS from F_4 and 143 SPS from F_2 generation in mungbean x mungbean crosses. Similarly, in mungbean x urdbean crosses, 56 SPS were taken from different segregating generations.

Maintenance breeding

Total 420 kg nucleus seed of four mungbean varieties (IPM 99-125, Samrat, IPM 2-3 and IPM 2-14) was produced. In addition 650 kg seed of two extra early genotypes (IPM 205-7 and IPM 409-4) was also produced. Similarly, >2400 single plant selections in 4 IIPR released varieties were also taken for growing plant progeny rows for producing nucleus seed.

Genetic Improvement for Yield and Resistance to Multiple Diseases in Urdbean

Performance of breeding lines in AICRP trials

IPU 11-1 has been promoted from IVT to AVT 1 in NEPZ for spring season.

Evaluation of promising breeding lines

Twenty two improved genotypes along with three checks (IPU 2-43, IPU 94-1 and Shekhar 2) were evaluated. Genotypes IPU 12-1(1750 kg/ha), IPU 10-21 (1250 kg/ha), IPU 12-9 (1050 kg/ha) and IPU 10-33 performed better than checks. Among 7 advance breeding lines, IPU 11-2 (63 days) and IPU 12-30 (65 days) were found early in maturity and IPU 11-2 produced highest yield (1682 kg/ha) against best check IPU 2-43 (1620 kg/ha), followed by IPU 12-30 (1453 kg/ha) at IIPR-Regional Centre cum Off-season Nursery, Dharwad. IPU 12-30 was found moderately resistant to powdery mildew at Dharwad.

Generation of breeding material

Twenty three new crosses were attempted at IIPR, Kanpur and IIPR-RC, Dharwad. Different generations of breeding materials were evaluated and selected on the basis of plant types, days to maturity, disease resistance and yield attributes for generation advancement. Superior single plants were selected in 29 F_2 (590 SPS), 18 F_3 (360 SPS), 2 F_4 (40 SPS) and 8 F_6 (80 SPS). Total 18 F_3 and 2 F_4 populations were advanced and 40 SPS were selected at IIPR-RC, Dharwad.

Multiplication of advanced breeding lines

Eight advance breeding lines *viz*., IPU 10-11, IPU 11-2, IPU 10-33, IPU 12-30, IPU 13-1, IPU 2-33, IPU 11-1 and IPU 10-26 were multiplied for AICRP evaluation.

Maintenance breeding

Nucleus seed of two released varieties IPU 2-43 (35 kg) and IPU 94-1 (40 kg) was produced.

Genetic Improvement for Plant Type and Grain Yield in Fieldpea

Variety developed



IPFD 12-2

IPFD 12-2: White and round seeded dwarf fieldpea variety developed from cross HUDP 15 x EC 342002 was identified for central zone comprising of Madhya Pradesh, Chhattisgarh, Gujarat and southern Rajasthan. It has average yield potential of 2433 kg/ha in Central Zone with yield advantage of 26.51% over check variety Prakash. It is resistant to powdery mildew disease and matures in 110 days. It is also resistant to pod borer and moderately resistant to aphid and leaf miner.

Promising varieties

IPFD 9-2: This variety exhibited >10% yield superiority over the popular check variety Sapna in Uttar Pradesh State Varietal Trial. Its identification proposal has been submitted.

IPFD 10-13:- This variety has been found promising over the popular check variety Sapna on basis of three years evaluation. Its proposal has been invited by the State Department of Agriculture for identification and release.

Promising entries in AICRP trials

Two tall entries IPF 2014-16 and IPF 2014-13 were promoted to AVT-1 for North Hill Zone and North-East Plain Zone, respectively. Two dwarf entries IPFD 2014-2 and IPFD 2014-11 were promoted to AVT-1 in NWPZ and CZ. Four new entries *viz*., IPF 15-13, IPF 15-21, IPFD 15-5 and IPFD 15-8 are being evaluated in IVT. Six entries were promoted in state coordination trial.

Generation of breeding material

Total 20 crosses were made using different donors possessing specific traits like large seed size, number of seeds/pods, pod length, number of pods, earliness, powdery mildew resistance and rust toleranc. Total 23 F_1 were raised and single plants were selected from 25 F_2 (250 SPS), 43 F_3 (430 SPS), 54 F_4 (540 SPS) and 513 bulks in F_5/F_6.

Evaluation of advance breeding lines

Ten dwarf entries were evaluated along with three checks and two entries IPFD 16-4 (3112 kg/ha) and IPFD16-3 (3105 kg/ha) were highest yielder as compared to best check HUDP 15 (2995 kg/ha). In another station trial, 11 tall entries were evaluated along with three checks and none of the entries was superior to check VL 42 (3008 kg/ha).

Development of mapping population

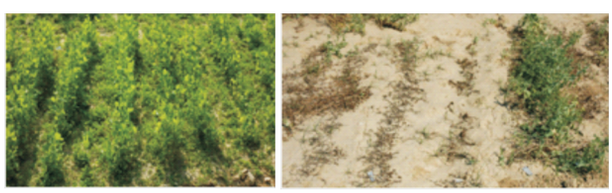
A mapping population of 220 F_3 individuals derived from HFP 4 (S) x FC1(R) for rust resistance has been advanced to next generation.

Maintenance breeding

Nucleus seed of Adarsh, Aman,Vikas, Prakash, IPFD 10-12, IPF 4-9, IPFD 11-5 and IPFD 12-2 was produced.

Screening for herbicide tolerance

Total 828 genotypes comprising of breeding lines, germplasm accessions and released varieties were evaluated against popular post-emergence herbicide metribuzin @ 500g/ha. There was ample amount of genetic variation. Based on visual observation and toxicity on plants five genotypes *viz*., P 729, P 637, P 1297-35-1, P 2016 and P 706 were found tolerant against metribuzin. The genotypes were categorized as highly tolerant (5), tolerant (21), moderately tolerant (133), susceptible (369) and highly susceptible (300).



Before herbicid After herbicide spray

Genetic Improvement for Yield and Multiple Stress in Lentil

Variety developed



IPL 220

IPL 220: This small seeded variety (2.4 g/100 seeds) has been developed through hybridization following pedigree method of selection from a three way crosses [(DPL 44 x DPL 62) x DPL 58]. Its average yield is 1378 kg/ha with yield superiority of 8.93% and 11.13% over check varieties HUL 57 and KLS 218, respectively. It has high concentration of Fe (87-

112 mg/kg), Zn (62-63 mg/kg) and Se (630 µg/kg) in their seeds. Its seeds are brown with orange cotyledons. It is resistant to rust, *Fusarium* wilt and stemphylium blight. It has been recommended for identification after one more year evaluation for Fe andZn.

Promising varieties


IPL 321

IPL 321: This variety derived from cross K 75 × DPL 62 has performed well over three years in UP State Adaptive Trials. Its average yield is 1274 kg/ha. This large seeded variety has shown high level of resistance to wilt, rust and ascochyta blight.


IPL 315

IPL 315: This variety derived from cross PL 4 × DPL 62 has performed well over three years in UP State Adaptive Trials. It has wider adaptability with average yield of 1235 kg/ha in Uttar Pradesh. This large seeded variety (2.9 g/100 seed weight) has brown, attractive seeds with orange cotyledons and is resistant to rust and tolerant to wilt.

Proposal of these promising varieties has been invited by State Department of Agriculture for identification and release.

Performance of breeding lines in AICRP trials

Total 10 entries were evaluated in AICRP trials. Two entries IPL 333 (1178 kg/ha) and IPL 334 (912 kg/ha) were promoted to AVT -1 in CZ, while extra early entry IPL 534 (827 kg/ha) has been retained in AVT-1.

Evaluation of promising breeding lines

Two station trials with 15 entries each and one preliminary yield trial with 60 entries were sown to evaluate their performance. In ST-I, entries IPL 131053 (1929 kg/ha), followed by IPL 121802 (1918 kg/ha) and IPL 10800 (1855 kg/ha) were high yielders as compared to best check DPL 15 (1488 kg/ha). In ST-II, two entries IPL 11872 (1940 kg/ha) and IPL 141560 (1961 kg/ha) were high yielders as compared to check IPL 316 (1918 kg/ha). In PYT, 6 entries *viz*., IPL 141550 (2098 kg/ha), IPL 1217854 (2123 kg/ha), IPL 141643 (2172 kg/ha), IPL 1217151 (2172 kg/ha), IPL 141519 (2246 kg/ha) and IPL 121546 (2444 kg/ha) performed better than check IPL 316 (2074 kg/ha). Under late sown conditions three entries, IPL 141562, IPL 141657 and IPL 141640 gave higher (352-366 kg/ha) yield as compared to check IPL 316 (276 kg/ha).

A station trial of 15 entries and PYT comprising of 60 entries along with checks IPL 316, IPL 526 and DPL 62 was conducted at IIPR-RS, Bhopal. IPL 121832 (933 kg/ha) and IPL 11738 (1039 kg/ha) gave higher yield than best check IPL 316 (725 kg/ha). These entries matured in 125 to 127 days. In PYT, IPL 141052 and IPL 121439 yielded 1496 kg/ha and 1522 kg/ha, respectively as compared to best check IPL 316 (922 kg/ha). Interestingly, these two entries flowered in 65-66 days and matured in 115-118 days.

Generation of breeding material

Total 6 crosses (IPL 220 x IPL 338, IPL 333 x IPL 338, IPL 321 x IPL 338, IPL 220 x IPL 337, IPL 334 x IPL 338, IPL 338 x IPL 337) were attempted among the elite breeding lines having earliness, high biomass and wider adaptability. Besides, nine fresh crosses *viz*., IPL 316 x L 4317, IPL 316 x IPL 321, IPL 316 x PL 07, IPL 316 x ILL 7663, IPL 316 x L 4710, IPL 316 x LL 931, IPL 316 x PL 117, IPL 316 x LL 699 and IPL 316 x DPL 62 were attempted under the national crossing programme. F_1s seeds were grown from 24 crosses including IPL 321 as donor for wilt, Bari Masoor 5 for seed size, IPL 534 for biomass and IPL 220 for Fe and Zn. Single plants were selected from 38 F_2 (456 SPS), 13 F_3 (264 SPS), 11 F_4 (280 SPS), 12 F_5 (123 SPS) and 180 bulk progenies were made from 33 F_6.

Development and maintenance of mapping populations

Total 160 F_8 RILs for wilt resistance derived from a cross Precoz (S) × PL-02 (R] and 160 F_8 RILs for earliness and seed size derived from cross L-4603 (Early) × Precoz (Late) were grown for maintenance of mapping populations. Trait specific mapping populations for early seedling vigor (ILL 7663 × DPL 15) having 236 F_4 SPS and root traits (IPL 98/193 × EC 208362) having 429 F_4 SPS were advanced to F_5 generation following single pod descent method.

Maintenance breeding

Total 168 kg nucleus seeds of six released varieties (IPL 81, IPL 406, DPL 15 and DPL 62, IPL 316 and IPL 526) were produced.

ICRADA nurseries

Five ICRADA nurseries including LISN-16 (small seeds), LIEN-MN-16 (mineral nutrients), LIEN-MH-16 (mechanical harvesting), LIEN-E-16 (earliness) and LIPBN-16 (pre-breeding) were evaluated. Two lines were selected for earliness, while flowering and podding were not observed in most of the entries.

Genetic Improvement of Rajmash for Yield and Management of Genetic Resources

Genetic diversity analysis

Diversity analysis among 60 accessions revealed substantially higher variability for more number of branches/plant, number of pods/plant, seeds/pod, seed colour, seed size and seed yield/plant. Classification of genotypes led to formation of 4 clusters. Cluster I had 14 genotypes, cluster II had 28 genotypes, cluster III had 7 accessions and remaining 11 accessions were grouped in cluster IV. Accessions within the same cluster either had little or no differences with respect to traits under study. Accessions belonging to different clusters exhibited more variability for quantitative traits and could be utilized as diverse parents in broadening the genetic base of rajmash through hybridization.

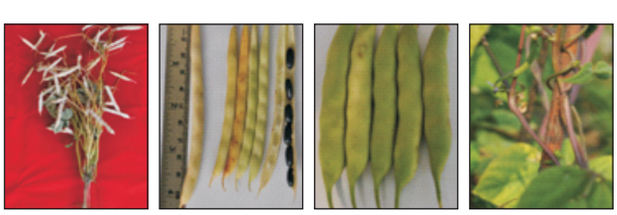


Variation for seed colour and seed size in rajmash accessions

Identification of trait specific accession

Total 320 accessions were evaluated for various quantitative traits. Following genotypes were identified promising for various traits:

Character	Promising accessions
Early flowering (< 50 days)	EC400419, GPR4189, EC56567
Late flowering (76-100 days)	IC-340902, IC341406
No. of primary branches (>3)	EC-400414, EC-564797,EC-15
Pod length (>10 cm)	EC-565673A, PL-227468, GPR-4189
No. of seeds per pod (> 5)	HUR-53, EC-500232, BLF-101
Flower colour (Deep red)	IC-340902, IC341406
Vegetable type	IC-341337, IC-391488, IC-391410
Resistance to BCMV	EC-400414, EC-400417, IC-340902
Upright branching	IC-31084, BLF-101, EC-500232
Large seed type	IC-340902
Purple stem anthocyanin	IC-341389, IC-341406
Large seeded	EC-400414



Upright branching | Long pod type | Bold seed type | Purple stem

Maintenance breeding

Total 101 kg nucleus seed of four released varieties *viz*., PDR 14, Arun, Utkarsh and Amber was produced.

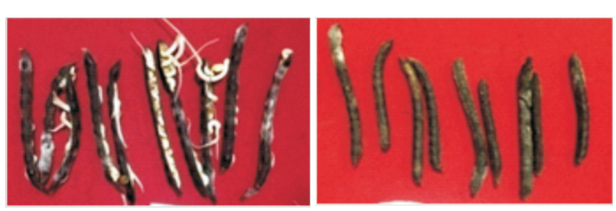
Improving Seed Quality of Major Pulses

Enhancing field emergence and seed storability of extra large seeded *kabuli* chickpea

Among ten treatments used for improving field emergence of extra large seeded *kabuli* chickpea cv. Kripa, seed priming with 10% lantana extract for 12h and polyethylene glycol @ -0.5 MPa recorded enhanced emergence (60-62%) over control (49%) leading to increased seed yield. Seed priming with PEG and lantana extract recorded seed yield of 1026 kg/ha and 1016 kg/ha, respectively, while control recorded only 736 kg/ha seed yield.

Measures to overcome pre-harvest sprouting in mungbean

Total 176 mungbean genotypes were screened in laboratory for pre-harvest sprouting (PHS) tolerance. CHAMU-4, DOPOLE, IC 52061, CHAMAH-1, BGG-1 and Pusa Ratna showed less than 10% seed germination in pods and were identified as PHS tolerant. Fresh seed germination in these six genotypes ranged from 4-10%, with high number of hard seeds indicating presence of physical dormancy. Pods of popular varieties like Meha, IPM 2-14, IPM 2-3 showed maximum pod loss (>70%) due to PHS. Seeds of these varieties lack dormancy with fresh seed germination per cent of 98, 84 and 92%, respectively.



Seed germination in pods of IPM 2-3 (A) and CHAMU 4 (B)

Pulses Genetic Resources Management and On-line Information Retrieval

Pigeonpea

A set of 48 wild accessions comprising of three genera *viz*., *Cajanus* (39 accessions belonging to eight species), *Rhynchosia* (seven accessions belonging to four species) and *Flemingia* (one accession of one species) and also a set 311 early and 276 late germplasms were rejuvenated (Fig. 1). Twenty best performing late germplasms were selected for further evaluation and for use in breeding programme.

Rajmash

Total 330 accession were multiplied and maintained. Out of these 270 accessions were indigenous type procured from NBPGR-S, Bhowali,

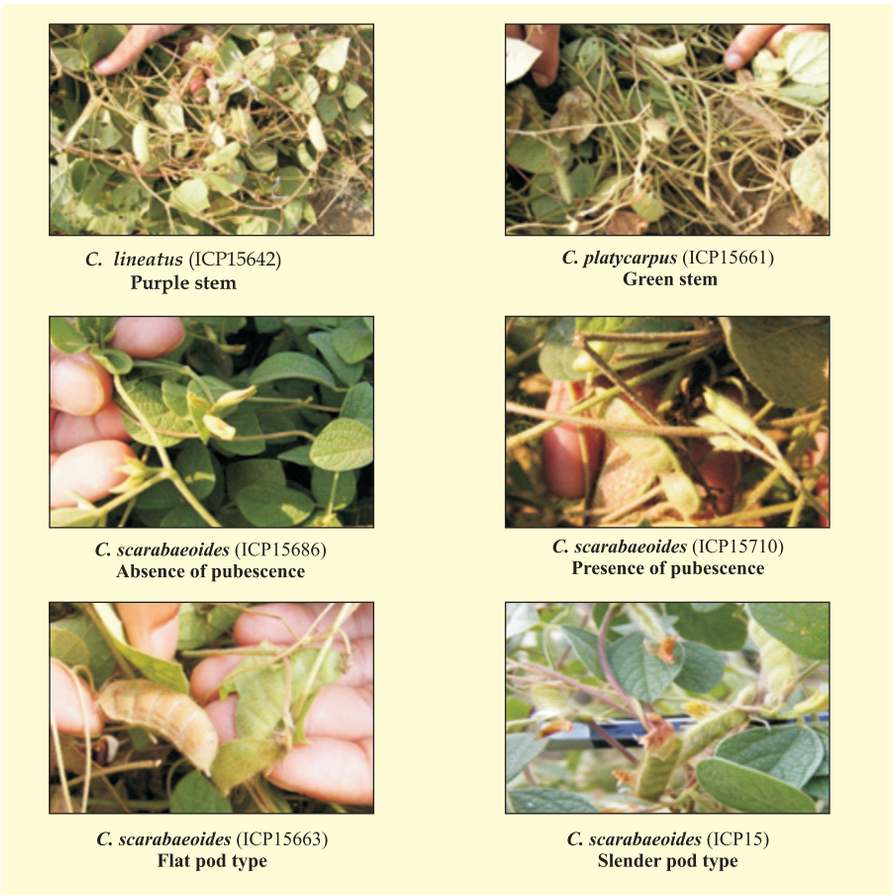


Fig. 1: Unique identification from wild accessions of pigeonpea for different traits of interest

Uttarakhand. These accessions were classified based on plant types *viz*., bushy and pole type, plant growth habit *viz*., determinate and indeterminate and seed colour.

Fieldpea

Total of 400 accessions of fieldpea were rejuvenated.

Lentil

Total 250 germplasm lines were rejuvenated. Besides, 343 active germplasm, 153 accessions of ICARDA mini-core, 339 accessions of six wild species and 90 land races were maintained.

Urdbean

Total 300 germplasm accession were rejuvenated.

Mungbean

Total 260 active germplasm lines were maintained and evaluated. Similarly, 515 germplasm lines were rejuvenated and data were recorded on morphological traits. Single plants were taken from each germplasm line to maintain genetic purity. Among wild species of *Vigna*, 98 accessions belonging to 18 different species (*V. trilobata:* 17 accessions; *V. umbellata:* 15; *V. stipulaceae:* 5; *V. hainiana:* 4; *V. glabrescens, V. trinervia, V. unguiculata, V. speciosa:* 1 each; *V. pilosa, V. dalzelliana; V. trinervia* var. *bournei;* 3 each; *V. setulosa, V. vexilalata, V. aconitifolia:* 2 each; *V. radiata:* 12; *V. mungo:* 9; *V. sublobata:* 6, *V. sylvestris:* 6 and 5 unknown) were maintained in wide hybridization garden as well as in net-house. Besides, 3 cowpea accessions of Goa region were also maintained. All the above accessions were evaluated for 17 morphological traits. Total genomic DNA was isolated from a set of 45 wild *Vigna* accessions and quantified. This was subjected to SSR marker polymorphism study and till date 21 SSR markers have been screened and 6 (28.6%) found polymorphic.

Chickpea

Total 515 accessions were rejuvenated. Entries ICC 98-12111 and ICC 12922 were observed to be initiating flowering at 40 days and thriving with vigorous plant type producing good yield. Accessions *viz*., ICE 1304151, IPC 11-109151-15/1, ICC14717 were identified as potential donor for phenological attributes and yield traits.



Medium term storage of pulse genetic resources

Following accessions of different pulse crops are being maintained in cold module:

Crop	Number of accessions
Chickpea	3000
Fieldpea	857
Lathyrus	456
Lentil	2200
Urdbean	328
Mungbean	465
Pigeonpea	1191

Breeder Seed Production

Total 555.66 q breeder seed of pulses varieties developed by IIPR was produced:

Crop	Name of variety	Production (q)
Pigeonpea	-	21.50
Mungbean	Samrat, IPM 2-03, IPM 2-14, Meha	111.80
Urdbean	Uttara, IPU 2-43	46.55
Chickpea	Ujjawal, Shubhra, DCP 92-3, Kripa, JG 16, JG 11	128.83
Lentil	DPL 15, DPL 62, IPL 406, IPL 316, IPL 81, JL 3	28.53
Fieldpea	Adarsh, IPF 4-9, IPFD 10-12	217.70
Rajmash	-	0.75
Total		**555.66**

EXTERNALLY FUNDED PROJECTS

Widening Genetic Base through Pre-breeding for Development of High Yielding Cultivars of *Kabuli* Chickpea

Total 179 germplasm lines including primitive land races possessing specific traits were maintained. Sufficient seed of 92 accessions belonging to six different wild species was harvested. Total 111 accessions of different wild *Cicer* species (*C. reticulatum*: 46, *C. judaicum*: 38, *C. pinnatifidum*: 17, *C. echinospermum*: 5, *C. cuneatum*: 3, *C. yamashitae*: 2) were maintained in concrete pots in wide hybridization garden. All accessions belonging to *C. bijugum* showed high level of tolerance to high temperature stress and set pods at more than 35^{0}C. It was also observed that leaves of accession remained green even at more than 35^{0}C temperature for two consecutive years confirming high temperature tolerance. Among other accessions, ILWC 115 and ILWC 21 exhibited heat tolerance.

Screening against diseases

Kabuli chickpea breeding lines *viz*., IPCK 2012-154, IPCK 2013-194, IPCK 2013-182, IPCK 2014-121 and IPCK 2014-38 exhibited resistance (<10% mortality) against *Fusarium* wilt in wilt sick plot predominantly having inoculums of *foc* race 2 for two consecutive years. Similarly, four landraces *viz*., IPC 79, IPC 129, IPC 93 and IPC 104 exhibited resistance against *Ascochyta* blight for two consecutive years.

Generation of breeding material

Nine new crosses *viz*., IPC 2009-50 x ILWC 115, HC 5 x ILWC 292, IPCK 2011-39 x ILWC 115, ILC 3297 x ILWC 185, IPC 2006-11 x ILWC 142, IPCK 2011-39 x ILWC 141, IPC 2004-98 x ILWC 238, IPC 2008-69 x ILWC 252 and IPCK 2009-40 x ILWC 115 made using genetically diverse parents (land races and acc. of wild *Cicer* sps.) were grown as F_3 populations and single plant selections were made. Large number of single plant selections were made form interspecific crosses from different segregating generations.

Evaluation of tall and erect *kabuli* types

Total 25 breeding lines were evaluated along with 3 checks (Shubhra, Pusa 1053, KAK 2). Among tall and erect genotypes, IPC 2010-130 (3362 kg/ha: 67.4 cm., 27 g/100 seed wt.), followed by IPCK 2011-37 (3195 kg/ha: 63.2 cm., 36 g/100 seed wt.), IPCK 2009-165 (2945 kg/ha: 63.3 cm., 27.1 g/100 seed wt.), IPCK 2012-07 (2917 kg/ha: 64.7 cm., 25.6 g/100 seed wt.) and IPCK 2013-163 (2888 kg/ha: 67.2 cm., 26 g/100 seed wt.) out yielded best check variety Shubhra (2858 kg/ha: 72.3 cm., 32.0 g/100 seed wt.)

Variability created

Interspecific cross involving IPC 2006-88 (cultivated) and ILWC 179 (*C. echinospermum*) resulted in release of tremendous variability for number of seeds/pod with mean value of 2.4 seeds/pod. On basis of number of seeds/pod and other

traits, 59 single plant selections were made. Similarly, large variations were recorded for pods/plant, primary and secondary branches/plant.



Wide hybridization garden



C. pinnatifidum

Development of Chickpea Genotypes Suitable for Mechanical Harvesting and Tolerant to Herbicide

Evaluation of tall and upright breeding lines

Total 29 tall and erect genotypes along with four checks (HC 5, DCP 92-3, JG 16 and KWR 108) were evaluated. Genotypes *viz*., IPC 2011-85 (2947 kg/ha: 64.9 cm), IPC 2014-48 (2855 kg/ha: 66.8 cm), IPC 2011-28 (2667 kg/ha: 64.7 cm), IPC 2010-142 (2649 kg/ha: 67.9 cm), IPC 2014-67 (2642 kg/ha: 65.0 cm), IPC 2014-143 (2641 kg/ha: 71.5 cm) and IPC 2012-30 (2614 kg/ha: 68.1 cm) out yielded best check varieties DCP 92-3 (2556 kg/ha: 46.7 cm) and JG 16 (2524 kg/ha: 49.9 cm) and HC 5 ((2336 kg/ha: 68.4 cm). Two genotypes (IPC2011-28 and IPC 2011-85) performed well for two consecutive years. All 7 genotypes had more than 60 cm plant height with more than 60^0 branch angle and had no lodging. Genotype IPC 2010-142 had 26.7 g/100-seed weight. The maturity period ranged from 112 to 116 days.

Screening for post-emergence herbicide Imazethapyr tolerance

Total 300 new entries were screened against post-emergence herbicide Imazethapyr. Several genotypes showed promise for herbicide tolerance. Two varieties (*Desi*: DCP 92-3, *Kabuli*: IPCK 2002-29) were subjected to mutagenic treatment using 3% EMS for inducing herbicide tolerant mutants. The bulks were screened against post-emergence herbicide but all plants showed sensitivity to Imazethapyr.

Generation of breeding material

Four new crosses *viz*., NBeG 47 x IPC 2007-28, IPC 2006-11 x IPC 2007-28, IPCK 2009-165 x ILC 3279 and IPC 2011-85 x BGD 99-71 were harvested successfully. Four crosses *viz*., JG 130 x IPC 2011-28, JG 130 x HC 5, JG 16 x IPC 2011-28 and JG 16 x HC 5 made to develop chickpea varieties suitable for machine harvesting were advanced to F_2 generation. F_3 seeds were collected from 7 crosses *viz*., JG130 x IPC2008-57, IPC2004-52 x IPC 2008-57, IPC 2008-83 x IPC 2008-57, IPC 2011 x IPC 2008-57, IPC 2006-11 x ICC1205, IPC2008-57 x ICC1205, HC 5 x ICC 1205. Six crosses *viz*., HC 5 x ICC 14778, IPC 2010-63 x IPC 2012-122, IPC 2012-100 x PA 1108, IPC 2009-50 x ICC 14778, IPC 2011-55 x ICCV 15614 and IPC 2012-122 x IPC 2010-63 were advanced to F_4 generation.

Agronomic trial on genotypes suitable for mechanical harvesting

An experiment was conducted to determine optimum plant geometry and genotypes for mechanical harvesting. Two genotypes (JAKI 9218 and HC 5) and four crop geometry (30×10 cm, 30×7.5 cm, 22.5×10 cm and 22.5×7.5 cm) were taken. Higher plant height at harvest was observed in HC 5 (77.29 cm) as compared to JAKI 9218 (52.13 cm). Further, highest point of podding from soil surface was also observed in HC 5 (33.71 cm) compared to JAKI 9218 when sown at the spacing of 22.5×7.5 cm (Fig. 2).

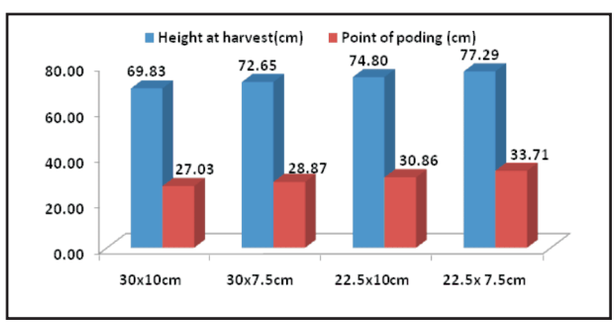


Fig. 2: Plant height and point of podding from soil surface in chickpea (HC 5)

HC 5 was out yielded JAKI 9218 at spacing of 22.5×10 cm (Fig. 3). Maximum grain yield was recorded in HC 5 sown at 22.5×10 cm (17.18 q/ha), followed by JAKI 9218 sown at 30×10 cm (16.06 q/ha). Density and grain yield in JAKI 9218 had inverse relationship, more the density lower the grain yield and vice versa. The order of yield increment in HC 5 was 22.5×10 cm>30×10 cm>30×7.5 cm>22.5×7.5 cm. This might be due to erectness of the genotype having lesser inter-row competition.

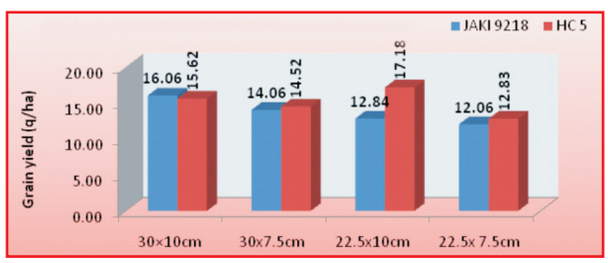


Fig. 3: Chickpea grain yield under varying genotypes and crop geometry

Agronomic trial on herbicide tolerance in chickpea genotypes

Chickpea genotypes *viz*., Shubhra, JG 16 and Ujjawal were tested under varying herbicide treatments *viz*., Carfentrazone-ethyl @ 20 and 30 g/ha, Imazethapyr @ 50 and 75 g/ha for herbicide tolerance, phytotoxicity and weed density.

Carfentrazone-ethyl @ 30g/ha recorded highest phytotoxicity in JG 16 (94.33 %), followed by carfentrazone-ethyl @ 20 g/ha, Imazethapyr @ 75 g/ha and Imazethapyr @ 50 g/ha. Least phytotoxicity was noticed in Ujjawal with application of Imazethapyr @ 50 g/ha. Spray of both herbicides Carfentrazone-ethyl (20 and 30 g/ha) and Imazethapyr (50 and 75 g/ha) had phytotoxicity in the chickpea plants. Toxicity level was more in *desi* type chickpea compared with *kabuli* type (Fig. 4). Variation in weed density at 75 DAS was also differed markedly due to application of different herbicides at variable doses. Application of Carfentrazone-ethyl @ 30 g/ha recorded least density of *Cyperus royundus* (6.39 m^2), followed by Imazethapyr @ 75 g/ha (6.44/m^2), Carfentrazone-ethyl @ 20 g/ha (7.62 m^2) and Imazethapyr @ 50 g/ha (9.29/m^2). Least weed density of *Coronopus didymus*, *Oxalis latifolia*, *Argemone Mexicana* and other weeds was observed with Imazethapyr @ 75 g/ha. This might be due to more toxic effect of Imazethapyr on these weeds as compared with Carfentrazone-ethyl. Higher weed density of *Cyperus rotundus* was noticed in *desi* chickpea (JG 16) as compared to *kabuli* (Shubhra and Ujjawal).

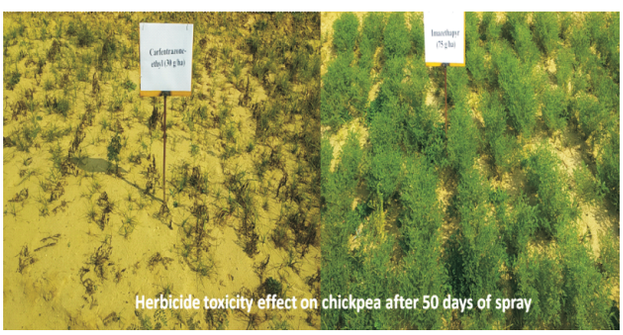


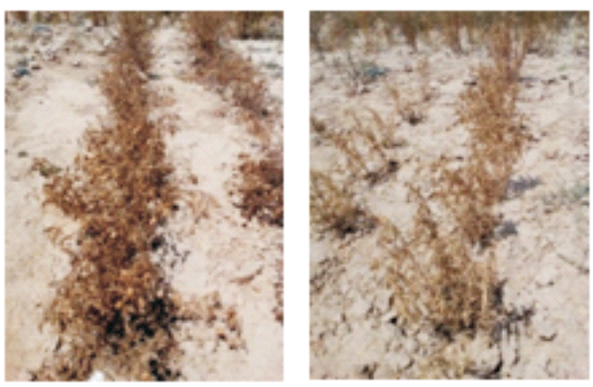
Fig. 4: Phytotoxicity in chickpea due to herbicide application

Major weeds re-emerged after 45 days of application of herbicides

Some of the weeds *viz*., *Cyperus rotundus, Coronopus didymus, Oxalis latifolia and Fumaria parviflora* re-emerged after 45 days of application of Imazathapyr even at higher dose of 75 g/ha. Likewise, *Cyperus rotundus, Coronopus didymus, Melilotus, Argemone mexicana* and *Oxalis latifolia* also re-emerged at the same time at higher rate of application of Carfentrazone ethyl @ 30 g/ha.

Breeding for Salinity Tolerance and BGM Resistance

A panel comprising of 120 chickpea germplasm lines was screened for tolerance to salinity-sodicity under field conditions having mean pH 8.5 and EC equivalent to 6 dS/cm. Eight lines *viz*., ICC 16690, ICC 11452, ICC 5445, ICC 12362, ICC 12354, ICC 6490, ICC 11505 and ICC 15040 were identified for salinity tolerance on the basis of good population stand and high plot yield. In addition to this, 4 lines *viz*., ICCV 6, ICC 4593, ICC 5003 and ICC 9942 showed modest plot yield and good population stand. However, 2 lines, ICC 6306 and ICC 15610 in spite of good population stand were unable to set seed under stress condition. Crosses were attempted utilizing potent lines as donor in the genetic background of KWR108.



(a)**KWR 108: good population stand with seed setting,** **(b) ICC6306: good plant population without any seed set**

CRP on Hybrid Technology

Evaluation of hybrids in initial trial

Six hybrids were evaluated in initial hybrid trial (IHT). Hybrid IPH 15-1, IPH 15-2, IPH 15-3 and IPH 15-4 exhibited more than 90% fertility in contrast to PHP 132 and PHP 130 which had only 50% fertility restoration. One hybrid IPH 15-3 showed considerably high yield advantage *i.e*., up to 38% over the best check Pusa 992 (1293 kg/ha).

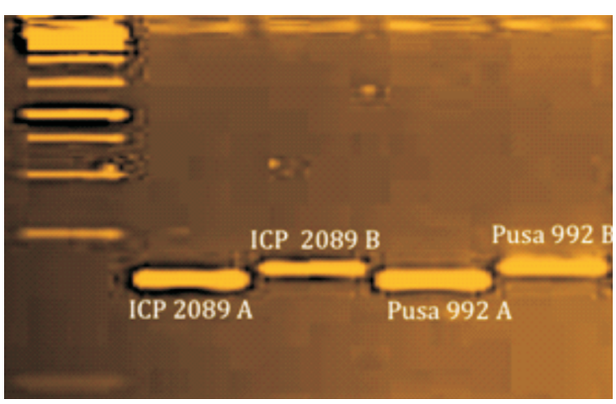
Development of experimental hybrids

Total 70 experimental hybrids were evaluated for fertility and heterosis. Five new hybrids *viz*., PA 163 A×Co 1R, CoRG 990052A×AK261354R, AL 101A×Co-1R, ICP 88039A×AK 250189R and ICP 2089A×AK 250189R were selected for further evaluation. A set of 40 new experimental hybrids was developed for testing. For fertility assessment various standing techniques such as 1% aceto-carmine solution, 1% iodide potassium iodide (IKI) solution and modified Alexander's staining protocol were used. Fertile pollen grains stained in red (pink in Alexander's stain and dark brown in case of I-KI)

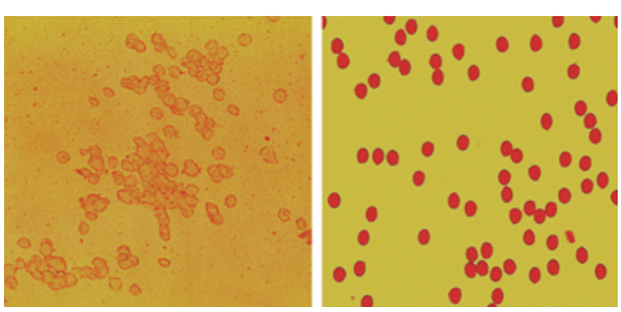
whereas sterile pollens remained almost colourless. Plants that were classified as male fertile and sterile, respectively, showed ≥80 % and ≤10 % stained pollen grains.

CMS diversification and inter-specific hybridization

Three new A lines *viz*., Pusa 992 A, ICPL 88039 A and DPP 3-2 A were developed through cytoplasmic substitutions to diversify CMS lines. Pusa 992 A carried the A_4 cytoplasm, whereas two CMS lines ICPL 88039 A and DPP 3-2 A harbored A_2 cytoplasm. Successful placement of A_4 cytoplasm in Pusa 992 background was evident from A_4-CMS specific marker that amplified 150 bp fragment in CMS lines carrying A_4 cytoplasm. This marker 'nad 7a_del' is specific to nad7 gene of the ETC chain of mitochondria. Several inter-specific crosses were attempted using wild relatives known to carry resistance against these diseases. However, seeds could be obtained from only three crosses *viz*., ICP 15847 (*C. scarabaeoides*) × ICPL 11255, ICP 15642 (*C. lineatus*) × ICPL 20340, and PAU 881 × ICP 15727 (*C. scarabaeoides*). Additional ten lines AL 15, ICP 7148, AL 201, Pusa 2002-2, MN 5, ICP 88034, ICP 20338, ICP 11255, ICP 20340 and PAU 881 were targeted for CMS diversification.

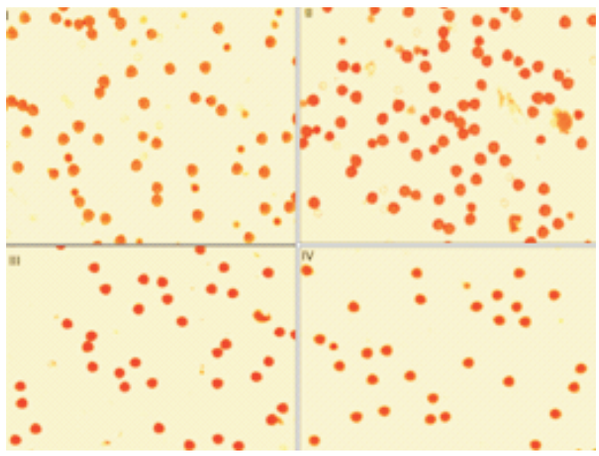


Mitochondrial marker assay on CMS (A)- and fertile maintainer (B)-lines: Differences between A- and B-lines carrying A_4 cytoplasm



Sterile and fertile pollen grains as stained in 1% aceto-carmine solution

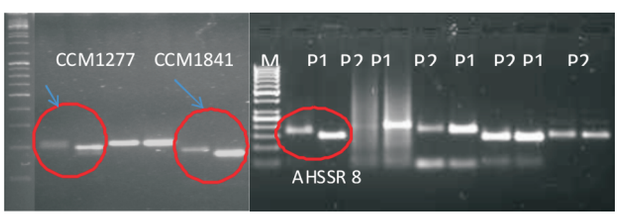
Concerning deployment of these newly developed CMS lines in hybrid breeding, these lines were crossed with twenty potential R-lines of which restorers AK 261322 R, AK 250173R, AK 250189 and AK 250204R showed more than 90% fertility restoration with ICPL 88039 A, while AK 250157R, Co-1R registered 100% restoration with Pusa 992 A. A near complete restoration of fertility in F_1 suggests a sporophytic mode of restoration in both A_2 and A_4 CMSs.



Acetocarmine stains illustrating restoration in F_1s derived from four promising 'A × R' combinations (i) ICPL 88039 A×AK 261322R (ii) ICPL 88039 A×AK 250189 R (iii) Pusa 992 A×AK 250157 R (iv) Pusa 992 A×Co 1R

Towards molecular mapping of nucleus-encoded *Rf* genes

Two genetic populations *i.e*., F_2 (ICP 88039 A×AK 261322 R) and BC_1F_1 [ICPL 88039 A×(ICPL 88039×AK 261322 R)] were used to study the inheritance of fertility restoration in A_2-CMS. Subjecting segregation data to goodness-of-fit test revealed $\chi 2$ values of 0.08 and 2.54 for F_2 and BC_1F_1, respectively. Based on the $\chi 2$ values, a monogenic dominant model could be proposed for fertility restoration in A_2-CMS. Total 164 markers (113 AHSSR, 44 CcM and 7 CCB markers) were screened between ICP 88039 A and AK 261322 R. Consequently, 25 markers showed polymorphism. In addition to this, a set of 317 hyper-variable SSR markers *i.e*., CcGM series were also synthesized.



DNA marker assay between ICP 88039 A and AK 261322 R

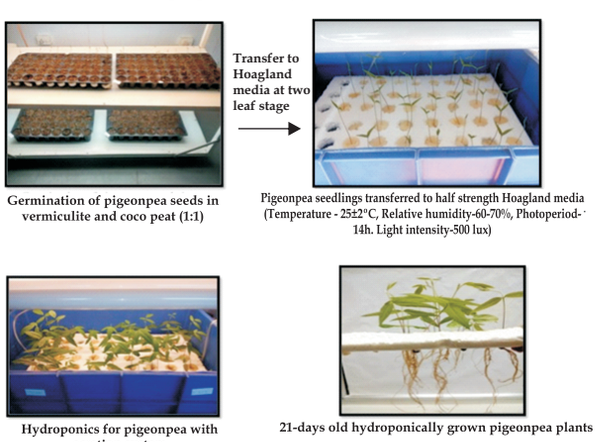
Network Project on Agricultural Bioinformatics and Computational Biology

Finding molecular markers related to male fertility/sterility for development of hybrid pigeonpea

One F_2 mapping population (PA 163 A×AK 261322 R) comprising of 200 individuals was developed. Thirty out of 250 SSR markers were found polymorphic on mapping parents. These polymorphic markers are being genotyped in F_2 mapping population, which is phenotyped precisely for fertility using pollen-staining techniques, *etc.*

Towards discovering function markers associated with *Fusarium* wilt in pigeonpea and thermo-tolerance in chickpea

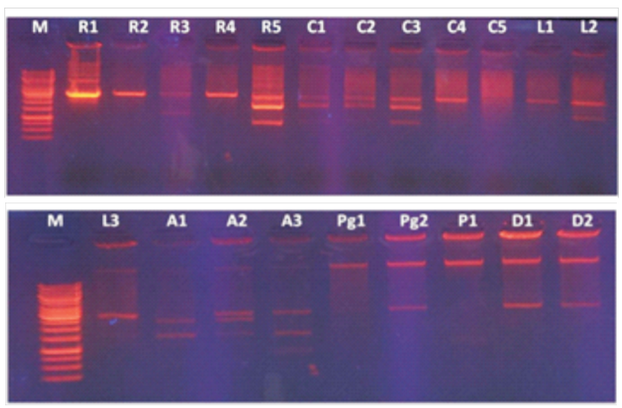
IPA 203, KPL 43 and KPL 44 (resistant) and Bahar (susceptible) pigeonpea genotypes were screened using four different *Fusarium udum* strains. A hydroponic technique was optimized (Temperature : 25 ± 2°C, relative humidity: 60-70%, photoperiod : 14h, light intensity : 500 lux) using half strength Hoagland media to enable screening under controlled conditions. Of these four strains, *Fu* 12 (variant 2) was found most virulent and these were further used to infect two differentially responsive genotypes *i.e.*, KPL 44 and Bahar. A simple microscopy analysis revealed the hyphae growth inside plant roots within 76 and 96 hrs. Root samples from the responsive genotypes along with control were selected for transcriptome sequencing. With regard to heat stress in chickpea two genotypes BG 256 and JG 16 were selected for transcript data generation. The experiments were conducted in growth chamber with temperature rising beyond 35^{0}C. Reproductive phase was targeted and RNAs from flowers extracted at three different stages were used for transcript profiling.



Standardization of the hydroponics technique in pigeonpea

Virus specific signature regions of nucleic acid for early detection of pulse viruses

Sequence data was generated for SoNPV that could act as a promising biocontrol agent (BCA) against a serious polyphagous insect *Spilosoma oblique*. This sequence data was assembled and annotation was performed. Further, NGS data was generated for different geminiviruses infecting different pulse crops viz., rajmash, chickpea, dolichos, pigeonpea and pea. Transcripome data is also being generated for the urdbean samples infected severely with urdbean crinkle virus, to enable the characterization of the previously unknown causal agent that underlies crinkle diseases,.



Plants showing viral etiology and suspected to be infected with geminivirus were collected, DNA was extracted and subjected for rolling circle amplification. The RCA products were confirmed for the presence of virus (~2.5-3.0kb DNA fragments in gel) by restriction digestion. Rajmash-Five samples (R1-R5), Chickpea-Five samples (C1-C5), Lentil-Three samples (L1-L3), Pigeonpea-Two samples (Pg1-Pg2), Dolichos-Two samples (D1-D2), Pea- one sample (P1), Ageratum-Three samples (A1-A3)

Development of Thermo-insensitive and High Yielding Cultivars in Greengram through AB-QTL Approach

Hybrid status of true F_1s was confirmed using polymorphic SSR markers. In different crosses 52 F_1 plants were found true out of 95 (Table 1). True F_1s were subjected to backcrossing with recurrent parents to generate BC_1F_1 seeds and in successful combinations (IPM 2-14 x VBG 04-008 and IPM 2-14 x *V. umbellata*), the BC_1F_1 seeds were harvested. Simultaneously, hybridization was also attempted between the donors (*V. umbellata*, VBG 04-008) and recipient genotypes (IPM 2-3, IPM 2-14 and PDM 139) to generate a backup set of F_1s. Total 55-86 out of 190 SSR markers from *V. unguiculata, Phaseolus* spp., *V. radiata* and *V. angularis* background were found polymorphic for different cross combinations.

Table 1: Status of true F_1 hybrids in distant crosses in *Vigna*

Name of cross	Total no. of F_1 Plants	True Hybrids
IPM 2-14 x VBG-04-008	7	4
IPM 2-14 x VBG-04-003	10	4
IPM 2-03 x VBG-04-008	23	9
IPM 2-03 x VBG-04-003	19	16
PDM 139 x VBG-04-003	5	2
PDM 139 x VBG-04-008	26	12
TCR 90 x IPM 2-14	4	4
IPM 2-14 x TCR 90	1	1
Total	**95**	**52**

National Innovations in Climate Resilient Agriculture

Eighteen mungbean genotypes were identified as heat tolerant based on field and controlled studies in polyhouse. Top 10 genotypes included IPM 02-1, IPM 02-16, IPM 2-14, PDM 139, IPM 9-43-K, PDM 288, IPM 5-3-22, IPM 9901-10, IPM 409-4 and IPM 02-3. From another set of 100 genotypes, 30 were identified as heat tolerant. These include PM 5, MH 98-1, Ganga 8, IC 296672, EC 520011, ML 682, HUM 12, EC 520016, MH 521, ML 515, TMB 96-2, EC 426841, China Mung 1, LM 258, AKM 96-1, EC 398889, EC 398891, BDYR 2, PS 16, Kopergaon, Pusa 9531, Saptari Local, EC 520026, NSB 007, UPM 98-1, BM 63, LGG 460, and EC 398886.

For molecular studies, eight genotypes *viz*., HUM 12, Ganga 8, EC 398889 (Heat tolerant), IPM 02-3, IPM 2-14 (Moderately tolerant), LGG 460, Kopergaon and NSB 007 (Heat sensitive) were selected. Sixteen primers were selected for polymorphism studies and from these, 3 primers CEDG 147, CEDG 044, CEDG 247 were found polymorphic and distinguished between all three categories of genotypes.

Thirty genotypes of urdbean were evaluated for heat and drought tolerance. Genotypes UG 14-14, PLU 96-6, NPU 240 and PDU 1 were found tolerant for heat and drought stress on the basis of total plot yield and related morphological traits.

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

Extensive hybridization was undertaken in different cross combinations (JG 16 x WR 315, JG 16 x Vijay and JG 16 x ICC 4958) to generate sufficient quantity of F_1 seeds for their subsequent backcrossing with the recurrent parent for marker assisted breeding programme. Total genomic DNA was extracted from all parental genotypes and SSR marker polymorphism survey was completed for identification of foreground markers for *Fusarium* wilt resistance and drought tolerance genes. Linked polymorphic markers for different cross combinations were identified and parental polymorphism studies were done.

Generation Advancement and Development of New Genotypes through Pre-breeding in Lentil

Maintenance of wild species and land races

Total 339 accessions of six wild species (*Lens orientalis, L. odemensis, L. nigricans, L. erevoides, L. tomentosus* and *L. lamottei*) and 90 accessions of Mediterranean land races were maintained.

Generation advancement

One fresh cross was made between IPL 316 x ILWL 63 for 5-6 pods/peduncle.



ILWL 63
F_1, BC_1F_1, and F_2

F_1, BC_1F_1 and F_2

Total 102 F_1 and BC_1F_1 plants were raised from 10 crosses [ILWL 97 x IPL 321, IPL 220 x ILWL 118, DPL 58 x ILWL 248, (IPL 406 × ILWL118) × IPL 406, (IPL 406 × ILWL248) × IPL 406, (IPL 406 × ILWL93) × IPL 406, (IPL 406 × ILWL350) × IPL 406, (IPL 220 × ILWL118) × IPL 220, (DPL 58 × ILWL248) × DPL 58, (IPL 220 × ILWL97) × IPL 220)] to obtain F_2 and BC_1F_2 seeds. F_2 populations were grown from 15 crosses involving *Lens orientalis* as wild species [IPL 220 × ILWL 145-*L. orientalis*, IPL 406 × ILWL 248 -*L. orientalis*, IPL 406 × IG136667-*L. orientalis*, IPL 220 × ILWL 11- *L. orientalis*].

F_3 and F_4

An F_3 population from a cross (DPL 58×IG 69517) was grown to advance F_4 generation and no selection was made from this cross. Total 646 single plant progenies from 5 F_3 crosses (DPL 58×LWL 7, ILWL 425×DPL 62, ILWL 366×DPL 58, DPL 58×ILWL 48, DPL 62×ILWL 189) were raised for selection of plants having agronomically important traits. Total 500 plants were selected from these crosses.

F_5

Total 80 F_4 single plant progenies were advanced to F_5 from a cross made between cultivated (DPL 58) and *Lens orientalis* (ILWL 118) species to study the range of variability.

Association mapping for early flowering in lentil

A diverse panel of lentil germplasm comprising of 57 accessions was taken to analyze genetic diversity using molecular markers and to identify molecular markers association with flowering time through association mapping. The results showed significant differences in flowering time over years and locations among genotypes due to differences in temperature and photoperiod. Genotype x Environment interaction was also observed highly significant. Flowering time showed high broad sense heritability estimate (h^2=0.99). Molecular diversity analysis with 61 polymorphic SSR markers resulted in amplification of 112 loci that generated 545 alleles ranging 2-26 loci per marker. The association mapping analysis showed significant association ($p < 0.05$) of 9 SSR markers (PBALC 0201, PBA LC 0205, PBA LC 0207, PBA LC 0250, PBA LC 0256, PBA LC 0260, PBA LC 0268, SSR 215 and ALD 70) with flowering time following GLM. These markers explained 0.29-0.53% of phenotypic variation. Among these linked markers, three SSR markers derived ESTs showed similarity with the genes sequences encoding proteins which regulate the flowering time in other plant species and hence might be potential candidate for flowering time in lentil.

Estimation of protein content

Total 71 genotypes including 31 varieties/breeding lines, 16 land races of Mediterranean regions and 24 accessions of wild species were analyzed for protein content in lentil. It ranged between 12. 5% (IPLS 9-7) to 23.7% (PL 5) in varieties/breeding lines, 10.5 % (EC 208355) to 27.1% (IG 5187) in land races and 18.07% (ILWL 337) to 32.7% (IG 72569) in accessions of wild species.

Development of Lentil Cultivars with High Concentration of Iron and Zinc

Significant genetic variability for Fe and Zn concentration was observed in 96 accessions of lentil grown over two years. It ranged between 71.3-124.3 mg/kg for Fe and 40.1-63.6 mg for Zn. A large proportion of total phenotypic variation was explained by environmental conditions as years and genotype × year interaction effects were found significantly high for both Fe and Zn. Thirty released Indian varieties were analyzed for Fe and Zn concentration in their seeds and Fe ranged from 17 to 128 ppm, while Zn ranged between 12- 63 ppm.

Breeding line IPL 220 identified as donor for Fe and Zn was used in crossing programme with cultivated genotypes as well as accessions of wild species (IPL 316 x IPL 220, IPL 220 x IPL 10829, ILWL 97 x IPL 220, IPL 321 x IPL 220**).** F_2 generations were grown for generation advancement. F_3 population of 5 crosses (IPL 316 x IPL 220, IPL 220 x IPL 328, IPL 534 x IPL 220, IPL 534 x IPL 321 and IPL 328 x IPL 534) was grown and single plants were selected.

An experiment was conducted with 10 genotypes having variable amount of Fe and Zn content in their seeds. For this, these genotypes were grown as mono crop, intercrop with linseed and mix crop with linseed. The analysis of seeds of these genotypes showed no signification effect of any cropping system on Fe and Zn concentration in the seeds.

Evaluation of Lentil Germplasm for Heat and Herbicide Tolerance

Evaluation of lentil germplasm for heat tolerance

Eighteen genotypes including 10 tolerant (DPL 15, IG 2507, IG 4258, FLIP 2009-55L, IG 3327, IG 3330, IG 3546, IG 3745, IG 5146, IG 3517) and 8 sensitive (IG 3973, IG 3364, IG 3575, IG 3568, IG 3558, IPL 81, Sehore 74-3, IG 4001) were evaluated under normal sown and late sown conditions for validation of results through physiological analysis.

Physiological chacterization of genotypes for heat tolerance

Eleven genotypes including 7 tolerant and 4 sensititive were evaluated for heat tolerance under late sown condition when the crop was subjected to experience high temperature (beyond 35°C) during reproductive stage under field condition. Flowers picked up directly from field follwed by pollen staining with 1% TTC or acetocarmine test revealed very large pollen sterility in almost all test lines. However, sensitivity to heat differed among the genotypes. *In-situ* pollen germination test was conducted by exposing excised flowers under controlled temperature at 43°C for 2 hours, followed by Alexander stain to view the pollen loading on stigma. Most of the genotypes did not show any pollen - germinated or non-germinated over stigmal tips, except few such as IG 3330, IG 3973 and IG 4258 which had *in situ* pollen germination over stigma. Maximum number of pollen viability with occassional germinating pollen tubes were detected in IG 4258, while a large proportion of sterile non-nucleated (unstained) pollens was observed in IG 3327. Even flowers exposed to day time maximums of > 35°C failed to show viable pollens under field conditions, however densely stained ovules were detected in all the test lines indicating that pollens are more susceptible to high temperature than ovules.

Physiological functionility was assessed using relative performance of photosynthetic electron transport rates (ETR) of the leaves treated at 43ºC heat shock for 1 hour. Quantum yield (Fv/Fm) images were apparent in light adapted leaves in IG 3973 and very faint in IG 3330, 3327, DPL 15 and IG 3575. Only distinct images of Fv/Fm explained the superior photosynthetic performance under high temperature (Fig. 5) which was further evident by light response of (ETR) (Fig. 6). Maximum membrane stability was observed in FLIP 2009-55L and IG 3568, while remaining were within the range of 15-25% (Fig. 7). However higher membrane stability did not reflect superior physiological functionility as described above probably more flexiblity in membrane could be useful for improved heat tolerance.

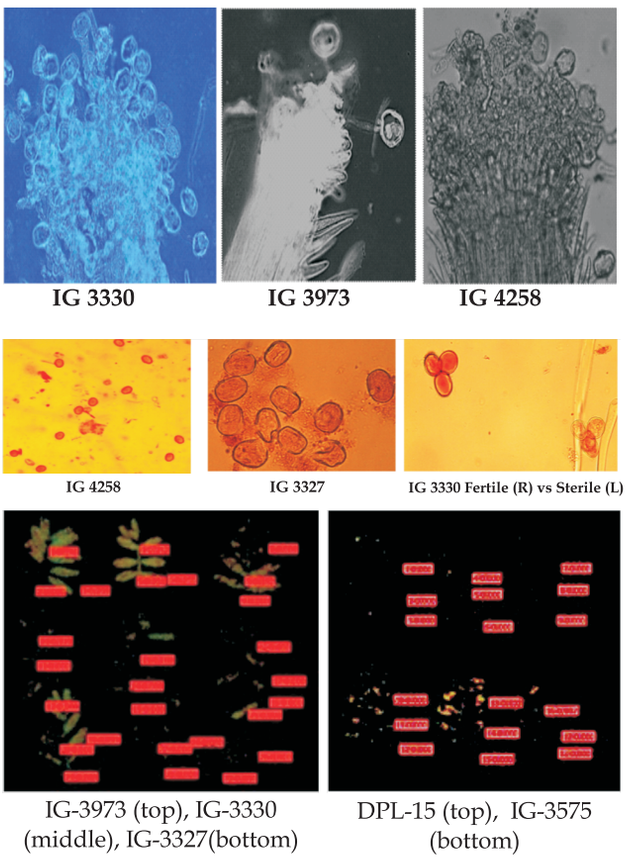


Fig. 5 : Quantum yield (Fv/Fm) images of light adapted leaves subjected to heat treatment at 43^{0}C

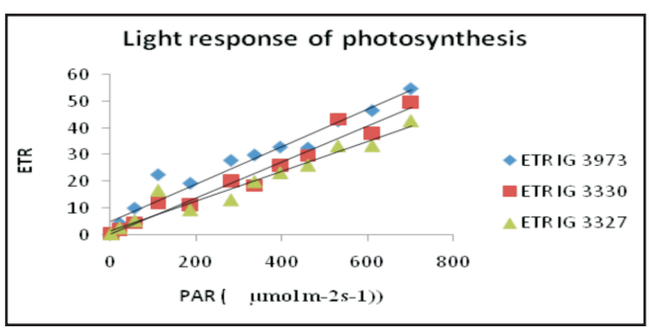


Fig. 6: Light response of photosynthetic electron transport rate (ETR) in heat shocked leaves

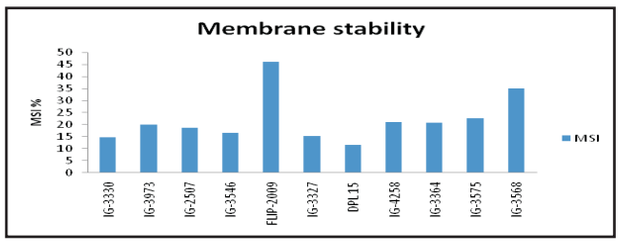


Fig. 7: Membrane stability index of lentil accessions

Evaluation of lentil germplasm for post-emergence herbicide

Total 130 genotypes showing tolerance to Imazethapyr (200g/ha) and seven genotypes including EC 78503, EC 225503, ILL 1915,VKS 13/15, ILL 916, ILL 4551, ILL5902 showed tolerance to Metribuzin in previous year, were again validated with same concentration of herbicides. These genotypes were characterized into 1 (resistant) and 5 (sensitive) scale. None of genotypes showed resistance to these herbicides. However, 14 genotypes *viz*., EC 208330, EC208355, T-36, IPL 222, IC211675, FLIP 98-3L-A, EC78525, ILL 1915, VKS-13/15, EC 78459, ILL 4770, IPL 2K-4, ILL 755 and ILL 364 showed tolerance to Imazethapyr (200g/ha). Based on restricted growth, among these 14 genotypes, 7 genotypes (IPL 222, IC211675, FLIP 98-3L-A, EC78525, VKS-13/15, ILL 4770, IPL 2K-4) were identified highly tolerant (score 2), while remaining were tolerant (scale 3) to Imazethapyr. On other hand, none of the lines was found tolerant to post-emergence herbicide Metribuzin (500g/ha).

Harnessing Favourable QTL for Yield Contributing Traits from Wild and Exotic Germplasm of Lentil Using AB-QTL Analysis

To generate advanced backcross populations, cross of the improved lentil variety (IPL 220) and breeding line (DPL 58) was attempted with wild species accession (ILWL 118) for yield traits and exotic germplasm line (ILL6002) for early growth vigour in off-season at IIPR Regional Centre, Dharwad. Total 24 F_1 plants were raised from cross IPL 220 x ILWL 118 for yield contributing traits, while 15 and 34 F_1 plants were raised from cross IPL 220 x ILL 6002 and DPL 58 x ILL6002, respectively, for early seedling vigour. After testing hybridity of F_1 plants, true F_1 plants are being backcrossed with recurrent parent IPL 220/DPL 58 to develop BC_1F_1 seeds.

Screening for polymorphic molecular markers

The parental genotypes including DPL 58, IPL 220, ILWL 118, DPL 15 and ILL 6002 were screened along with other genotypes with 126 SSR markers. Total 61 markers showed polymorphism among the parental lines.

Plant Biotechnology

Gene Discovery and Transgenic Technology for Pulses Improvement

Genetic engineering for development of pod borer resistant chickpea using multi-gene approach

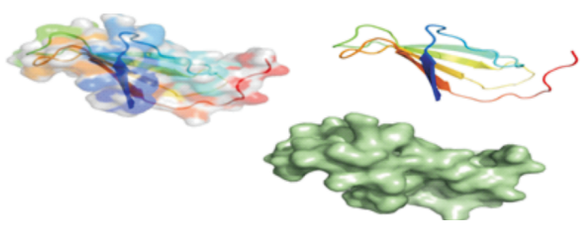
To develop multi-gene constructs bearing anti-insecticidal genes using novel approaches and genetic transformation, the genes involved in pod development and their regulatory elements were studied. Since the draft genome of chickpea is available, information for genome wide identification of MADS box transcription factors (TF) and WRKY TFs involved in flower/pod development and other physiological responses was utilized. HMM (Hidden Markov Model) profile using HMMER 3 software for MADS and WRKY TF in chickpea to derive a consensus sequence has been developed to be used as query amino acid sequence for genome wide search. Using the HMMER consensus sequence 60 MADS TF and 78 WRKY TF were identified. Genomic distribution of both the TFs was found even across the genome. Gene structure analysis revealed that majority of the genes possessed introns. Phylogenetic analysis of the above mentioned TFs was done with arabidopsis and rice to infer about evolutionary relationships. Protein motif and synteny analysis for identifying new motifs and detecting gene duplications has been performed, respectively.

Based on the transcriptome data of chickpea available in the lab in response to herbicide: Imazethapyr, differential expression analysis of WRKY TFs were analysed in leaf tissue. Chickpea WRKY4 TF was significantly upregulated in Imazethapyr treated plants, but not in control plants. Chickpea WRKY4 TF was also found to be responsive to multiple stresses, shedding light on its central or top player in the stress signalling mechanisms. Homology modeling and prediction of DNA binding sites of chickpea WRKY4 TF has been done (Fig. 8).

Promoter sequences of all protein coding genes of chickpea (chr 1-chr 8) have been retrieved by programming and a repository of chickpea promoters have been created. Gene constructs bearing anti-insecticidal genes, *cry*2Aa and *cry1*Ac genes have been procured from NRCPB. Restriction mapping was performed to verify the presence/absence of different restriction sites and cloning strategy was developed. As a part of the cloning strategy, *pBin-cry*2Aa construct was digested with KpnI-HindIII, and *cry2Aa* gene along with *ocs* terminator was released and was subcloned into pTZ19R vector. The cloning of the *cry*2Aa gene was further confirmed through PCR (Fig. 9) and restriction digestion (Fig. 10). Primers have been designed for amplification of *cry1*Ac and pod specific promoter and subsequently cloning will be carried out to generate individual gene cassettes.

Prospecting alleles for enhanced drought tolerance in chickpea and pigeonpea

Pigeonpea and chickpea genotypes were selected from pigeonpea mini-core and chickpea core set, respectively, for prospecting alleles of two drought responsive factors (DRFs) gene *viz*., CcCYP (Acc. No. GU444041.1) and CcHyPRP (Acc. No.GU444042.1) and CAP2 gene (homolog of the DREB2A gene; Acc. No. DQ321719.1). Nucleotide polymorphism of the alleles were documented and submitted to EMBL (LN 873257 to LN 873410). Overall the polymorphism was very low among the alleles.



Homology modeling and Structure prediction of *Cicer arietinum* WRKY TF4

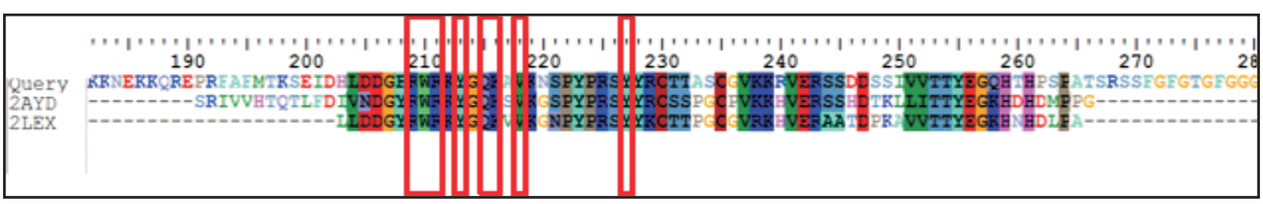
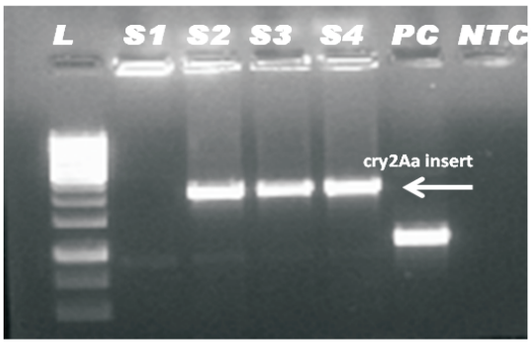
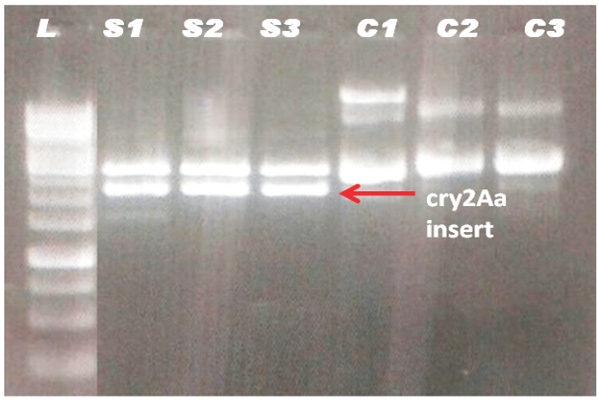


Fig. 8: Identification of DNA binding residues of *cicer arietinum* WRKY TF4



L: 1Kb Ladder
S: pTZR19-cry2AaTransformants
PC: PCR Control
NTC: Non Template Control

Fig 9 : Screening of pTZ19R-cry2Aa transformants through colony PCR using M13 primers



L: 1Kb Ladder
S: pTZR19-cry2Aa recombinants (KpnI-HindIII digested)
C: Control (Undigested plasmid)

Fig 10 : Confirmation of pTZR19-cryAa recombinants using KpnI-HindIII restriction digestion analysis

Genomic Enabled Crop Improvement for Pulses Improvement

Marker assisted gene introgression for pod borer resistance and drought tolerance in elite chickpea

An attempt was made to pyramid genes/QTLs for drought as well as pod borer resistance gene, inelite chickpea genotypes using marker assisted backcrossing breeding (MABC). Chickpea events *viz*., BS 5A, BS 6H, BS 6L, BS 5A (-Ve), BS 6H (-Ve) and Jimbore obtained from Assam Agricultural University, Jorhat were rigorously evaluated for different agronomic traits (germination %, initial plant stand, flowering time, branching pattern, podding, *etc*.). A transgenic event (BS 6L) harboring *cry*2Aa gene was taken as donor for introgression in background of JG 11 and DCP 92-3. Crosses were made in physical containment facility and seven seeds in background of JG 11 and five in background of DCP 92-3 were obtained, respectively. The seeds were sown under greenhouse condition and presence of gene was confirmed by targeted PCR amplification of gene *cry*2Aa from leaf tissue DNA. The level of gene expression (*cry*2Aa) was also assessed through qualitative ELISA and found positive in one out of five plants from DCP 92-3 x BS 6L and two out of seven from JG 11x BS 6L cross. Same lines were put for detached leaf insect bioassay with 1st instar neonents of *H. armigera* to test the level of toxicity and few events were found showing 60% of insect mortality.

Molecular dissection of response to terminal heat in chickpea

To dissect the response to heat stress in chickpea, 22 heat stress responsive genotypes were tested in late sown condition (DOS: 8-1-2016) to evaluate their performance under high temperature regime. Genotypes *viz*., ICC 4567, ICC 1356 and BG 256 had no seed/pod set and were highly sensitive to heat stress, while JG 14, ICC 12155 and ICC 15614 had high seed setting. ICCV 2 is heat escape genotype by flowering early *i.e*., 39-40 days after sowing in late and normal sown conditions. Chickpea grown under late sown condition had 5-70% increase in flowering time as compared to a normal sown. Especially susceptible genotypes like ICC 10685 and ICC 5912 had over 65 and 70% increase for days to flowering, respectively, and tolerant genotype JG 14 had 40% increase for days to flowering. Tolerant genotypes like, Annegiri, ICC 1356, ICC 6874, ICC 8950, ICCV 7110 and susceptible genotype ICC 16374 were early flowering in late sown condition as compared to normal sown crop (Fig. 11). All genotypes had reduced plant height in late sown condition and height reduction varied from 19-54% (Fig. 12).

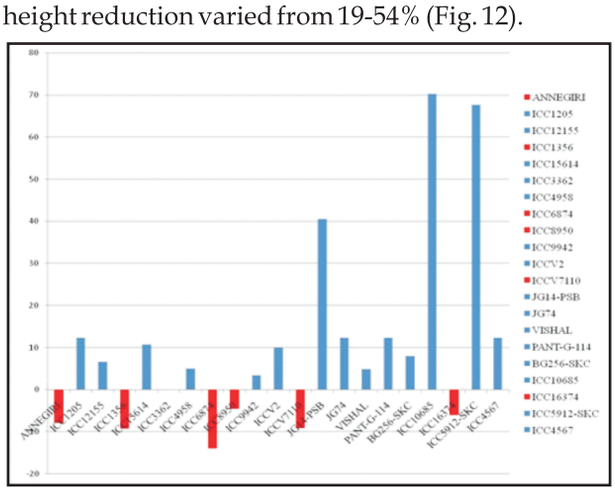


Fig. 11: Percent increase or decrease in flowering time in response to heat stress

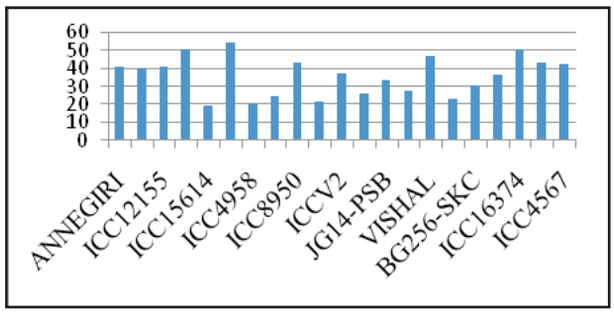


Fig. 12: Percent decrease in plant height in response to heat stress

For development of mapping population F_1s were generated by crossing between sensitive x tolerant, tolerant x tolerant, sensitive x sensitive genotypes and obtained sufficient number of F_1s except in the cross between sensitive x sensitive (Table 2).

Table 2 : Development of mapping population in chickpea to map QTLs for heat toleranc

Cross	Type	No. of F_1s
BG256 x JG14	S x T	19
BG256 x ICC12155	S x T	13
BG256 x EC556270	S x T	30
Pant G-114 x ICC15614	S x T	14
ICC12155 x ICC15614	T x T	15

Molecular insight into *Fusarium*-chickpea interaction

A differential set containing 10 genotypes was grown in growth chamber and also in sick plot and sick tank conditions. A set of these genotypes were challenged with *Fusarium oxysporum pv ciceri* by sick pot method and hydroponic inoculation method. Pathogenecity was observed in pot inoculation and sick tanks. The technique of microtome was standardized using TBA based protocol to study the anatomical features occurring during pathogenesis. A genome wide search for NBS-LRR containing genes was done. Genic SSRs were mined within these genes using MISA software. Primers have been synthesized and 30 genotypes are being screened for polymorphism among these genotypes. The QTL identified for wilt resistance lies between the two markers TA27 and TA110 on the linkage group 2 of chickpea draft genome. The sequence between these two primers has been retrieved and annotated for presence of genes using FGENESH software. The predicted genes are then subjected to BLAST analysis for gene functional annotation. An F-box LRR gene is found to be located within the QTL region and its alleles have been amplified from 25 genotypes for sequencing.

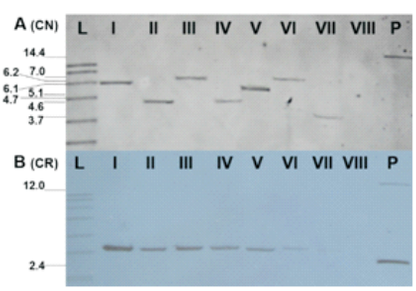
EXTERNALLY FUNDED PROJECTS

Development of Pod Borer Resistant Transgenic Pigeonpea and Chickpea

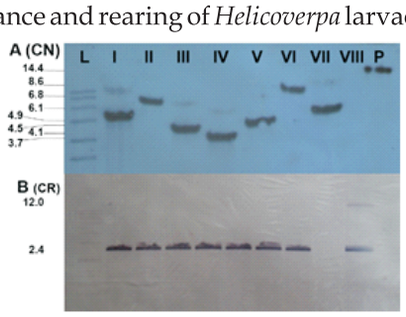
For development of transgenic pigeonpea and chickpea for gram pod borer resistance, utilizing efficacy proven *Bt* gene (*cry1*Ac), total 53,608 explants of chickpea and 43,827 explants of pigeonpea were co-cultivated and 20 and 14 kanamycin resistant shoots were established at transgenic containment facility, respectively.

In pigeonpea, 1924 T_4 progenies (2 T_0), 1834 T_3 (2 T_0), 621 T_2 (4 T_0) and 311 T_1 (6 T_0) were screened through qualitative ELISA, from which 11 T_4 progenies (2 T_0), 8 T_3 progenies (2 T_0), 5 T_2 (2 T_0) and 8 T_1 (5 T_0) were found positive. RT-PCR indicated expression of the gene in progenies of identified lines. Whole plant insect bioassay of the two lines (T_3) indicated larval mortality ranging from 70-80%. In chickpea, 2269 T_4 seeds (16 T_0), 1640 T_3 seeds (16 T_0), 182 T_2 (7 T_0) and 714 T_1 (77 T_0) were sown at transgenic containment facility for generation advancement and screening of positive lines. Southern blot hybridization of 7 events (5 T_1 and 2 T_2) indicated presence and integration of gene. LAMP PCR protocol was standardized for detection of transgene in the transgenic lines (Fig. 13).

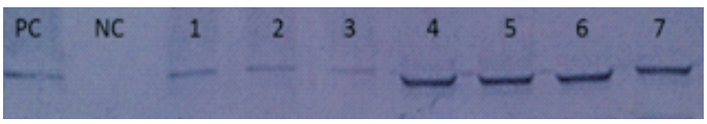
Attempts were made to rear *Helicoverpa armigera* larvae in pigeonpea based artificial diet (pigeonpea seed diet (100 %), pigeonpea flour + chickpea diet (80:20) and pigeonpea flower + chickpea diet (80:20) and chickpea diet (100 %), as an alternative to chickpea based diet, which was better for maintenance and rearing of *Helicoverpa* larvae.



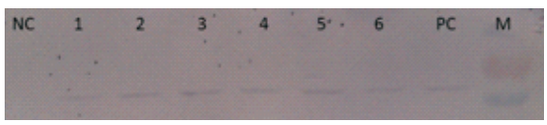
Southern hybridization in T_1 and T_2 pigeonpea progenies [A.CN: Copy Number, B.CR: Cassette Release]



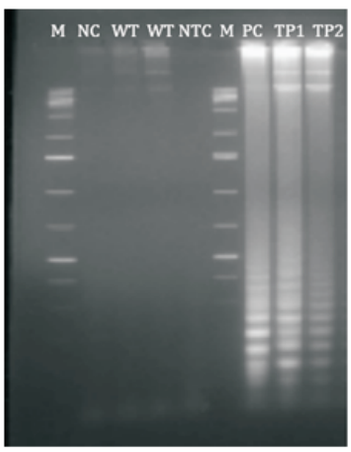
Southern hybridization in two T_3 pigeonpea progenies (Lane I and II) [A.CN: Copy Number, B.CR: Cassette Release]



Western blot hybridization of 7 transgenic chickpea lines (T_1)



Western blot hybridization using TSP from different tissues (leaf, pod wall and immature seeds)



[M: 1Kb plus ladder; NC: Negative Control; WT: Wild Type;NTC: No Template Control; PC: Positive Control; TP 1 & TP 2: T_3Transgenic pigeonpea lines]

Fig. 13: Standardization of LAMP assay in transgenic pigeonpea lines

Transgenic Development in Chickpea and Pigeonpea

To develop transgenic chickpea and pigeonpea for gram pod borer resistance, utilizing the domain modified *Bt* gene (*cry1*Aabc), total 45,857 explants of chickpea and 3090 explants of pigeonpea were co-cultivated, and 46 and 3 kanamycin resistant shoots were established at transgenic containment facility, respectively.

In pigeonpea, 2295 T_6 progenies (2 T_0), 303 T_5 progenies (1 T_0), 344 T_4 progenies (1 T_0), 482 T_1 progenies (7 T_0) were screened through qualitative ELISA, from which 15 T_6 progenies (2 T_0), 3 T_1 progenies (2 T_0), 14 T_5 progenies (1 T_0) were found positive. PCR analysis of 2297 T_6 progenies from 2 T_0 indicated 17 T_6 progenies from 2 T_0 were found positive using gene specific primers. Southern blot hybridization of 2 events (advanced till T_6 stage) indicated presence and integration of gene. Insect bioassay (detached leaf) of the identified lines indicated larval mortality ranging from 95-100%. LAMP (Loop mediated Isothermal Amplification) assay was standardized to identify positive progenies based on isothermal amplification using *Bst* polymerase.

In chickpea, 4396 T_5 progenies (3 T_0), 39 T_2 (2 T_0), 297 T_1 (38 T_0) were sown at transgenic containment facility for generation advancement and screening of positive lines. Qualitative ELISA in 900 T_5 chickpea progenies (1 T_0) were analyzed, of which 8 progenies from 1 T_0 were found positive. Two events one each of chickpea (IPCa2) and pigeonpea (IPCc2) were selected for event selection trial.

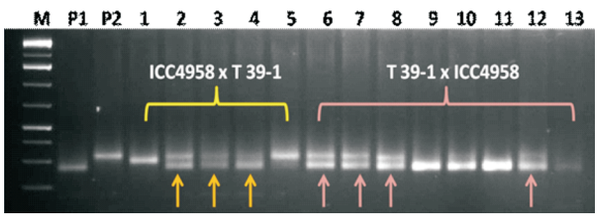
Utilizing Chickpea Genome Sequence for Crop Improvement

The phenotypic observation were recorded for germination, early wilt infestation, initial flowering, days to 50% flowering, flower colour, growth habit, plant height, yield/plot, primary branch, secondary branch, tertiary branch, yield/plant *etc*., in a global composite set of 3000 chickpea accessions. Wide range of phenotypic variartion was observed in the germplasm lines in terms of maturity, branching, plant height, flower colour, *etc*. The basic purpose of generating large data on phenotype and genotype is to establish marker trait association for marker assisted breeding programme.

The phenotypic evaluation for important agronomic traits *viz*., initial germination, initial flowering, days to 50% flowering, flower colour, growth habit, 100 seed weight, plot yield, *etc*., was carried out in 100 advance breeding (including 7 checks) lines developed by IIPR, Kanpur, ICRISAT, Patancheru, Hyderabad, ICARDA, New Delhi, RAK College, Shehore, JAU, Junagardh and RARI, Durgapura for selecting superior line performing good over the years and over the locations.

The F_1 crossed seeds developed for nested association mapping (NAM) population of ICC 4958 x T 39-1 and T 39-1 x ICC 4958 were tested for true hybridity using SSR markers as shown in (Fig. 14). Out of five F_1 (ICC 4958 x T 39-1) three plants were positive and four out of eight in T 39-1 x ICC 4958 crosses were positive. Fresh crosses were made between ICC 4958 x T 39-1 and ICC 4958 x KWR 108, and 93 and 39 F_1 crossed seeds, respectively were harvested. The recombinant inbred lines (RILs) of WR 315 x JG 62, K 850 x IPC 04-52 and DCP 92-3 x ICC 4958 were used to tag early/late resistance

responsive genes for *Fusarium* wilt and QTL governing seed size, respectively. The phenotyping of mapping population (DCP 92-3 x ICC 4958) for seed size has been carried out.



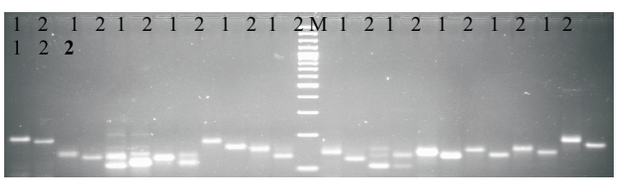
P1- T39-1; P2- ICC4958; M- 1 Kb plus

Fig. 14: True hybridity test for F_1 plants of NAM population

Transcriptomic profiling in contrasting genotypes of chickpea for seed protein and herbicide response was conducted to decipher basic molecular mechanism for traits. The trancriptome studies on two extreme chickpea genotypes ICC 1205 (herbicide tolerant) and ICC 5434 (susceptible) for imidazolin were done and reported 4979 DEGs, 973 miRNAs, 692 transcription factor associated with 235DEG, 38 Hub proteins, 3540 SSR-FDM, 13778 genic SNP and 1174 Indels.

Incentivizing Research in Agriculture

To map genes/QTLs underlying resistance to salt stress in chickpea, parental polymorphic survey was done in mapping parent DCP 92-3 and ICCV 10 (Fig. 15) using 500 SSR markers, in which 63 SSR markers were found polymorphic. Preliminary phenotypic evaluation of F_5 population under field condition was evaluated for seed germination, root length, shoot length, proline content at pH 9.0 and ECiw 6.0 and same lines were advanced for F_6 generation (Fig. 16).



M: 1 Kb plus DNA ladder. 1: DCP 92-3; 2: ICCV10

Fig. 15: Parental polymorphic survey in mapping parent DCP 92-3 and ICCV 10 using SSR markers

Screening of chickpea germplasm under salinity stress

A panel comprising of 120 chickpea germplasm lines along with local checks *viz*., KWR 108, HC 5, DCP 92-3 and CSG 8962 was screened for tolerance to salinity-sodicity under field conditions. The trial was

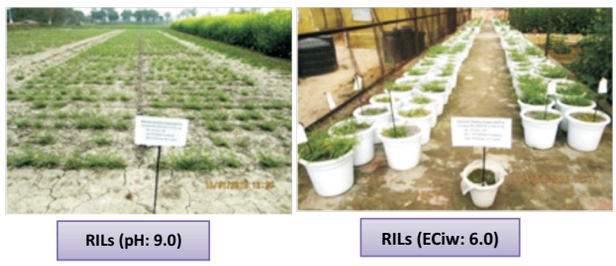


Fig. 16: A panel of 233 (DCP 92-3 x ICCV 10) F_5 population was phenotyped under the field as well as pot condition at CSSRI, Karnal under ECiw 6 dS/m and pH 9.0

laid in a saline-sodic patch of mean pH 8.5 and EC equivalent to 6 dS/cm. Six potential lines having tolerance to salinity already reported by Vadez *et al*. (2014) were taken as reference panel for expression of salinity tolerance.

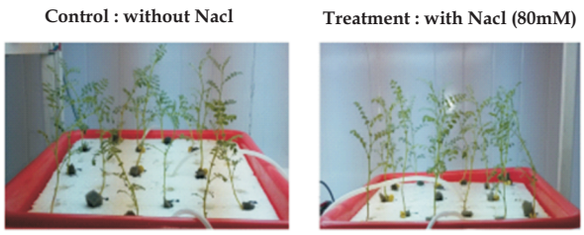
Among local checks, KWR 108 and CSG 8962 showed tolerance response against DCP 92-3 and HC 5, which did not germinate at all. However, same seed lot of the four replicated controls had good germination and plant population under normal field condition. Four lines *viz*., ICCV 6, ICC 4593, ICC 5003 and ICC 9942 out of the reference panel (Vadez *et al*. 2014) of tolerance expression for salinity thrived with modest plot yield and good population stand. Two lines, ICC 6306 and ICC 15610 in spite of good population stand were unable to set seed under stress condition.

Six lines from the trial, namely ICC 5445, ICC 12362, ICC 12354, ICC 6490, ICC 11505 and ICC 15040 were observed with good population stand and high plot yield. Crosses were attempted utilizing the potent lines as donor in genetic background of KWR 108.

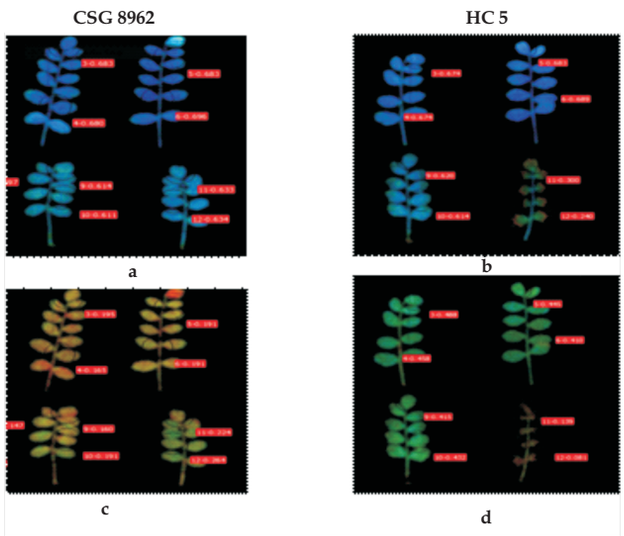
Salt induced physiological response in chickpea

To determine physiological mechanism of salt tolerance, 4 genotypes *viz*., CSG 8962 and K 850 (salt tolerant), and HC 5 and Pusa 256 (salt sensitive) were grown in sand under controlled condition and 8 days seedling were transferred into hydroponics solution. Modified concentration of Hoagland solution is being used as a source for growing plants. Salinity was imposed (80mM NaCl) at 5 days after transferring of plants and physiological parameters were observed *viz*., length of shoot and root, dry matter of shoot and root, chlorophyll content, carotenoids, osmotic potential and chlorophyll fluorescence. No significant change occurred in osmotic potential in control condition. In contrast,

CSG 8962 showed higher osmotic potential as compared to HC 5 in NaCl treated conditions.



Comparative growth in chickpea genotypes under control and salt stress (NaCl=80mM)



Figures a & b showing quantum yield of PS II under dark adapted leaves and c & d showing quantum yield of PS II from light adapted leaves Upper two leaves & lower two leaves detached from non saline & saline conditions

Chickpea Genomics

Mapping population consisting of 250 individuals derived from JG 62 X WR 315 crosses was advanced to F_7 generation. Same population was screened against *foc* race-2 in sick plot. DNA isolation of the population is completed and polymorphic markers are being screened.

Genetic Mapping of *Fusarium* Wilt and SMD in Pigeonpea

Biparental crosses were attempted between Bahar (wilt susceptible) and KPL 43, KPL 44 (resistant donors). The putative F_1s derived from these crosses were raised in field and true hybridity was tested using SSR (Fig.17) markers. Total nine true hybrids derived from cross Bahar x KPL 43 and four true hybrids from Bahar x KLP 44 were identified using HASSR markers (Fig. 18). These true hybrids were selfed to harvest seeds for F_2 mapping population. Parental polymorphism is being studied to identify polymorphic SSR markers for mapping work. Trait mapping is being initiated to compliment mapping work using 151 pigeonpea germplasm set. These genotypes were got phenotyped for variant 2 of *Fusarium udum* in the wilt sick plot



Fig. 17: Raising and selfing of true F_1s to harvest seeds of F_2 mapping population, (a) putative F_1s of cross Bahar x KPL 43 (b) putative F_1s of Bahar x KPL 44

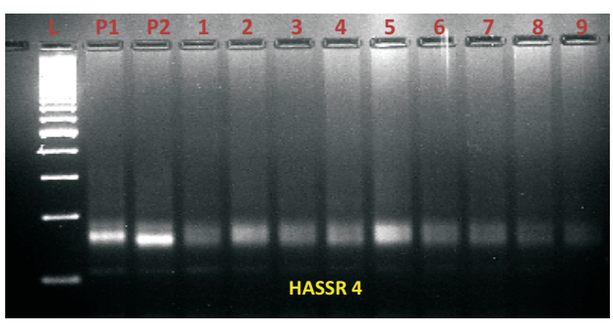


Fig. 18: True hybridity testing using SSR marker for nine putative F1s derived from Bahar x KPL 43 on 3% agarose gel. [Where,P1- Bahar; P2- KPL 43, Lanes 1-9 true F1s as confirmed from HASSR 4 marker]

Crop Production

Long-term Fertility and Cropping System Studies

Maize and *bajra* based cropping system

Four cropping sequences, based on both maize and b*ajara viz.,* Maize based : maize-wheat (MW), maize-wheat-mungbean (MWMb), maize-wheat-maize-chickpea (MW-MC) and pigeonpea-wheat (PW) and *Bajra* based: *bajra*-wheat(BW), *bajra*-wheat-mungbean (BWMb), *bajra*-wheat-*bajra*-chickpea (BW-BC) and pigeonpea-wheat (PW) were evaluated at three nutrient management practices *viz.*, control, integrated nutrient management-INM (crop residues+biofertilizers *viz.*, Rhizobium for pulses and phosphate solubilizing bacteria for cereals, +farm yard manure @ 5 t/ha +50% NPK) and inorganic fertilizers (recommended dose of NPKS Zn and B). Among different cropping systems, maize-wheat-mungbean system fetched highest pigeonpea equivalent yield (2801 kg/ha), followed by pigeonpea-wheat (1497 kg/ha), maize-wheat-maize-chickpea (1310 kg/ha) and maize-wheat (1224 kg/ha). Likewise, highest pigeonpea equivalent yield (PEY) was recorded under inorganic plot (1925 kg/ha), followed by integrated nutrient management (1871 kg/ha) and least under control plot (1328 kg/ha) in the maize based cropping system (Fig. 19).

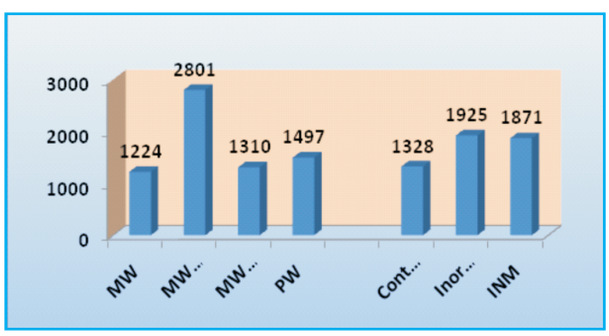


Fig. 19: Long term effect of maize based crop rotation on PEY

Highest system productivity in terms of PEY was recorded under *bajra*-wheat-mungbean (2688 kg/ha), followed by pigeonpea-wheat (1509 kg/ha), *bajra*-wheat-*bajra*-chickpea (1229 kg/ha) and *bajra*-wheat (1153 kg/ha) (Fig. 20). Among nutrient management practices, recommended fertilization through chemical fertilizers resulted in higher PEY, followed by integrated nutrient management practices under *bajra* based cropping system. Higher grain yield of pigeonpea was recorded under integrated nutrient management, followed by inorganic fertilization and least under control.

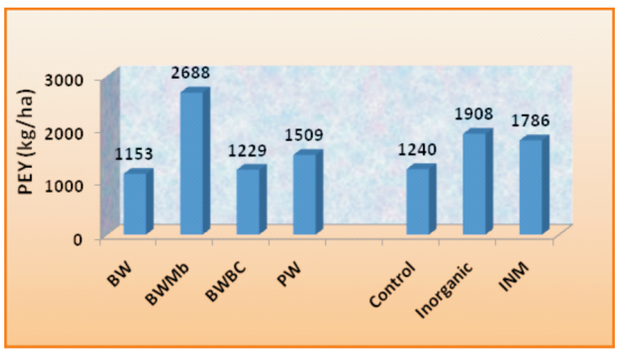


Fig. 20: Long term effect of *bajra* based crop rotation on PEY

Rice based cropping system

Four rice based cropping systems *viz.*, rice-wheat (RW), rice-chickpea (RC), rice-wheat-mungbean (RWMb) and rice-wheat-rice-chickpea (RWRC) were evaluated at three nutrient management systems *viz.*, control, integrated nutrient management (crop residues+biofertilizers *viz.*, *Rhizobium* for pulses and phosphate solubilising bacteria for cereals+farm yard manure @ 5t/ha+50% NPK) and inorganic fertilizers (recommended dose of NPKS Z and B). All component crops *viz.*, rice, wheat, chickpea and mungbean performed best under INM (Fig. 21).

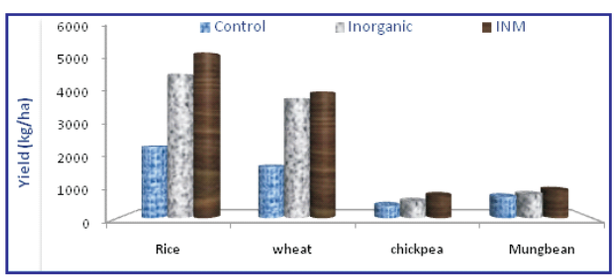


Fig. 21: Performance of different crops under different cropping systems and nutrient management

System productivity in terms of chickpea equivalent yield was highest in rice-wheat-mungbean (4479 kg/ha), followed by rice-wheat (3064 kg/ha) and least under rice-chickpea (2449 kg/ha) (Fig. 22). Highest productivity was recorded in INM (3894 kg/ha) and least under control (1862 kg/ha). Highest net return (Rs. 64259/ha) and B:C ratio (1.79) were recorded in rice-wheat-mungbean, followed by rice-wheat (Rs 42666/ha and 1.73) and least under rice-wheat-rice-chickpea (Rs. 18549/ha

and 1.35). Higher net return and B:C ratio were recorded in INM (Rs. 56379/ha and 1.84) and least under control. Among cropping systems, continuous cultivation of rice-wheat-mungbean significantly ($p \leq 0.05$) increased SOC and available NPK compared to other three cropping systems (Table 3). Similarly, significant improvement in SOC and available NPK was recorded under integrated nutrient management over control.

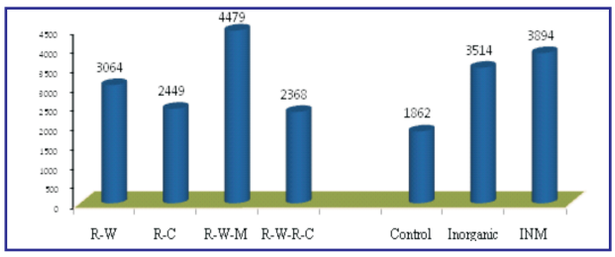


Fig. 22: System productivity in terms of chickpea equivalent yield under different treatments

Table 3: Effect of cropping systems and nutrient management on soil fertility

Treatment	Soil organic C (%)	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)
R-W	0.35c	258.9c	18.1c	222.9c
R-C	0.38b	272.5b	20.7ab	237.9b
R-W-R-C	0.37bc	266.6b	19.2b	238.0b
R-W-M	0.42a	286.3a	21.1a	262.2a
Control	0.33c	254.1c	14.6c	220.0c
INM	0.43a	289.6a	23.9a	267.1a
Inorganic	0.39b	269.5b	21.0b	239.0b

Nutrient Management

Micronutrient fortification of *kharif* pulses

To find out relative performance of ferti-fortification approaches, seed treatment (Seed coating and priming), soil and foliar applications were evaluated for enriching mungbean and urdbean grains. Spray concentration tested for foliar fertilization (Zn) was 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4% at pre-flowering stage. Foliar spray of zinc enhanced its concentration in leaves, stem and grain from 7 to 16% both in mungbean as well as urdbean. Levels of Zn applied were no Zn, 0.5, 1.0, 1.5, 2.5, 3.0, 3.5 mg Zn/kg soil. Concentration of Zn was improved from 6 to 14 % in root, shoot, leaves and grains. Seed priming fetched better germination, faster initial growth, higher chlorophyll content and leaf area index both in mungbean and urdbean over no priming. Zinc nutrient application through seed coating (control, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 g Zn/kg seed) had positive and marked effect under lower levels. Seed coating beyond 5.0 g Zn/kg seed in mungbean and 6.0 g Zn/kg seed in urdbean showed toxicity symptoms at germination stage. Likewise, effect of seed coating on per cent weight by seed basis (0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5) having two sources of zinc (Zinc sulphate and zinc oxide) in mungbean and urdbean was analysed. Findings revealed that seed coating with zinc oxide was superior over zinc sulphate and enhanced zinc concentration in different plant parts to the tune of 8 to 17% at various growth stages both of mungbean and urdbean plants.

Evaluating next generation fertilizers in maize-chickpea

A field experiment was carried out to evaluate the influence of intercropping and different blends of fertilizers including customized fertilizers in maize-chickpea sequence. Treatments comprised of intercropping (Sole maize, maize+urdbean and maize+soybean) and varying blend of fertilizers (RDF_1, RDF_2, RDF_3, CFG_1, CFG_2, CFG_3, CFG_4 and control). Urdbean and soybean were intercropped with maize and fertilizers were applied as per recommendation for maize. No additional fertilizer was added to intercrop or component crop (urdbean and soybean). Application of maize formula (6:5.4:10:6.0:1.0:0.6:0.2) prepared locally at IIPR had marked influence on improvement of nutrient content in urdbean and soybean intercropped with maize. Recommended dose of fertilizer (120:26:50:30:5:3:1) supplied through straight fertilizer also improved nutrient content (NS Zn and Fe) in urdbean and soybean grains over control or no fertilizer application. Locally prepared maize formula (CFG) enhanced NP Zn and Fe content in urdbean grains to the tune of 8.14, 7.64, 7.95 and 7.52%, respectively, over RDF applied through straight fertilizers. The rates of improvement were again higher over no fertilizer.

Enhancing Resource Use Efficiency

Resource use efficiency enhancement in pigeonpea-wheat system

A field experiment was conducted on a *Typic Ustochrept* soil of Kanpur to evaluate three sowing times and crop geometry for early pigeonpea to fetch higher profitability and productivity. Tillage options were also evaluated in wheat crop following pigeonpea. Sowing of early pigeonpea on 5th June yielded highest (15.93 q/ha), followed by 25th May (14.62 q/ha) and 15th June (13.34 q/ha). Among variable crop geometry, sowing of early pigeonpea at 50×15cm recorded highest grain yield (16.84 q/ha), followed by 60×15cm (14.43 q/ha) and 40×15cm (12.63 q/ha). Studies showed the pertinent role of planting density and sowing time on the productivity of pigeonpea. Taller plants and lesser pods were observed under high density (40×15 cm) planting in comparison to lower density or optimum density.



Sowing of pigeonpea and wheat on raised bed in succession

Evaluation of system productivity in terms of pigeonpea equivalent yield (PEY) showed that higher PEY was noticed when early pigeonpea was sown on 25th May (28.53 q/ha) following wheat sowing in succession (Fig. 23). Early sowing of pigeonpea gives more time to wheat in maturity and ultimately grain yield. Likewise, sowing of 3 rows of wheat on raised bed (50×15cm) and conventional tillage gave higher grain yield of wheat.

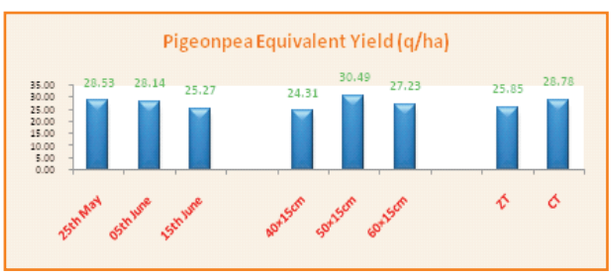


Fig. 23: System productivity of early pigeonapea-wheat

Efficient crop geometry and sowing dates for hybrid pigeonpea in IGP

The study was undertaken on a *Typic Ustochrept* soil of Kanpur to evaluate suitable crop geometry and sowing time for early pigeonpea hybrid (IPH 09-5) to fetch higher profitability and productivity. Sowing at 70×20 cm recorded highest grain yield (17.96 q/ha), followed by 60×20 cm (17.21 q/ha) and 50×20 cm (16.99 q/ha). Highest grain yield was recorded when early pigeonpea hybrid was sown on 1th June (20.71 q/ha), followed by 15th June (18.01 q/ha) and lowest in 30th June (12.64 q/ha) sown crop (Fig. 24). Studies showed the pertinent role of planting density and sowing time on the productivity of hybrid pigeonpea. Lesser leaf area index (LAI), taller plants and lesser pods were observed under high density (50×20 cm) planting in comparison to lower density or optimum density. More light penetration was noticed under wider crop geometry compared with narrower crop geometry. In succession, wheat crop responded upto 125% recommended dose of fertilizers.

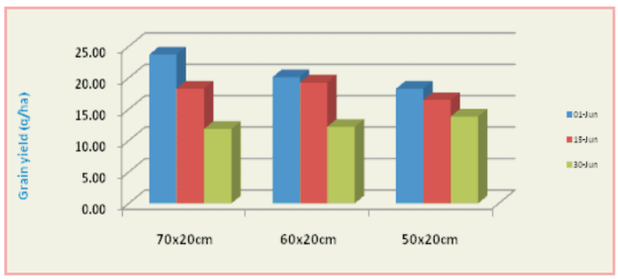


Fig. 24: Grain yield (q/ha) of hybrid pigeanpea under varying crop geometry and sowing dates

Resource Conservation Technology

Conservation tillage and residue management in pulse based system

To study the effect of resource conservation technology in pulse based cropping system, two tillage practices (zero tillage: ZT and conventional tillage: CT), three cropping systems (rice-wheat, rice-chickpea, rice-chickpea-mungbean) and two residue management practices (residue retention and residue removal) were evaluated. Tillage management practices did not influence rice yield, however 5.6% improvement in rice yield was recorded due to residue incorporation. Improvement in rice yield (11.6%) was observed in rice-chickpea-mungbean system over rice-wheat. Same trend was observed in *rabi* crops (wheat and chickpea), however, due to continuous intermittent rains, chickpea performance was poor, which resulted in higher equivalent yield under wheat crop. Summer mungbean performed better under residue incorporation. Yield of mungbean was higher in residue incorporation (9.94%) in comparison to no-residue (1399 kg/ha). In contrast to previous year, system productivity in terms of chickpea equivalent yield was 9.9% higher in conventional tillage than zero-tillage (3905 kg/ha). Improvement in system productivity (7.06%) was recorded due to residue incorporation. In cropping systems, highest system productivity in terms of chickpea equivalent yield (CEY) was obtained in rice-chickpea-mungbean (5208 kg/ha), followed by rice-wheat (4219 kg/ha) and lowest in rice-chickpea (2870 kg/ha). Net return and B:C ratio were higher in rice-chickpea-mungbean (Rs. 79633/ha and 2.04, respectively) and least under rice-chickpea (Table 4). Economics were also higher in residue incorporation over no-residue. Similarly, sustainability index was also higher in rice-chickpea-mungbean (0.77) and residue incorporation (0.61). Yields of rice, wheat, chickpea and mungbean were higher under conservation tillage (zero-tillage and residue incorporation).

Table 4: Effect of tillage and residue incorporation in rice - pulse cropping system

Treatment	CpEY of system (kg/ha)-2013-14	Net return (Rs/ha)	B:C ratio	Sustainability index	Energy use efficiency (%)
Tillage					
ZT	3905	54, 967	1.87	0.57	3.10
CT	4293	61, 938	1.91	0.60	3.22
CD	NS				
Cropping system					
R-W	4219	68, 039	2.16	0.55	2.77
R-C	2870	27, 686	1.47	0.45	2.72
R-C-M	5208	79, 633	2.04	0.77	3.96
CD	176				
Residue management					
Residue	3665	50, 743	1.85	0.61	2.83
No-residue	3423	44, 982	1.78	0.57	2.63
CD	NS				

Water Management

Efficient management of water for higher productivity in pulses

Tillage x sprinkler irrigation in chickpea

A field experiment was carried out with chickpea var. JG 16 to study the effect of irrigation (sprinkler irrigation *vis-à-vis* normal flood irrigation) accompanied with tillage options (conventional, reduced and zero tillage). The crop was planted under flat condition and was given optimum dose of fertilizers and other inputs. The tillage options despite their inherent differences in terms of frequency and time could not influence grain and straw yield of the crop. More prominently, the growing season was a climatologically scanty monsoon year with uneven distributed rainfall which amounted to 53.45 mm total rainfall (from only 2 rainy days) against 581.9 mm evaporation cumulated over *rabi* season (Mid Nov 2015 to end March 2016). However, it led to normal crop growth following timely intervention of irrigation scheduling and recharge of soil moisture storage resulting in realization of normal crop yield (with average of 2512 kg /ha).

Conservation tillage (zero till or reduced tillage) could not influence crop performance. Similarly, straw yield, total biomass and other yield attributes were not influenced by different tillage treatments during the 2nd year (Table). Nevertheless plant height was significantly higher under zero-tilled plot (ZT) compared to reduced (RT) or conventional tilled plot (CT). Conservation tillage could not influence chickpea productivity during the second year of study.

Significantly higher grain yield was recorded with irrigations applied at branch and pod development (2 number) or applied during branch to pod development (2 number). Because of less water availability due to scanty rainfall, irrigation at branching only was not adequate to compensate soil water loss. Quantitatively on an average the difference in yield was in the range of 372-461 kg/ha (Table 5) and there was an increase in yield to the extent of 20.7% when sprinkler irrigation was scheduled at both the above stages over that at a single stage (branching). Similar increase in total biomass was observed at harvest following application of sprinkler irrigation at both the stages. Although the influence of irrigation at both stages was not apparent for straw yield at harvest, yet the trend was similar to those of grain and biomass production.

Significantly higher no. of pods/plant was recorded under sprinkler irrigation (branch+pod). In addition, higher seeds/pods, 100 grain weight and grain weight/plant were observed under double irrigation applied at or during branch to pod development. The study emphasized the beneficial role of sprinkler irrigation at branch and pod development for realization of higher yield in chickpea.

Higher water use efficiency (WUE- 111.3 kg/ha-cm) was recorded under sprinkler at branch and pod development with the lowest WUE of irrigation at branch and pod (84.7 kg/ha-cm). With respect to gross return higher values were recorded with double irrigation applied either through normal flood or sprinkler irrigation. Because of higher initial cost of sprinkler system flood irrigation gave highest BCR (5.08) compared to sprinkler (branch/pod) although these were statistically similar (Table 6). Similarly significantly higher crop productivity/day and water productivity was recorded with sprinkler

Table 5: Growth, yield and yield attributes of chickpea at harvest under varied tillage and irrigation schedules

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biomass Yield (kg/ha)	Yield attributes			Grain wt. (g)/ plant	Branches plant	Dry wt. plant (g)	Plant height (cm) at maturity
				Pods/ plant	Seeds/ pods	100 seed wt. (g)				
Tillage										
ZT	2699	2567	5267	72.2	1.42	18.5	16.1	4.68	33.0	43.4
RT	2430	2399	4829	73.4	1.43	19.3	17.5	5.00	33.3	41.9
CT	2408	2192	4599	72.1	1.45	18.9	16.3	5.22	34.8	41.3
CD (P=0.05)					NS					1.23
Irrigation schedule										
Flood irrigation at branch (Ibr)	2315	2294	4610	61.5	1.32	18.4	13.5	4.47	26.3	41.5
Flood irrigation at Branch+ Pod (Ibr+pod)	2647	2750	5397	70.0	1.43	18.9	17.3	5.07	37.0	41.9
Sprinkler irrigation at 2226 branch (Sbr)	2166	4392	65.5	1.30	18.5	15.4	4.53	29.7	42.8	
Sprinkler irrigation at branch +pod (Sbr+pod)	2672	2362	5033	84.7	1.55	19.4	18.1	5.43	39.1	42.2
Sprinkler irrigation at branch to 2702 pod (Sbr-pod)	2358	5060	81.1	1.57	19.2	19.1	5.33	36.4	42.5	
CD (P=0.05)	302	NS	609	14.2	0.20	0.69	3.26	0.71	6.04	NS
Interaction effect was not significant.										

Table 6: Water related attributes, its use efficiency and economics of chickpea (during whole crop season)

Treatment	Water	WUE use cm	Gross kg/ ha-cm	Net return (Rs)	BCR return (Rs)	Productivity/ day(kg/day)	Water productivity (kg/M3)
Tillage							
ZT	25.85	106.5	97032	80732	4.97	20.76	2.07
RT	25.23	98.1	87462	70662	4.22	18.70	1.94
CT	24.12	100.3	86449	69149	4.02	18.52	1.91
CD (P=0.05)	-				NS		
Irrigation schedule							
Ibr	24.33	95.2	83336	68136	4.49	17.81	1.89
Ibr+pod	31.26	84.7	95389	79689	5.08	20.36	1.73
Sbr	20.03	111.3	80071	62371	3.53	17.12	2.19
Sbr+pod	24.16	110.7	95857	78157	4.44	20.55	2.09
Sbr-pod	25.55	106.2	96918	79218	4.49	20.78	1.98
CD (P=0.05)	-	12.3	10583	10583	0.65	2.34	0.24

Interaction effect was not significant.



Field performance of chickpea at full branching stage under different tillage options

Influence of sprinkler irrigation and row spacing in mungbean

A confirmatory field study was carried out involving two popular varieties (Samrat and IPM 205-7) and four agro-technologies (Row spacing at 30 cm+flood irrigation as farmers' practice, row spacing at 22.5 cm + flood irrigation as recommended practice, paired row planting at 15-30 cm +flood irrigation as modified recommended practice and over head sprinkler irrigation with row spacing of 22.5 cm as improved practice). The intra-row distance was maintained at 10 cm. The aim was to refine the optimum row spacing and sprinkler irrigation need of mungbean for enhancing crop productivity and profitability in the backdrop of meager summer rains, if any, so as to quantify irrigation water use and its efficiency in summer mungbean. This year spring/summer season was climatologically normal with relatively even distributed rainfall, which amounted to 34.2 mm of total rainfall (from 4 rainy days) against 502.1 mm evaporation cumulated over the season (March end to May). The deficit in rainfall was supplemented with irrigation (sprinkler *versus* normal flooding). On an average, 1189 kg/ha grain yield was realized irrespective of treatments.

Samrat produced significantly higher (9%) seed yield in comparison to IPM 205-7. Yield attributes such as pods/plant and seeds/pod and plant growth attributes *viz*., dry weight/plant and plant height were significantly improved in Samrat over IPM 205-7. With regard to 50% flowering, Samrat took one day early, while with regard to 80% maturity it took two days later than that in IPM 205-7 (Table 7).

Row spacing of 22.5 cm on an average produced 173-230 kg additional grain yield over farmers' practices of 30 cm row spacing. Similar trend was evident in the case for straw, total biomass and other yield attributes, although relatively higher 100 grain weight was recorded in wider row spacing of 30 cm following farmers' practices. This was compensated by relatively higher pods/plant and seeds/ pods in other agro-techniques (Table 8).



Effect of varied row spacing and (sprinkler) irrigation scheduling in mungbean (Spring planted)

Table 7 : Growth and yield performance of mungbean at harvest under various agro-techniques

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biomass yield (kg/ha)	Yield attributes			Dry wt/ plant (g)	Plant height (cm)	50% flower (days)	80% maturity (days)
				100 grain wt.(g)	Pods/ plant	Seeds /pod				
Variety										
Samrat 1240	2064	3304	4.38	14.8	8.7	12.2	36.7	38	58	
IPM 205-71138	1902	3040	4.39	13.6	7.1	11.5	32.1	39	56	
CD (P=0.05)	35.0	NS	NS	NS	1.1	0.95	0.18	1.6	-	-
Agro-techniques										
Sprinkler +22.5x10	1275	2140	3415	4.33	14.0	8.08	12.0	33.0	38	58
Flood+22.5 x 10cm	1218	2028	3245	4.30	14.6	7.88	11.8	35.2	38	57
Flood +15-30x10cm (Paired row)	1220	2028	3248	4.37	14.7	7.90	11.3	35.5	39	57
Flood+ 30x10 cm (farmers' practice)	1045	1737	2782	4.54	13.4	7.70	12.2	33.9	39	56
CD (P=0.05)	113	158	190	NS	NS	NS	NS	NS	-	-
Interaction effect was NS										

Table 8: Crop water use, WUE and economics in mungbean under improved agro-techniques

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)	Water use (cm)	WUE (kg/ ha-cm)	WP (Kg grain/ M water)	Gross return (INR)	Net return (INR)	BCR
Variety									
Samrat	1240	2064	37.6	26.32	48.5	1.29	59124	48399	4.51
IPM 205-7	1138	1902	36.5	25.68	45.4	1.21	54270	43545	4.06
CD (P=0.05)	35.0	NS	NS	-	1.5	NS	1167	1445	0.07
Agro-techniques									
Sprinkler+22.5x10	1275	2140	37.3	20.22	63.0	1.69	60788	48888	4.11
Flood + 22.5x10cm	1218	2028	37.6	27.42	44.4	1.18	58038	47537	4.53
Flood + 15-30x10cm (Paired row)	1220	2028	37.6	28.63	42.7	1.14	58157	47657	4.54
Flood+ 30 x 10 cm (farmers' practice)	1045	1737	37.6	27.72	37.7	1.01	49806	39805	3.98
CD (P=0.05)	113	158	NS	-	4.8	0.08	5179	5591	NS
Interaction effect was NS									

Enhancing RUE in pulse based cropping system in central India

An experiment was conducted in diversifying soybean (and its cropping system) for its sustainable intensification through inter/multiple cropping in enhancing its unit area productivity, efficiency and farm income. Integration of crop management modules such as land configuration (broad bed furrow *vis-a-vis* flat planting) and intercropping of cereal/pulses/oil seed groups *viz*., maize (RASI 4242), sorghum (MGSH 55), urdbean (IPU 2-43), pigeonpea (TJT 501) and sesame (Western) in prevailing soybean (RSV 2001-4) was carried out during *kharif*, while in *rabi* lentil (IPL 316) was grown in rotation with or without supplementary irrigation.

Raised bed had distinct advantage for both *kharif* and *rabi* crops (Table 9 and Fig. 25). Significant enhancement in crop productivity to the tune of 19.2, 16.6, 18.5 and 16.7 per cent in soybean alone, lentil alone and total productivity were recorded under raised bed over flat planting. All the intercrops had similar effect on soybean productivity, but considering on total *kharif* productivity (soybean+intercrops), soybean+sesame (2:2) had lowest productivity. It was significantly lesser in comparison to soybean+pigeonpea. Significantly higher total productivities were recorded with soybean+pigeonpea/urdbean-lentil. As both pigeonpea and sorghum were harvested late (early December) thereby delayed lentil sowing which affected both *rabi* crop (lentil) and total productivity adversely. Yet, the higher pigeonpea yield compensated the loss in yield of lentil. Supplementary irrigation once to lentil could enhance its productivity over the rainfed crop (Table 10). As a result, significantly higher soybean equivalent yield of lentil was obtained following irrigation due to scanty rainfall received during the season although total productivity of soybean-lentil system was not influenced by irrigation (Table 11).



Fig. 25: Comparative crop performance in intercroppping (2:2) situation with soybean (from left- lay out, pigeonpea, urdbean, maize and jowar) and lentil during *rabi*

Table 9: Effect of land configuration and soybean based intercropping on grain yield (kg/ha)

Treatment	Soybean (*Kharif*) Grain	Intercrop grain yield during *Kharif*						Lentil grain yield (*Rabi*)		
		Stalk (t/ha)	Pigeonpea	Sorghum	Urdbean	Maize	Sesame	SEY (For inter crops)	Lentil	SEY (for lentil)
Land configuration										
Flat	421	904	1967	833	333	917	377	1110	693	832
Raised bed	502	1072	2219	1057	472	1209	410	1312	808	971
CD (P=0.05)	68	142	231	NS	46.9	278	29.8	96.4	63.5	76.3
Soybean based intercropping (2:2)										
Pigeonpea	432	926	2093	-	-	-	-	3556	584	702
Sorghum	465	1000	-	945	-	-	-	565	604	726
Urdbean	481	1027	-	-	403	-	-	684	1049	1260
Maize	483	1032	-	-	-	1063	-	544	765	918
Sesame	445	957	-	-	-	-	393	707	750	901
CD(P=0.05)	NS	NS	-	-	-	-	-	274	82.5	99.1
Interaction	NS	NS	-	-	-	-	-	388	117	140

Table 10: Effect of land configuration and suppl. irrigation on grain yield of lentil, SEY and total yield (based on SEY, kg/ha)

Supplementary irrigation	Lentil yield		*Rabi* yield (SEY)		Total Yield (*Kharif*+*Rabi*)	
	Flat	Raised bed	Flat	Raised bed	Flat	Raised bed
Rainfed	605	715	726	859	2317	2798
Suppl. Irrig.	780	902	937	1084	2409	2771
CD (P=0.05)						
Rainfed/Sup.						
Irrgn	29.0		34.9		NS	
Flat/Raised bed	75.7		91.0		108.4	
Interaction	NS		NS		NS	
SEY (Soybean equiv. yield)						

Table 11: Effect of land configuration and soybean based intercropping on total yields (kg/ha)

Treatment	Lentil			Total yield (SEY)		
	Grain	SEY (for lentil)	Stalk (kg/ha)	*Kharif* (Soybean+ intercrop)	*Rabi* (Lentil)	*Kharif* + *Rabi* (SEY)
Supplementary irrigation						
Rainfed	660	793	867	-	793	2558
Supplementary irrigation	841	1010	1306	-	1010	2590
CD (P=0.05)	29.0	34.9	35.2	-	34.9	NS
Land configuration						
Flat	693	832	959	1531	832	2363
Raised bed	808	971	1214	1814	971	2785
CD (P=0.05)	75.7	91.0	105.2	128	91.0	108.4
Soybean based intercropping (2:2)						
Pigeonpea	584	702	849	3989	116.7	4691
Sorghum	604	726	878	1030	116.7	1756
Urdbean	1049	1260	1508	1165	116.7	2425
Maize	765	918	1118	1026	116.7	1945
Sesame	750	901	1079	1152	116.7	2053
CD(P=0.05)	74.1	89.0	103.7	273	89.0	192
InteractionCD (P=0.05)	105	126	147	386	126	272

Weed Management

Weed management in mungbean

Effectiveness of post-emergence herbicides was evaluated in mungbean during *kharif*. Treatments comprised of pendimethalin @ 0.75 kg/ha *fb* fenoxaprop-p-ethyl (100 and 150 g/ha), clodinafop-propargyl (100 and 150 g/ha) and propaquizafop (100 and 150 g/ha) along with pendimethalin @ 1.0 kg/ha *fb* imazethapyr @ 100 g/h, imazethapyr @ 100 g/ha, pendimethalin @ 1.0 kg/ha, weedy check and weed free. The results revealed maximum grain yield of mungbean under weed free (927 kg/ha), followed by pendimethalin *fb* imazethapyr (864 kg/ha), pendimethalin *fb* clodinafop-propargyl @ 150 g/ha (780 kg/ha) and lowest under weedy check (365 kg/ha). Fenoxaprop-p-ethyl and propaquizafop were effective in controlling grassy weeds. Clodinafop-propargyl was able to control *Digera arvensis* (a major broad leaved weed in *kharif* mungbean) which enhanced the weed control efficiency and grain yield of mungbean.

Performance of post-emergence herbicides in chickpea

A field experiment was conducted at ICAR-Directorate of weed Research, Jabalpur in collaboration with ICAR-IIPR, Kanpur on post-emergence herbicides *viz.*, topramezone, imazethapyr+imazamox, oxyfluorfen and clodinafop-propaygyl+Na- acifluorfen to assess their phytotoxicity and efficacy on chickpea. Results revealed that phytotoxicity of imazethapyr + imazamox 60 g/ha was prolonged and chickpea recovery was poor. Phytotoxicity of topramezone 40 and 60 g/ha and clodinafop propargyl+Na-acifluorfen 300 and 500 g/ha were minimal and crop growth was more vigorous after the recovery at 25 days after application of herbicides.

Major weed flora in chickpea were *Sonchus arvensis* (L.)., *Chenopodium album* L., *Euphorbia geniculata* (L.) and *Vicia hirsuta* (L.) Gray. Significantly lower weed population by 66 and 54% were recorded in topramezone 60 g/ha and clodinafop propargyl+Na-acifluorfen 500 g/ha, respectively, than unweeded control besides significant reduction in dry weight of weeds. Weed control efficiency (WCE) higher in topramezone 60 g/ha (71.6 %) and had an edge over two hand weedings (54.5%) and quizalofop ethyl (recommended post-emergence herbicide) (40.5%) in chickpea. Topramezone 40 g/ha recorded 49.2% and 20.3% higher chickpea dry weight than unweeded control and two hand weedings, respectively at 65 days after sowing (DAS). These also recorded significantly higher grain yield by 26.4 and 20.1% over quizalofop-ethyl 50 g/ha indicating broad-spectrum herbicides are needed in chickpea. Therefore, topramezone and clodinafop propargyl+Na- acifluorfen could be a option for controlling the diversified weed flora particularly broad-leaved weeds in chickpea with further studies under different agro-ecological condition (Table 12).

Table 12: Effect of different weed control practices on weed and chickpea growth at 65 DAS

Treatment	Dose (g/ha)	Total weed population (No./m²)#	Total weed dry weight (g/m²)*	Chickpea dry weight (g/m²)	Weed control efficiency (%)	Weed control index (%)	Grain yield (t/ha)
Quizalofop-ethyl	50	4.2 (22.7)	7.1 (49.3)	15.3	40.5	24.0	2.39
Clodinafop- propargyl	60	2.6 (6.7)	4.1 (20.9)	13.8	58.0	60.3	2.52
Imazethapyr	50	2.7 (6.7)	5.9 (38.2)	13.7	56.5	40.6	2.48
Oxyfluorfen	150	2.3 (9.3)	3.4 (11.4)	5.3	71.6	63.0	2.68
Topramezone	40	3.5 (21.3)	4.1 (17.7)	27.3	56.6	57.0	3.02
Topramezone	60	2.3 (9.3)	4.5 (29.4)	7.3	71.6	53.9	2.57
Imazethapyr + imazamox	40	2.7 (14.7)	3.1 (9.3)	4.8	67.0	67.9	2.48
Imazethapyr + imazamox	60	3.8 (21.3)	4.3 (24.0)	5.3	52.0	58.4	2.15
Clodinafop- propargyl + Na-acifluorfen	300	3.8 (14.7)	3.7 (18.3)	9.2	36.1	64.2	2.25
Clodinafop propargyl + Na-acifluorfen	500	3.1 (10.7)	4.4 (19.1)	16.0	53.1	51.3	2.87
Two HW(30 and 50 DAS)	-	2.9 (9.3)	4.4 (22.8)	22.7	54.5	49.1	2.47
Unweeded control	-	6.8 (52.0)	9.6 (95.8)	18.3	0.0	0.0	2.15
SEm±	-	0.7	1.1	1.1	-	-	0.18
CD (P=0.05)		2.1	3.2	3.2	-	-	0.48

#Data were transformed through through square-root [$\sqrt{(x+0.5)}$] *Original values are given in parentheses.

EXTERNALLY FUNDED PROJECT

Mitigating Abiotic Stresses and Enhancing Resource-use Efficiency in Pulses in Rice Fallows through Innovative Resource Conservation Practices

Rice culture methods and foliar nutrition

Three rice culture methods *viz*., puddled transplanted rice (PTR), unpuddled transplanted rice (UPR) and direct seeded rice (DSR) and three foliar nutrition practices (2% urea, micronutrients+2% urea and control) were evaluated. Soil moisture content (SMC) was taken with the help of soil moisture probe at 15 days interval during *rabi* season at 10, 20, 30, 40, 60 and 100 cm soil depth. Maximum SMC in root zone (0-40 cm) was retained under UPR and DSR and minimum under PTR. Similar trend was observed in case of nodules number and nodules dry weight/plant under rice planting methods. Later stage at flowering and pod filling stages (60 and 90 DAS) foliar nutrition of 2% urea and micronutrients enhanced nodulation in chickpea. Consequently, maximum grain yield was observed in UPR (1498 kg/ha), followed by DSR (1468 kg/ha) and least under PTR (1216 kg/ha). Similarly, maximum chickpea grain yield was recorded in micronutrients (1512 kg/ha), followed by 2% urea (1434 kg/ha) and least under control (1237 kg/ha). Thus, for achieving higher yield in chickpea under rice fallows, UPR or DSR in rice and foliar nutrition of micronutrients and 2% urea may be followed.

System based nutrient management

A field study was conducted to evaluate the nutrient management strategies for rainfed chickpea under rice fallow condition. The study was conducted with three levels of nutrient management (NPK + 5 t FYM, NPK and farmer's practice), two levels of water management (rainfed and life saving irrigation) and two levels of foliar nutrition (micronutrients foliar application and control). The data revealed that application of recommended NPK+FYM to rice crop conserved higher soil moisture over farmers' practice in all crop growth stages. This resulted in higher chickpea yield under NPK+FYM (57.4%), followed by NPK (27.4%) over farmers, practice. Increase in grain yield of chickpea was also recorded due to life saving irrigation (16.3%) and foliar application of micronutrients (8.93%) over rainfed and no-foliar nutrition (control), respectively.

Recommendations

- ✓ Suitable varieties of rice (110-120 days) and lentil, lathyrus, chickpea and urdbean having early high vigour for rice fallows.
- ✓ Rice stubble retention (20-30 cm) for conserving soil moisture and higher productivity in rice+pulse relay cropping system.
- ✓ Sowing of pulses with conservation tillage (zero tillage coupled with rice residue mulch/ stubbles) under rice–pulse sequential cropping.
- ✓ Paired rows planting (22.5 cm x 45 cm) of chickpea.
- ✓ Foliar application of 2% urea / DAP (in T.N.) at flowering and 10 days thereafter in pulses for alleviating N stress and enhancing seed yield under rice fallow.
- ✓ Application of quizalofop-p-ethyl @ 100 g/ha post-emergence to control rice ratoons at 2-3 leaves stage.
- ✓ Two prototypes of manual operated single row ZT drill for sowing of pulses under rice fallows of heavy and medium textured soils.

Crop Protection

DISEASES

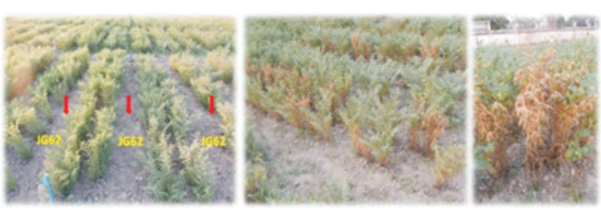
Wilt of chickpea

Host plant resistance

Wilt disease caused by *Fusarium oxysporum* f. sp. *ciceri* has been a major biotic stress for chickpea. Total 354 lines received from NBPGR and elite breeding lines were screened against Kanpur race (race 2) in wilt sick plot. Disease development was very high with 100% mortality in susceptible check cv. JG 62.

Out of 125 lines including *kabuli* and *desi* types received from NBPGR, 21 lines (EC - 223519, -267154, -267308, -267437, -440552, -441805, -489919, -489991, -498818, IC-83523, -83530, -83538, -83539, - 83542, -83556, -83558, -83748, -83750, -83751, -83570 and IC -83757) were resistant, while 15 (EC-267293, -267511, -441725, -489845, -489905, IC-83519, -83523, -83526, -83527, -83529, -83534, -83535, -83541, -83551 and IC-83569) were moderately resistant and remaining 89 were susceptible.

Out of 229 advanced breeding lines (20 *kabuli* and 209 *desi* type) tested, 3 *Kabuli* entries namely, IPCK 2015-235, -264 and -266 were found resistant and four (IPCK 2015-261, 241, 111, and -239) moderately resistant. Among *desi* type, 39 lines (IPC 2015-6,- 10, -11, -34, -35, -65, -71, -72, -75, -77, -82, -85, -90, -92, -99, -115, -120, -125, -147, -148, -151, -154, -155, -156, -158, -165, -170, -171, -176, -188, -194, -201, -208, -205, -207, -230, -251,-273 and -281) were found resistant and 64 were moderately resistant.



View of wilt sick field, JG-62: susceptible cultivar (Check)

Race specific resistance in chickpea

Twenty five lines comprising of NBPGR and elite breeding lines were screened against six races (race 1, 2, 3, 4, 5, 6) maintained individually in large cemented pots. Six lines (IC 83603, IPC 2005-18, -19, -27, -37 and IPC 2004-03) were found resistant to 4 races, 1 line (IPC 2005-34) was resistant to 3 races, 8 lines (IC-83559, -83560, -83587, -83614, IPC 2004-08, IPC 2005-15, -26, and IPC 2005-35) were resistant to 2 races, 8 lines (IC -83563, -83565, -83567, -83601, IPC 2004-34, IPC 2005-24, -30 and -43) were resistant to single race.



Evaluation of NBPGR and elite breeding lines against races of *Foc*

Wilt of Pigeonpea

Host plant resistance

Total 402 pigeonpea lines were screened against *Fusarium udum* in sick plot. Variety Bahar used as susceptible check showed 100% mortality. Percent wilt incidence were recorded at monthly intervals. Out of 34 promising lines screened under natural epiphytotic conditions, 12 (DPPA 85- 3, -5, -7, -8, -11, -12, -13, -14, -16 and IPA-38, IPA 16F and IPA 15F) showed resistant reaction against *F. udum* with wilt incidence ranging from 0-10%. Out of 31 genotypes from ICRISAT, 5 (ICPL 99044, ICPL 20095, ICPL 87051, ICPL 99009 and ICPL 99055) showed resistant reactions with wilt incidence from 0-10%.

Out of 84 genotypes of AICRP, 10 (BWR 133, GRG -140, -160, -177, DRG 107, KDVP 935, LRG 15, TRG 59, WRGE 90 and RVSA 07-31) were found resistant, whereas BRG 3, -4, -5, BSMR 736, BSMR 853, IPA 204, KPL 43 and Mahabeej105 showed moderately resistant reaction with 10.1-20% wilt incidence.



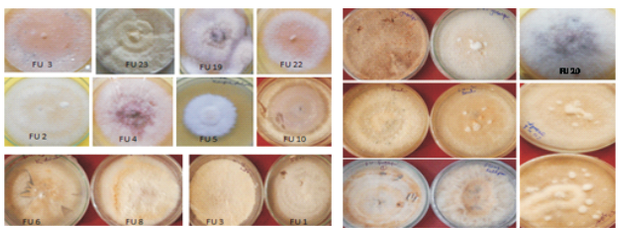
Panoramic view of the wilt sick plot



Wilt resistant genotypes

Variability in *Fusarium udum* isolates

Thirty isolates of *Fusarium udum* (*Fu*) were collected from farmers' fields of Kanpur Dehat, Hamirpur, Jalaun and Fatehpur districts of Uttar Pradesh, Panna and Jabalpur districts of Madhya Pradesh and Dholi, Bihar for variability analysis. Morphological and pathogenic variability of *Fu* isolates was recorded on colony colour, growth pattern of mycelium, size and shape of conidia (micro and macro).



Variability among *Fusarium udum*



View of the Phytophthora blight sick field



PSB resistance genotypes

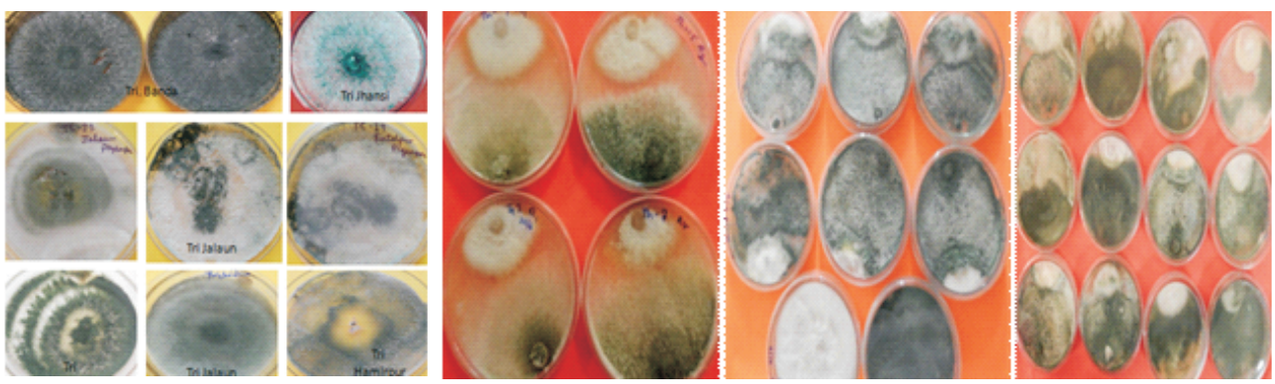
Phytophthora stem blight

Host plant resistance

Total 104 lines were screened against Phytophthora stem blight (PSB) in sick field under natural conditions. UPAS 120 was sown as check after every two rows of test entry. PSB incidence ranged from 0 to 100% in different genotypes. Based on the mean disease incidence of the three replications, nine pigeonpea lines *viz.*, IPAC 3-2, IPAC 42, IPAC 79, IPAPB 7-2-1-7, KPBR 80-2-1, IPAC 66-7, IPAC 66-9, WDBCU 1, WDBCE 5-4, IPA 14-4, IPA 38A, PH1063 and WD 5-4 were identified as resistant showing disease incidence between 0-10% and 10 were found moderately resistant to PSB with disease incidence between 10.1-25%.

Characterization of *Trichoderma* sp associated with pulse rhizosphere

Soil samples were collected from chickpea, pigeonpea and lentil rhizosphere from farmers' fields of different districts. Thirty isolates of *Trichoderma* spp. were isolated by serial dilution technique using Trichoderma selective sedium (TSM). On the basis of cultural and morphological characteristics, *Trichoderma* isolates were classified into four species, *T. harzianum, T. viride, T. virens* and *T. pseudokoningii.* Among the isolates of *Trichoderma* sp., *T. harzainum* was most efficient in inhibiting growth of *F. udum*, *F. oxysporum* f. sp. *lentis* and *F. oxysporum* f. sp. *ciceris*. *T. viride, T. virens* and *T. pseudokoningii* were also promising.



Characterization of *Trichoderma* sp against wilt of chickpea, pigeonpea and lentil associated with pulse rhizosphere

Lentil

Development of wilt sick plot

Wilt susceptible genotypes of lentil, K 75 and L 9-12 were sown in field marked for development of wilt sick plot for screening lentil genotypes. Culture of *Fusarium oxysporum* f. sp. *lentis* multiplied on lentil grains was added to the field. Development of wilt was monitored. In both genotypes wilt incidence recorded at three random places reached up to 16-18 %.

Wilt management

Seed treatment with talc based formulations of the *Trichoderma harzianum* (Th 31 and Th 11) @ 4 g/kg and fungicides Carbendazim 50 WP and Vitavax power @ 2 g/kg reduced wilt incidence by 18-38%. Application of *Trichoderma harzianum* inoculated FYM @ 100 kg/ha also reduced wilt incidence by 17-24%.

Genetic variability in isolates of *Fusarium oxysporum* f sp. *Lentis*

Using primers pair ITS 1/ITS 4, genetic diversity in 24 isolates of *Fusarium oxysporum* f.sp. *lentis* was studied. PCR products subjected to gel electrophoresis revealed DNA bands of ~600bp. Out of 13 restriction enzymes used, only *alu* 1 gave polymorphic bands.

Diversity Analysis, Identification of Resistant Donors and Management of *Rhizoctonia Bataticola* Causing Dry Root-rot in Chickpea

Attempts were made to identify the sources of resistance against dry root-rot (DRR) in chickpea caused by *Rhizoctonia bataticola* (synonym-*Macrophomina phaseolina*).

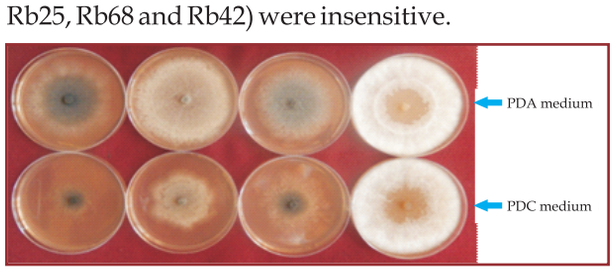
Host plant resistance

Out of 59 advanced breeding lines screened at Durgapura and Rajasthan, none was found resistant against dry root rot pathogen. However, 10 lines *viz*., IPC 2005-30, -34, -44, -52, -59, IPC 2007-48, -51, IPC 2010-03, -123 and IPC 2011-65 were found moderately resistant and remaining were highly susceptible.

Variability in *Rhizoctonia bataticola* isolates

Total 38 isolates of *Rhizoctonia bataticola* were subjected to pathogenic variability study on BG 212 cultivar. All isolates were found highly pathogenic and disease incidence ranged between 55.6 to 100%. Among 38 isolates of DRR, 6 isolates were highly pathogenic and caused 100% plant mortality.

Variability in utilization of potassium chlorate ($KClO_3$) was observed among 45 isolates. Based on the phenotypes observed on PDA supplemented with 140 mM $KClO_3$, isolates were grouped in three types *viz*., sensitive, moderately sensitive and insensitive. Nine isolates (Rb 1d, Rb23, 3, 22, Rb44, Rb18, Rb8, Rb14, Rb21) were sensitive, 10 isolates (Rb 1, 47, 52, 63, Rb65, Rb72, Rb16, Rb13 D, Rb61 and Rb10) were moderately sensitive and remaining 26 isolates (Rb 1a, 2, 5, 7 , 24, 26, 28, 30, 34,39, 44, 46, 48 49, 57, 64, Rb77, Rb19, Rb9, Rb43, Rb40, Rb60, Rb PK, Rb25, Rb68 and Rb42) were insensitive.



PDA: Potato Dextrose Agar and PDC: Potato Dextrose Chlorate

Variability in chlorate utilization of *Rb* isolates

Dry root rot management

Total 71 bacterial isolates were isolated from chickpea rhizosphere and rhizoplane. These were subjected to confrontation assay against *R. bataticola* isolate under *in-vitro* condition. Isolates IIPR-B11 and IIPR-B38 were found highly effective in inhibiting pathogen by 43.6 and 40.9 per cent, respectively, followed by IIPR-B3 (30.8%) and IIPR-B7 (28.1%).



Identification of bacterial strains against management of DRR

Identification of Resistant Sources against Yellow Mosaic in *Vigna* Spp.

Total of 104 mungbean and 182 urdbean genotypes were screened against yellow mosaic disease (YMD) under natural conditions using infector row technique. Twenty two mungbean genotypes *viz*., IPM 411-9, IPM 125, IPM 312-19K, IPM 03-1xSPS-4, PDM 99-262x1PM3-1-2, PDM 139xEC94 (2K8-7), Pant M 5, IPM 312-379, IPM 9-324K, IPM 02-03, IPM 99-108, IPM 99-1-1-3, IPM 03-1xSPS5-5, IPM 03-1xSPS5-1, IPM 205-9, IPM 302-2, IPM 6-15-1, IPM 2K 8-1-1, IPM 139xSPS9871, IPM 05-17/IPM9901-6, IPM 410-3, IPM 312-17, and 108 urdbean genotypes *viz*., IPU 88-31, IPU 99-96, IPU 99-62, IPU 99-25, IPU 99-91, IPU 99-33, IPU 99-63, IPU 99-248, KARS 228, KARS 257, LGG 460, No. 68313, NP 21, PLU 158, PLU 1, TU 98-85, UK 3, US 5, UH 80-19, WBU 108, 2K 1, 2K 13, 2K 14, 2K 21, 2K 7, NDU 1, PLU 722, STY 2289, STM 6,SPS-43, WBV 107, IC 43647, TU 99-293, T 9, STY 2834, STY 2868, NHKD 31, NKDU 2, IPU 99-200, IPU 99-204, IPU 99-211, IPU 99-237, PLU 570, PLU 648, UPU 85-86, UPU 85-15, V 108, PLU 826, PLU 791, IPU 99-220, IPU 99-213, IPU 99-218, IPU 99-31, IPU 99-336, PDU 2E, PDU 3, No. 236818, IPU 4812, IPU 02-33, IPU 10-33, IPU 2-43, U 79-7, UH 82-2, UH 82-5, UH 83-2, UH 84-01, UH 84-4, UH 86-4, IPU 96-6, PLU 96-06, IPU 99-1, IPU 99-4, PLU 99-10, PLU 99-12, IPU 9-13-2, IPU 13-1, IPU 13-2, IPU 13-5, IPU 6-2, IPU 13-6, IPU 13-7, IPU 13-8, IPU 9-13, IPU 13-9, IPU 9-16, IPU 9-26, IPU 10-1, IPU 13-10, IPU 10-16, IPU 10-21, IPU 10-23, IPU 10-26, IPU 11-1, IPU 11-4, IPU11-6, IPU13-11, No.13/11, PKU 11-14, No.11/19, IPU 12-4, IPU 12-5, IPU 12-9, IPU 12-13, IPU 12-18, IPU 12-21, IPU 12-29 and IPU 12-30 were found resistant.

INSECTS

Eco-friendly Management of Spotted Pod Borer *Maruca Vitrata* Fabricius in Short Duration Pigeonpea

Total 47 pigeonpea genotypes were screened against *M. vitrata*. ICPL 87 recorded highest pod damage (89.81%) and was most susceptible genotype, while JA 4 recorded lowest pod damage (13.93%) with highest pest resistance (84.49%). Among seven different border crops deployed for

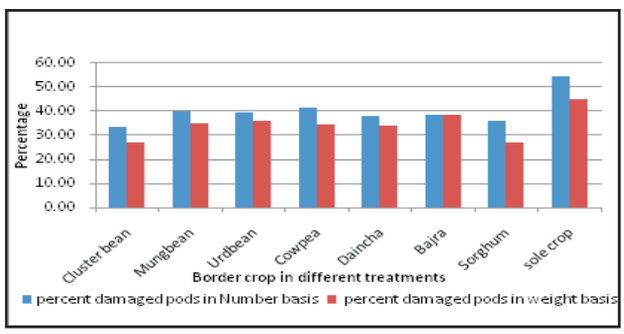


Fig. 26: Effect of border crops on pod damage in pigeonpea

management of *M. vitrata,* sorghum bordered crop recorded lowest pod borer damage in number (36.15) and weight basis (26.80), whereas highest was recorded from pigeonpea sole crop (54.56 and 44.92) (Fig. 26). The average yield was also high in sorghum bordered crop (3.07 kg/30m^2), whereas lowest (1.58 kg/30m^2) in urdbean and *bajra* bordered crop (Fig. 27). The number of larvae/plant varied from 0.33 to 5.53. Sorghum bordered crop recorded lowest spotted pod borer population in pigeonpea ICPL 67B from 41st to 47th SMW.

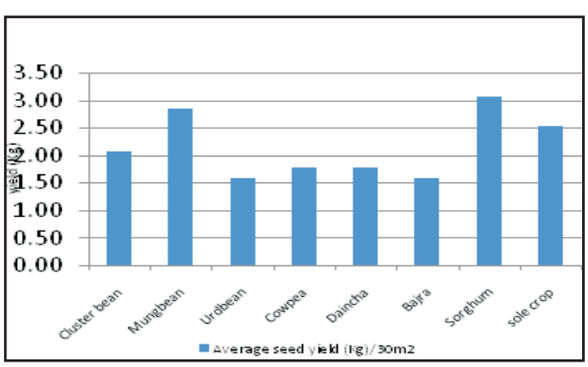


Fig. 27: Effect of border crops on pigeonpea yield

NEMATODES

Screening for Resistance against Root-knot Nematode *Meloidogyne Javanica*

Thirty genotypes of pigeonpea, eight lines of mungbean, 23 lines of each urdbean and fieldpea and 78 lines of chickpea were evaluated for resistance against root-knot nematode *Meloidogyne javanica*. Six genotypes of pigeonpea (BDN 2004-1, BDN 2011-1, RVSA 07-10, Pusa 84, TJT 501 and Manak), six lines of mungbean (GM 04-02, HUM 1, HUM 27, KM 2342, RMG 1028 and RMG 1030), two lines of urdbean (MU 44 and NUL 205), two lines of lentil (L 4076 and DPL 15), three lines of fieldpea (IPF 13-14, Adarsh and IPFD 12-2), ten lines of chickpea (GJG 1209, Phule G 0611, GAG 1107, IPC 14-73, IPC 14-143, IPC 14-05, IPC 14-137, IPC 14-107, IPC 14-146 and IPC 10-72) were found resistant.

Damage Threshold Level of *Heterodera Cajani* in Urdbean

In light soil (pH 7.9) urdbean plants (var. Uttara) inoculated with juveniles of *Heterodera cajani* @ 100 juveniles or more per plastic pot (8" size) showed significant reduction in plant height, fresh and dry plant weights and fresh root weight, number of branches and number of pods after 45 days of inoculation. Dry root weight was significantly reduced at inoculation level of 2000 juveniles and above. The cysts in soil and root and the juvenile population increased with increase in initial inoculums (Table 13).

In alluvial soil (pH 7.6), plants inoculated with 500 juveniles or more showed significant reduction in fresh and dry plant weights, dry root weight and number of branches. Plant height was reduced significantly at 100 juveniles and above, fresh roots weight at 1000 and number of pods at 2000 juveniles and above. The cysts in soil and root and the juvenile population increased with initial inoculums (Table 14).

When the nematode multiplication was compared in two types of soil, there was more nematode multiplication in medium textured soil compared to light textured soil. Juveniles population, cysts on the roots and cysts in soil were more in medium textured soil (Fig. 28). The damage threshold level was low in medium soil then in light soil.

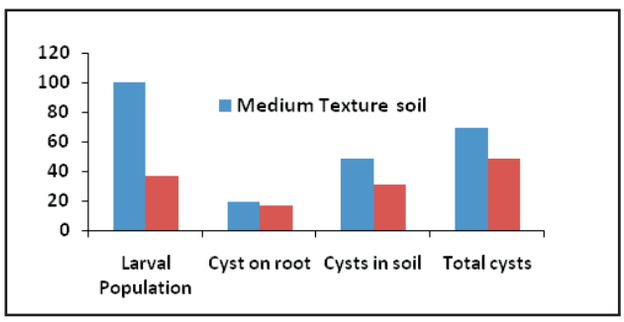


Fig. 28 : Effect of soil types on *Heterodera cajani* multiplication

Table 13: Damage threshold level of *Heterodera cajani* in urdbean variety Uttara in light texture soil

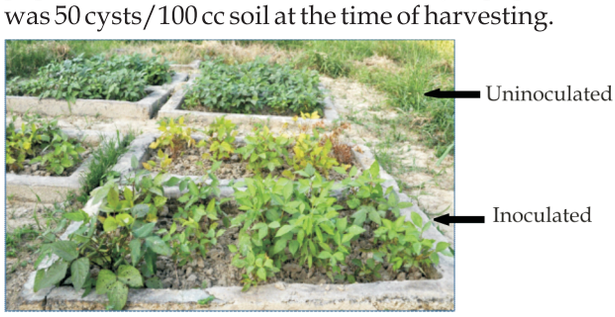
Treatment	Plant height (cm)	Shoot wt (g)		Root wt. (g)		Branches	Pods	J2/100 cc soil	Cysts/ 100 cc soil	Cysts/ root
		Fresh	Dry	Fresh	Dry					
Check	22.5[a]	12.40[a]	3.72[a]	2.57[ab]	0.44a	12.7[a]	11.5[a]			
10	22.8[a]	12.58[a]	3.77[a]	2.60[a]	0.44[a]	12.3[a]	9.5[a]	1.3[a]	1.7[a]	1.3[a]
100	21.7[ab]	11.94[ab]	3.58[ab]	2.47[ab]	0.42[a]	9.3[b]	5.2[b]	10.0[a]	3.3[a]	5.3[a]
500	21.3[ab]	11.75[ab]	3.53[ab]	2.43a[b]	0.41[a]	7.7[bc]	5.5[b]	27.7[b]	9.0[b]	21.3[b]
1000	19.2[b]	10.56[b]	3.17[b]	2.19[b]	0.37[a]	6.3[cd]	1.8[c]	35.3[b]	19.3[b]	26.7[b]
2000	13.7[c]	7.53[c]	2.26[c]	1.56[c]	0.26[b]	4.0[d]	1.5[c]	55.7[c]	34.0[c]	67.7[c]
3000	13.5[c]	7.44[c]	2.23[c]	1.54[c]	0.26[b]	3.7[d]	0.5[c]	94.0[d]	40.3[d]	65.3[c]
CD at 5%	3.3	1.84	0.55	0.38	0.07	2.8	2.5	14.9	4.1	8.5

Table 14: Damage threshold level of *Heterodera cajani* in urdbean variety Uttara in medium texture soil

Treatment	Plant height (cm)	Shoot wt (g)		Root wt. (g)		Branches	Pods	J2/100 cc soil	Cysts/ 100 cc soil	Cysts/ root
		Fresh	Dry	Fresh	Dry					
Check	22.5[a]	12.98[a]	2.70[a]	2.23[a]	0.24[a]	6.7[a]	4.7[a]	-	-	-2
10	20.6[ab]	13.83[a]	2.88[a]	2.18[a]	0.24[a]	5.7[ab]	5.3[a]	5[a]	1[a]	2[a]
100	18.0[bc]	12.13[ab]	2.52[ab]	1.92[ab]	0.21[ab]	5.3[ab]	4.7[a]	19[a]	5[a]	9[a]
500	17.5[c]	10.90[bc]	2.27[bc]	1.70[ab]	0.18[abc]	3.3[b]	4.0[ab]	74[b]	14[b]	20[a]
1000	17.0[cd]	9.20[cd]	1.91[cd]	1.47[bc]	0.16[bc]	3.3[b]	3.7[ab]	119[b]	21[b]	58[b]
2000	14.3[de]	8.68[d]	1.80[d]	1.42b[c]	0.15[bc]	3.3[b]	2.0[b]	184[c]	36[c]	91[c]
3000	13.8[e]	7.59[d]	1.58[d]	1.27[c]	0.14[c]	3.3[b]	2.0[b]	202[c]	46[d]	115[c]
CD at 5%	2.8	2.01	0.42	0.53	0.06	2.5	2.2	51	7	31

Yield loss due to *H. cajani* in urdbean

Two months after germination, Uttara variety of urdbean grown in cemented pots (2'x3') containing soil inoculated with cysts of *Heterodera cajani* @ 8 cysts/100 cc soil showed 78.9% reduction in grain yield as compared to un-inoculated pots. Juvenile population was 142/100 cc soil and cyst population was 50 cysts/100 cc soil at the time of harvesting.



Urdbean in inoculated and uninoculated pots

Survival of eggs/juveniles of *H. cajani* in brown cysts

Observations on the viability of *Heterodera cajani* cysts in moist as well as dry soil kept in polyethylene bags and stored in net house and laboratory (room temperature) conditions indicated that cysts remained viable under all these conditions for two years. Hatching was observed in the cysts stored under different conditions, but it was maximum in cyst collected from moist soil stored in lab, followed by cysts collected from dry soil kept in net house. There was less hatching from cysts extracted from dry soil kept in lab and moist soil kept in net house (Fig. 29).

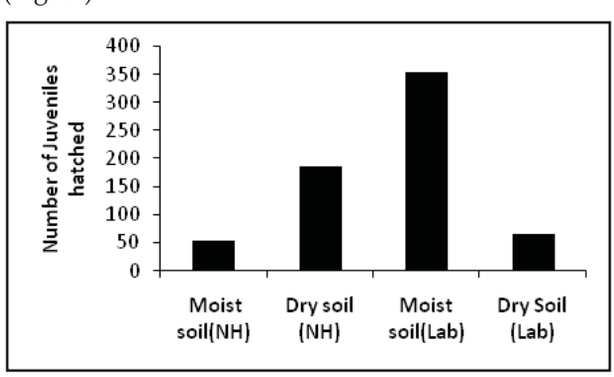


Fig. 29: Hatching of J_2 from the brown cysts stored in moist and dry soil in lab and net house for 2 years

Effect of root exudates/extracts of different crop plants on hatching of brown cysts of *H. cajani*

Effect of root exudates of seven crop plants *viz*.,, urdbean, mungbean, pigeonpea, pearl millet, sorghum, sesamum and maize and roots extract of these seven crops plants and of soyabean on hatching of brown cysts *H. cajani* was studied. Hatching was maximum (93 juveniles) in root exudates of sesamum, followed by pigeonpea (34 juveniles) and maize (33 juveniles). Minimum hatching (5 juveniles) was in water (Fig. 30).

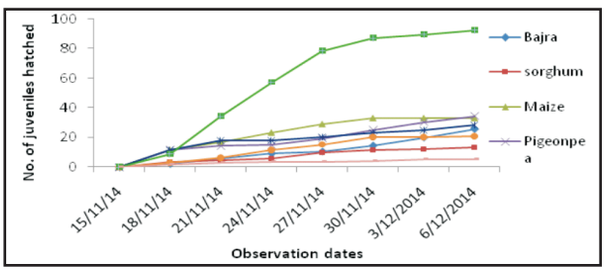


Fig. 30: Effect of root exudates on the hatching of *H. cajani* juveniles from brown cysts

Hatching of brown cysts was maximum in root extract of pigeonpea (117 juveniles), followed by soyabean (114 juveniles). Minimum hatching in root extract of *Bajra* (2 juveniles) was less than water where 10 juveniles were hatched (Fig. 31).

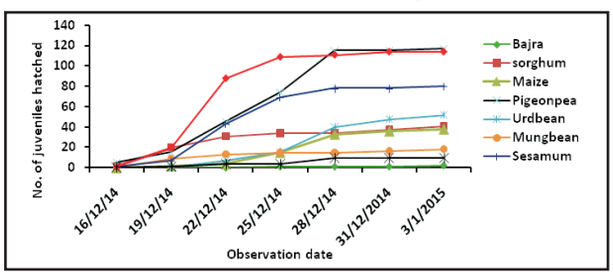


Fig. 31: Effect of root extract on the hatching of *H. cajani* juveniles from brown cysts

Validation of Screening Technique against Lesion Nematode in Chickpea

Screening technique based on lesion nematode multiplication index (NMI) was validated. Earthen pots of 6 inch were filled with sterilized soil to which nematode inoculums @ 1 nematode/cc soil was added. Sowing of eighteen genotypes of chickpea along with susceptible check DCP 92-3 was done. Two plants were maintained in each pot and each genotype was replicated three times. Two and half months after germination, total nematode population in root and soil was counted and nematode multiplication index was calculated in comparison to susceptible check. Based on the NMI the genotypes were designated as resistant or susceptible as per the scale given below:

NMI	Reaction
1-10%	Highly resistant
11-30%	Resistant
31-60%	Moderately resistant
61-90%	Susceptible
91-100%	Highly susceptible

Eight genotypes *viz*., Phule G-5, RSG 991, RSG 931, JG 6, RSG 10, Flip 06-72C, IPC 09-161 and Phule G 96006 were observed as resistant as NMI of these genotypes was less than 30%. Four genotypes *viz*., RAU 52, ICC 8950, ICC 1356 and GG 2 were moderately resistant, five genotypes were susceptible and one highly susceptible (Table 15). Comparison of these reactions with the previous year indicated 78% repeatability of the screening technique .

Management of lesion nematode in chickpea

In 8 inch diameter plastic pots filled with soil having lesion nematode infestation level of 2.5 nematodes/cc soil, different treatments *viz*., vermicompost @ 500 kg/ha, neem cake @ 500 kg/ha, neem seed powder @ 50 kg/ha, carbofuran @ 1.5 kg a.i./ha were applied in soil calculated on weight basis and carbosulfan was used as seed treatment @ 1.5% v/w. Seeds of chickpea variety DCP 92-3 were sown and after germination three plants were maintained in each pot. Three and half months after sowing, observations recorded on plant growth parameters and nematode populations indicated that plant height was not affected by any treatment. Fresh and dry shoot weight was more in carbofuran treated pots, followed by vermicompost treatment as compared to other treatments. Nematode population was reduced in all treatments over check, but minimum nematode population in roots and soil was found in carbofuran treated pot, followed by root population in vermicompost and soil population in *neem* cake treated pots.

Management of root-knot nematode in chickpea

The treatments *viz*., vermicompost @ 500 kg/ha, *Neem* cake @ 500 kg/ha, *neem* seed powder @ 50 kg/ha, *Trichoderma harzianum* @ 1 kg in 1q FYM/ha, carbofuran @ 1.kg/ha, seed treatment with carbosulfan @ 0.1% v/w and check without any treatment were evaluated with chickpea variety DCP 92-3. Observations were recorded on plant growth parameters, nodules and root knot nematode galls after one, two and three months of sowing. At harvest

Table 15: Reaction of chickpea genotypes based on NMI of *Pratylenchus thornei*

Genotype	Total nematode population (root+soil)	NMI	Reaction	Previous year's reaction
Phule G 5	975	12.7	R	R
RSG 991	1071	14.0	R	R
RSG 931	1072	14.0	R	MR
JG 6	1389	18.2	R	MR
RSG 10	1513	19.8	R	R
Flip 06-72C	1568	20.5	R	MR
IPC 09-161	1757	23.0	R	MR
Phule G 96006	1916	25.0	R	S
RAU 52	3328	43.5	MR	R
ICC 8950	3679	48.1	MR	S
ICC 1356	4012	52.4	MR	HS
GG-2	4143	54.1	MR	R
Katila	4852	63.4	S	R
ICC 1205	5209	68.1	S	HS
ICC 4567	6409	83.8	S	S
Flip 06-12C	6578	86.0	S	HS
Flip 05-154C	6585	86.1	S	HS
IPC 09-35	7299	95.4	HS	HS
DCP 92-3	7651			

of the crop data was recorded on bio mass, grain yield, plant height, number of pods/plant, grains/pod, 100 seed weight, soil population of root knot nematode and gall index on the roots in different treatments.

Data recorded after three months of sowing showed that nodule number, fresh and dry nodule weight was significantly less in chemical treated plants and check. Maximum number of nodules (12.8) was observed in *Trichoderma* treated plants, followed by *neem* cake treated plants. Fresh and dry nodule weight was more in *neem* cake and vermicompost treated plants. Root knot nematode galls were significantly less in all treatments as compared to check (Table 16).

At harvest, plant length was significantly more in treatments with *neem* cake and carbosulfan as compared to check. Dry matter/plant was significantly more in *neem* cake, carbofuran and vermicompost treatments over check. Effect of the treatments on pods/plant, grains/pod, grain yield/plant and 100 seed weight were non-significant.

Table 16: Growth and yield parameters, root knot nematode population and gall index in chickpea at harvest

Treatment	3 Months after sowing						At harvest								
	Nodule No.	Fresh nodule wt. (g)	Dry nodule wt. (g)	Root-knot galls	Pl. ht. (cm)	Dry matter/ plant (g)	Pods/ plant	Grains /pod	Grain yield/ plant (g)	100-seed wt.(g)	Bio-mass (q/ha)	Grain yield (kg/ha)	HI*	G.I.*	Soil popul/ 100 cc
Vermicompost @500kg/ha	11.0	0.275	41	11	32.8	10.63	20	1.0	4.04	12.5	15.2	468	0.29	2.6	133
Neem Cake @500 kg/ha	11.3	0.275	44	13	35.0	13.05	26	1.0	4.19	12.7	16.2	536	0.34	2.5	123
Neem Seed Powder 50 kg/ha	9.6	0.215	35	17	32.5	8.77	23	0.7	2.57	12.5	14.8	476	0.29	2.9	159
Trichoderma @ 1kg in1qFYM/ha	12.8	0.263	30	18	34.3	9.17	23	0.9	3.13	12.2	15.4	466	0.30	2.9	209
Carbofuran @1kg a.i./ha	5.5	0.257	23	11	35.5	11.15	24	0.6	3.17	12.7	17.0	518	0.33	1.9	101
Carbosulfan ST @1% v/w	6.0	0.215	22	13	34.0	9.99	23	0.7	2.60	12.8	16.0	460	0.31	2.8	173
Check	4.2	0.199	20	25	32.0	8.54	20	0.9	2.74	12.2	14.7	425	0.28	3.3	635
CD at 5%	2.1	0.068	7	4	2.6	1.97	NS	NS	NS	NS	1.9	62	0.04	0.8	51

Maximum bio mass (17.0 q/ha) and grain yield (518 kg/ha) was observed in carbofuran treatment, followed by *neem* cake. Harvest index was significantly more in carbofuran and *neem* cake treated plots as compared to check plots. Root knot gall index was lowest (1.9) in carbofuran treated plots as compared to 3.3 in check plants. Juveniles population in soil was lowest (1.1 juveniles/100 cc soil) in carbofuran treated plots and maximum (635 juveniles/100 soil) in check plots (Table 16).

Potentials of Biocontrol Agents for Management of Parasitic Nematodes

Survey was conducted in Ranchi and Khutti districts of Jharkhand and nearly 50 soil and plant samples were collected for analysis. Analysis of soil sample revealed that root knot nematode *Meloidogyne* spp. is prevalent in these areas. The population density was recorded up to 10 J_2/g of soil. Attempts to isolate nematode parasitic fungi from the soil samples yielded negative results.

EXTERNALLY FUNDED PROJECTS

Outreach Project on *Phytophthora, Fusarium* and *Ralstonia* Diseases of Horticultural and Field Crops

Diversity in *F. oxysporum* f sp. *Ciceri*

Fifty nine isolates of *F. oxysporum* f sp. *ciceri* were inoculated on 14 differential genotypes of chickpea (JG 62, CPS 1, C 104, JG 74, JG 315, BG 212, K 850, Chaffa, KWR 108, DCP 92-3, GPF 2, Annegiri, L 550 and IPC 2004-52). Isolates could be categorized in seven races (Table 17). Majority of the isolates (19 nos.) could be grouped in race 2, whereas 14 isolates grouped in to race 5. Only one isolate resembled race 1.

Diagnostics

Molecular characterization of isolates of *F. oxysporum* f. sp. *ciceri* and *F. udum*

Comparative sequence analysis of mitochondrial small subunit ribosomal DNA (SSU rDNA) in16 *F. oxysporum* f. sp. *ciceri* and 15 isolates of *F. udum* isolates was done and phylogenetic relationships was established using neighbor-joining (NJ) methods as shown in Fig. 32. The sequence alignments of *F. oxysporum* and *F. udam* showed highly conserved region and isolates grouped in clades. Multiple alignments of sequences, however, showed some region of greater variability between isolates. In order to get the better resolution between these taxa, additional 13 rDNA SSU sequences from *Fusarium* species were also included in computational analysis (Fig. 33).

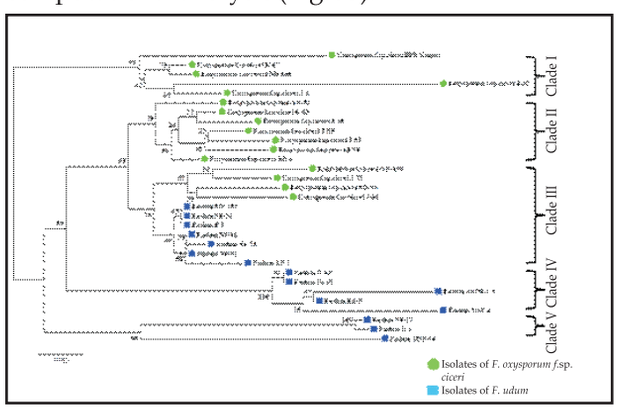


Fig. 32. Sequences based phylogenetic analysis of *Fusarium* species using *neighbor*-joining (NJ) methods

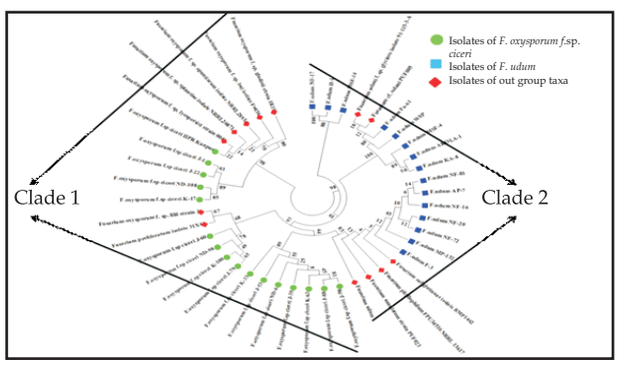


Fig. 33. Sequences based phylogenetic analysis of *Fusarium* taxa using *neighbor*-joining (NJ) methods

Table 17: Grouping of isolates of F. oxysporum f.sp. ciceri based on their reaction on differentials

Race	Isolates	Number of isolates
Race 0	NDFoc 36, NDFoc 108, NDFoc 7, NDFoc 100, KFoc 81, KFoc 73	6
Race 1	KFoc 42	1
Race 2	JFoc 77, JFoc 1, JFoc 98, JFoc 39, JFoc20, JFoc 71, JFoc 53, JFoc 59, JFoc 22, JFoc 21, JFoc 90, JFoc 31, NDFoc 6, NDFoc 90, NDFoc 83, KFoc 76, KFoc 79, KFoc 40, KFoc32	19
Race 3	JFoc35, JFoc 79, NDFoc 50, NDFoc 96, KFoc 1, KFoc 77, KFoc 72, KFoc 33	8
Race 4	JFoc 33, JFoc 37, 66, NDFoc 98, NDFoc 68, KFoc 63, KFoc 29	7
Race 5	JFoc 94, JFoc 8, JFoc 32, JFoc 88, JFoc 57, JFoc 5, JFoc 58, NDFoc 29, NDFoc 67,NDFoc 15, KFoc 25, KFoc 100, KFoc 78, KFoc 17	14
Race 6	NDFoc 64, NDFoc 72, KFoc 65, KFoc 68	4

Based on the variability in the analyzed sequences, taxa were divided into three groups differing in unique nucleotide sequences, indicating insertion-deletion in the domain. The grouping of test sequences with those of closely related out-group taxa confirmed the evolution of closely related species. Homogeneity of substitution patterns in isolates indicates the neutral evolutionary sites are potentially evolving with significantly different substitution patterns. The level of genetic variation observed in the SSU data set ranged from 0.4 to 15.6% and 247 sites were informative showing intergenic variation of SSU sequences between *F.udum* as well as *Foc.* The conservation of the mitochondrial SSU rDNA sequences within species and the degree of inter and intra specific variation found in the *Fusarium* species can be used in developing specific molecular markers.

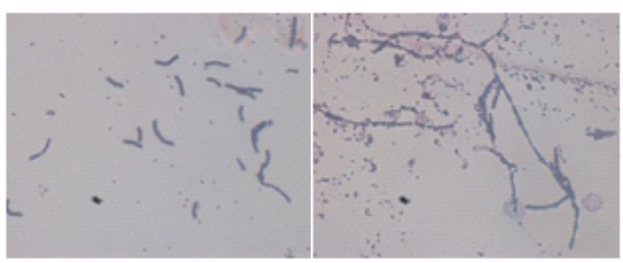
Host Resistance

Chickpea: Total 75 IIPR promising lines consisting of *kabuli* and *desi* types were screened against wilt in a wilt sick field, where susceptible check (JG 62) showed 100% mortality. Thirty one genotypes *viz*., IPC 2005-18, -19, -26, -44, IPC 2007-48, -50, -51, -56, -98, IPC 2009-153, IPC 2010-05, -71, -120, -123, -146, -173, IPC 2011-94, IPCK 2012-154, -198, IPCK 2013-182, IPCK 2013-194, IPC 2014-19, -35, -38, -77, -78, -112, -119, -121, -123 and IPC 2014-136 were found resistant, 18 lines *viz*., IPC 2005-41A, -41B, -52, -59, -62, IPC 2008-10, IPC 2010-61, -185, IPC 2011-28, -76, -99, IPC 2013-37, IPC 2014-124, -129, -133, -156, -158 and IPC 2014-160 were moderately resistant since 2-5 years.

Pigeonpea: Reaction of 29 genotypes *viz*., KPL 44, ICP 8862, KPL 49, IPA 38A, IPA 38B, GPS 33, BSMR 736, BSMR 853, KPBR 80-2-1, PI 397430, KPL 43, IPA 40, Sujatha, ICP 8858, IC8859, Banda Palera, BWR 377, ICP 89046, ICP93812, ICP 89048, ICP89049, ICP 14722, ICP 9174, ICP 93011, AWR 74/15, JAW 5-6A, BDN 1, BDN 2 and ICP 8863 used as donors for wilt resistance was monitored by growing them in wilt sick plot. All the donors were found resistant.

Characterization and Development of Bio-pesticide from Native Microbes for Management of Bihar Hairy Caterpillar in Pulse Crop

In an attempt to isolate *Bacillus thuringiensis,* 41 bacterial isolates isolated from rhizosphere soil were characterized by their 16srRNA sequences. Gram staining was done for all bacterial strains. Twelve isolates shared phylogeny of *B. thuringiensis*, 5 of *B. megaterium*, 3 of *B. cereus*, 18 of *Lysinibacillus* sp. and 2 were outliers (*Pseudomonas* sp. and *Rhodococcus*). Biochemical tests such as sucrose, lactose and trehalose utilization were done for representative bacterial isolates.



Spilosoma obliqua NPV (SpobNPV) isolated from haemocoel of *S. obliqua* larva and mRNA were extracted. RTPCR was conducted and *Polh* gene of SpobNPV was amplified, sequenced and submitted to NCBI Data Bank. Three different formulations of SpobNPV were developed and tested against *S. obliqua*. SpobNPV DNA isolation protocol was standardized. Mitochondrial *CoI* gene was extracted and amplified from *S. obliqua* eggs and thorax.

Basic Science

Identification and Physiological Evaluation of Chickpea Germplasm for Combined Tolerance to Drought and Heat for Improving Yield under Changing Climate

A set of advanced breeding lines from the crosses derived from Tyson x Kaniva were evaluated for combined tolerance to drought and heat under laboratory condition, to inherit high osmotic adjustment and high root biomass in the offspring towards development of combined stress tolerance. One of the parents Tyson has high osmotic adjustment, while Kaniva has low osmotic adjustment with high root depth and mass. A large variation in root traits and osmotic adjustment was observed among the breeding populations, which were further tested at various levels to validate their performance under individual or combined stresses.

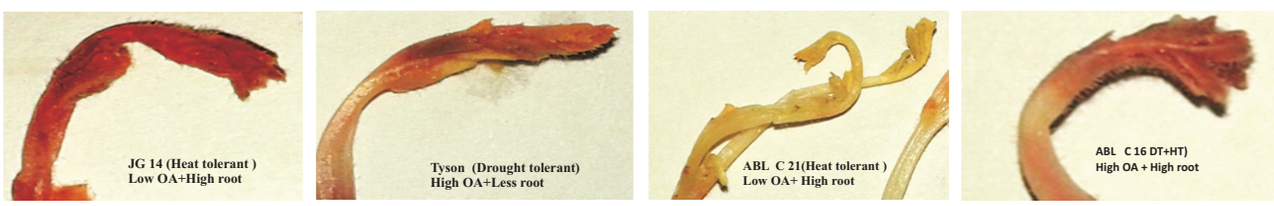
Cell viability: For combined stress treatment seedlings were raised under 20% PEG at 25^{0}C and thereafter high temperature shock was given for 1 h at 43^{0}C. Cell viability was tested by using 1% TTC solution. Lines not taking purple colour to TTC test were selected as sensitive to either high temperature or combined stress. The known heat tolerant genotype JG 14 and drought tolerant variety Tyson were identified as TTC positive as their shoot tips developed purple colour to 1% TTC. Breeding line C 16 expreesed high root as well as heat tolerance indicating combined tolerance to heat and drought (Fig. 34).

Fluorescence imaging: Phenotyping for drought and heat combined using chlorophyll fluorescence imaging revealed that genotypes C 214 and C 235 both were adversely affected when both stresses were imposed as the intense blue colour quantum yield (Fv/Fm) images largely deviated from the normal heat treatment alone (Fig. 35). On the contrary, the drought tolerant genotype Tyson with high osmotic adjustment ability was least affected under combined stress.

Photosynthetic electron transport rate (ETR): The relative comparison of photosynthetic electron transport (ETR) demonstrated that under combined stress high irradiance tolerance limit diminished and almost declined to minimal level if PAR exceeded beyond 300 (µmol $m^{-2}s^{-1}$). Breeding lines C 7 and C 8 derived from Tyson x Kaniva showed very high ETR under limiting irradiance level. Osmolytes content, SPAD chlorophyll and membrane stability in Tyson x Kaniva derived lines showed significant variation indicating reasonably moderate to high heritability in above traits. The osmolyte content in dehydrated leaves had fairly good association with chlorophyll content and membrane stability. The results showed that for combined tolerance, tagging of root traits and osmotic adjustment could be useful for efficient water mining as well as accumulation of osmoprotectants to impart tolerance to heat stress. Heat tolerant chickpea variety JG 14 and drought tolerant variety Tyson showed high degree of TTC positive test indicating high heat tolerance, however both the genotypes had different mechanisms of tolerance that is JG 14 has high root system, while Tyson has high ability of osmotic adjustment. Therefore it is essential to combine both traits for inheriting combined tolerance.

Mitigation of drought by using elicitor SA and foliar application of nitrogen

Foliar spray of 2% urea along with 1 µmol salicylic acid significantly increased the total number of seeds, seed weight , biomass per three plants and plot yield. SA acid alone could mitigate the adverse effect of drought and improved yield and biomass significantly (Table 18), however supplementing nitrogen application had additional advantage towards further yield increase.



OA;osmotic adjustment ; DT : Drought tolerant ; HT: Heat tolerant ; ABL : Advanced breeding lines

Fig. 34: Cell viability after heat shock at 39^0 C of known heat and drought tolerant chickpea genotypes and advanced breeding lines with different physiological attributes

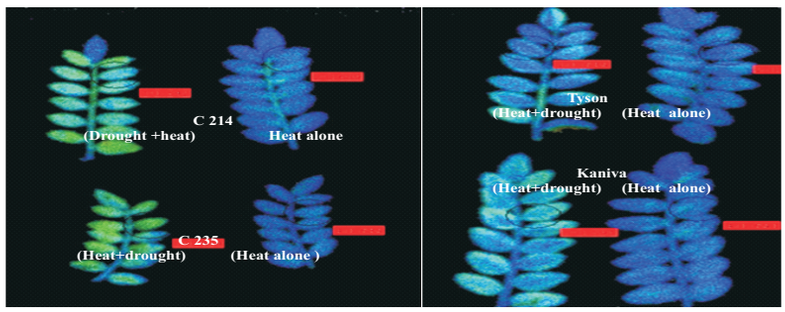


Fig. 35 : Photosynthetic quantum yield (Fv/Fm) images of chickpea subjected to heat alone or combined stresses *e.g.* drought (PEG 20%) and heat shock at 39^{0}C

Table 18: Effect of salicylic acid (SA) on yield attributing traits under drought

Treatment		Seed wt (g)	Seed number	Biomass(kg)	Yield/plot(kg)
Drought	ICC 92944	12.95	51.00	10.37	0.67
	DCP 92-3	10.95	38.33	5.93	0.58
SA + Drought	ICC 92944	8.53	83.33	14.50	0.75
	DCP 92-3	5.87	72.00	11.57	0.66
Urea + Drought	ICC 92944	11.37	72.33	12.70	0.69
	DCP 92-3	10.74	70.00	11.43	0.67
Urea + SA + Drought	ICC 92944	18.94	121.67	21.27	0.81
	DCP 92-3	12.95	93.00	11.13	0.73
CD 1%		2.65	7.86	2.05	0.08

Treatment difference is significant at 1% level.

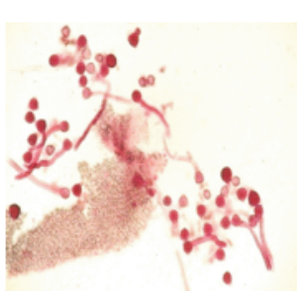
Physiological Response of Mungbean to Photo-thermo-periods and Identification of Insensitive Genotypes for Different Photo-thermal Regimes

Mungbean genotypes were screened for their response to photo-thermo-periods and five mungbean genotypes *viz.*, IPM 203-4, IPM 2-16, IPM 302-2, IPM 99-125, IPM 3-1 were identified as photo-sensitive, while PDM 54, PDM 288, IPM 03-2, IPM 2-14, IPM 03-3 were photo-insensitive. Genotypes *viz.*, PDM 139, Pusa Vishal, Pusa Bold, PDM 281 and PDM 84-143 were identified as high yielding genotypes. Seeds of above genotypes were sown in glass house on 3 January at normal temperature. Pots with 28 days old plants of each genotype were shifted to growth chambers having temperature regimes of 25^{0}C, 36^{0}C, and 40^{0}C. Observations were taken on phenological characters *viz.*, days to flowering, podding, maturity, pollen viability, and pollen germination. Pollen germination was poor in plants grown at 40°C as compared to 25°C, 36°C temperature and recorded higher yield reduction (Table 19).

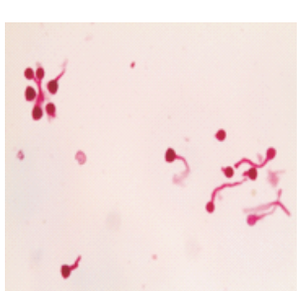


Mungbean growth at 25°C, 36°C and 40°C

Pollen germination: At 25°C temperature pollen germination took place in all the genotypes whereas, minimum germination were observed when temperature increased above 40^{0}C. Good growth of pollen tube was observed in genotype PDM 288, PDM 54, PDM 2-3, PDM 2-14 and IPM 03-2.



Pollen tube formation at 25°C in genotype PDM 288



Pollen tube formation in genotype PDM 54 at 40°C

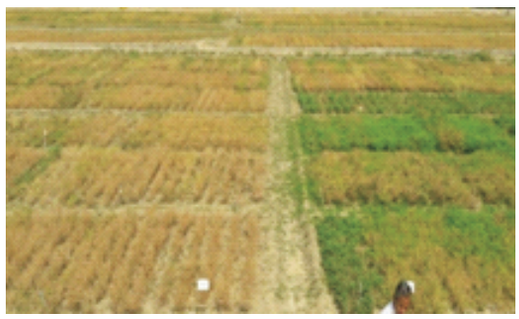
Table 19: Days to flowering and podding at 25^{0}C and 40^{0}C temperature in mungbean genotypes

Variety*	Days to flowering		Days to podding		Photo period sensitivity (%)
	40^{0}C	25^{0}C	40^{0}C	25^{0}C	
PDM 54	20	20	56	59	0.00
PDM 288	19	19	56	67	0.00
IPM 03-2	20	19	59	59	5.26
IPM 02-14	22	21	56	67	5.26
IPM 03-3	21	21	57	67	14.28
IPM 203-4	26	22	58	58	9.52
IPM 02-16	25	20	60	67	18.18
IPM 302-2	22	19	57	68	25.00
IPM 99-125	22	21	58	60	15.78
IPM 03-1	29	25	61	68	13.63
PDM139	25	22	61	69	4.76
Pusa Vishal	26	24	62	68	4.00
Pusa Bold	27	25	61	37	8.33
PDM 281	25	20	63	69	25.00
PDM 84-143	29	24	59	70	16.00

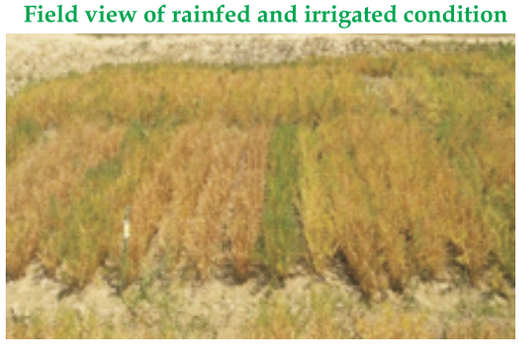
*Genotypes PDM 54, PDM 288, IPM 03-2, IPM 02-14, IPM 03-1, Pusa Vishal are photo insensitive types.

Drought Induced Leaf Senescence in Chickpea: Amelioration through Plant Growth Regulators

One hundred chickpea genotypes including released varieties and ICRISAT mini-core were sown in augmented design under rainfed and irrigated conditions to screen the genotypes having drought induced delayed leaf senescence trait. Plants were assessed for leaf greenness using SPAD chlorophyll meter reading (SCMR), relative water content (RWC), membrane stability index (MSI), leaf senescence rate (LSR), greenness index (GI) and yield components. Lines with delayed senescence showed to resist drought induced premature plant senescence. Delayed senescence genotypes showed lesser reduction in LSR and significantly higher GI as compared to genotypes with faster senescence. Genotypes with delayed senescence showed higher biomass, grain yield, harvest Index (HI) and better adaptation under drought. Genotypes possessing ability to maintain delayed senescence and high relative water content traits throughout grain filling are potential candidates to assure higher yield. Visual score ratings were a reliable indicator of leaf senescence and could be useful for chickpea breeders in evaluating physiological changes of chickpea leaf canopy over time. The results showed that there are some genotypes which show contrasting behavior for senescence in chickpea under rainfed and irrigated conditions.



Field view of rainfed and irrigated condition



Evaluation of chickpea lines for drought induced leaf senescence

Physiological Basis of Salt Tolerance in Blackgram

In a pot experiment 50 blackgram genotypes were evaluated under saline and non-saline conditions. Mixtures of salt were applied through nutrient solution at the time of sowing, equivalent to 5.8 dS m^{-1}. Vegetative dry weight revealed significant difference between the genotypes under the saline and non-saline conditions. Under saline conditions, the per cent reduction in biomass at vegetative stage increased as compared to the non-saline conditions. Comparatively less reduction (6.16-11.36 %) in biomass was recorded over non-saline condition in genotypes *viz*., IC 21001, IPU 2-43, IPU 99-123, MS 131, NODAI URD, RTM 10, LBG 645, STY 2801, Bara nabada and UH 85-3, whereas, more biomass reduction (28-41%) was observed in WBU 108, TU 91-22, TU 17-4, LBG 685, KUG 365, CO 5, TU 40 and SPS 39 (Fig. 36).

Quantification of Biologically Active Components in Pulses Having Potential Impact on Human Health

Mature seeds of 22 pigeonpea and 26 urdbean genotypes were analyzed for second consecutive year to study the genotype as well environmental variability on quality components like protein content, carbohydrate content, total dietary fibre, raffinose family oligosaccharides and also for

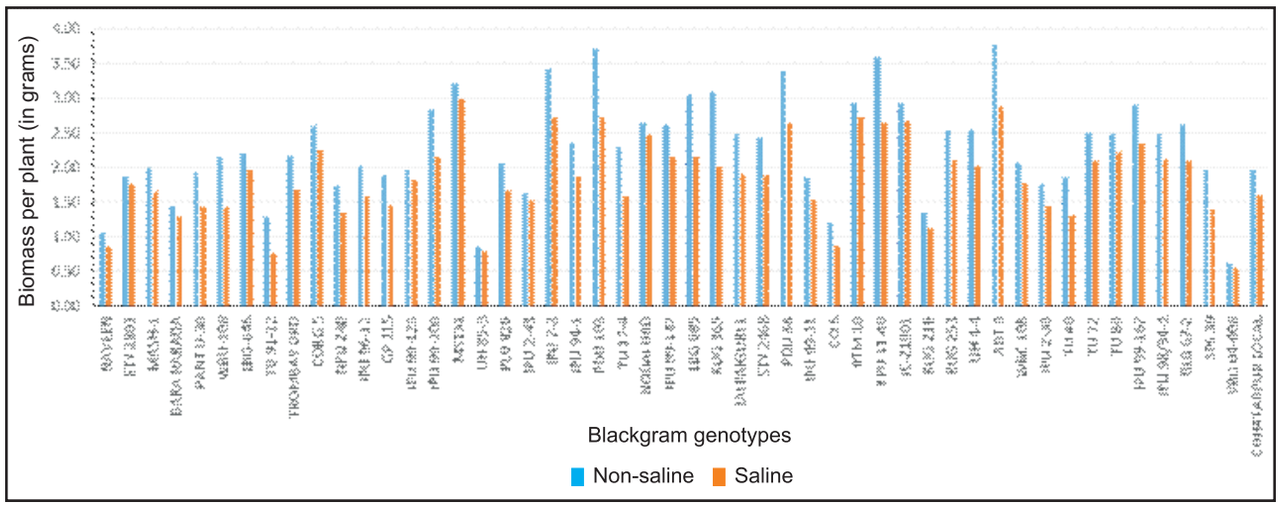


Fig. 36: Effect of salinity on dry biomass at vegetative stage of blackgram

micronutrients like Zn and Fe. Besides this the anti nutrients like phytate, phenol content and trypsin inhibitor activity as well total antioxidant activity was also analyzed in the same set of genotypes.

Carbohydrate profile in pigeonpea and urdbean genotyes

Total carbohydrate content in pigeonpea genotypes ranged from 46 to 68.6 %, whereas it was 36.7 to 76.7% in urdbean. In pigeonpea genotypes the D-glucose concentration ranged from 1.37 to 2.02, sucrose from 1.65 to 7.04 and oligosacchardies ranged from 4.49 to 7.95 mMoles/100g, whereas in urdbean genotypes it ranged from 1.27 to 1.49, 1.32 to 4.53 and 2.61 to 5.21 mMoles/100g, respectively. Comparatively higher oligosaccharide concentration was recorded in pigeonpea genotypes (Mean= 6.53 mMoles/100g), as compared to urdbean (Mean= 3.52 m moles/100g). Total dietary fibre ranged from 13.7 to 36.4% in pigeonpea and 10.8 to 33.5% in urdbean genotypes. Mean dietary fibre content was higher in pigeonpea (24.6%) as compared to urdbean genotypes (21.5%).

Genetic variability for micronutrients

In pigeonpea, mean Fe content of two years ranged from 53.57 to 77.04 ppm with mean value of 64.01 ppm, whereas, Zn content ranged from 16.72 to 34.82 ppm with mean value of 24.90 ppm (Fig. 36). Comparatively higher Fe (71.02 to 100.20 ppm) and Zn (18.93 to 60.58 ppm) content was recorded in urdbean genotypes (Fig. 37). In contrast to Zn with significant genotype x year variation, Fe content of the genotypes remained stable over the years and did not vary significantly from one year to other. No significant positive correlation was found between Fe and Zn. There were some urdbean varieties like Shekhar 2, PDU 1 and PU 31 which showed high Fe as well as Zn content, however some varieties like MASH 114, RTM1 and MS 131 had high Fe content, but very low Zn content.

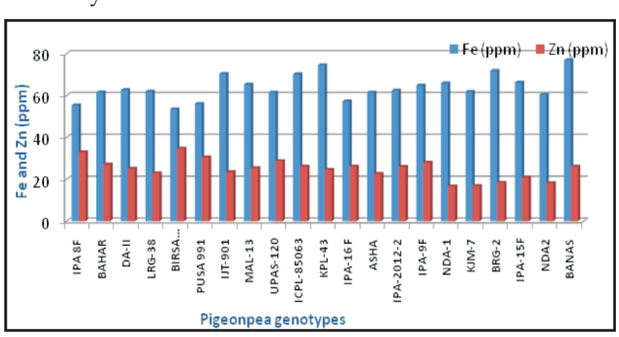


Fig. 36: Fe and Zn content in pigeonpea genotypes

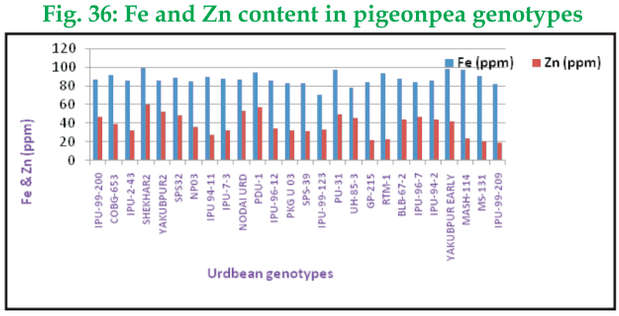


Fig. 37: Genetic variability for Fe & Zn in urdbean

Total phenol content and antioxidant activity

The mean of phenol content of two years in pigeonpea genotypes ranged from 0.6 to 5.6 mg GAE/g with mean values of 3.2 mg GAE/g and it was 4.6 to 9.3 mg GAE/g, with mean values of 6.6 mg GAE/g in urdbean. Total antioxidant activity utilizing DPPH was estimated in pigeonpea and urdbean genotypes for both the years. Mean AOA activity in pigeonpea genotypes ranged from 0.45 to 3.25 µmoles TEA/g, whereas, in urdbean it ranged from 12-26 µmoles TEA/g.

Variability for phytic acid and trypsin inhibitor activity

Phytic acid content in the pigeonpea genotypes was estimated using the megazyme kit. The mean values for two years varied from 0.14 to 0.86 %, with mean values of 0.34 % (Fig. 38), whereas in urdbean it ranged from 0.07 to 0.0.37 g/100g, with mean of 0.21% (Fig. 39). In pigeonpea, mean trypsin inhibitor activity of two years was 3.38 TIU/mg protein and it ranged from 1.35 to 6.95 TIU/mg protein, while in urdbean it was 0.57 to 10.9 TIU/mg protein with mean of 4.23 TIU/mg.

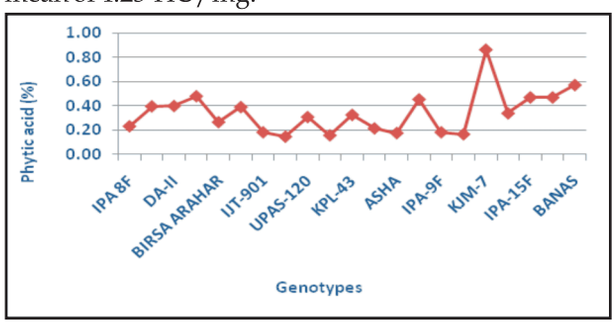


Fig. 38: Mean phytic acid in pigeonpea genotypes

Correlation among seed quality parameters in urdbean genotypes

The genotypic and phenotypic correlations coefficients between four seed quality traits in urdbean are presented in Table 20 and 21. Fe content in genotypes showed positive phenotypic correlation with Zn content only, while at genotypic level in addition to Zn, it showed positive correlation with phytic acid and polyphenol content as well. This indicates that although the traits are genotypically correlated, the expression is masked by the environmental influence. The zinc content among the genotypes showed positive correlation with polyphenol content at both phenotypic and genotypic level. Such linkage is undesirable and may lead to decreased bioavailability of essential amino acids, enzymes and proteins. The phytic acid showed negative correlation with polyphenol content among genotypes. Thus with an increase in phytic acid content, there is a corresponding decrease in the polyphenol content.

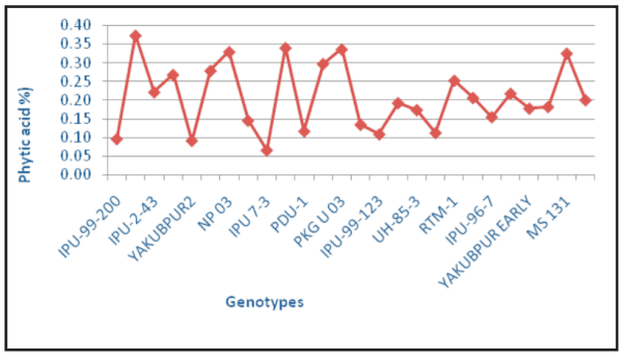


Fig. 39: Mean phytic acid in urdbean genotypes

Table 20: ANOVA for quality traits in 26 lines of urdbean

Source	Mean sum of square due to				
	df	Fe	Zn	Phytic acid	Polyphenols
Replications	2	0.45	2.40	0.00	1.38**
Genotype	25	255.66**	864.57**	0.05**	3.22**
Year	1	2.80	32.89**	1.97**	197.66**
Genotype x year	25	13.06**	8.84**	0.05**	4.95**
Error	102	3.24	2.43	0.00	0.10

** Significant at P = 0.01

Table 21: Estimates of genotypic (rG) and phenotypic (rP) correlation coefficient among quality traits in urdbean

Character		Zn (ppm)	Phytic Acid	Polyphenols
Fe (ppm)	rG	0.234*	0.363**	0.330**
	rP	0.226*	0.146	0.203
Zn (ppm)	rG	1.000	-0.049	0.624**
	rP	1.000	-0.006	0.416 **
Phytic acid	rG		1.000	-0.041
	rP		1.000	-0.438 **

** Significant at P = 0.01, * Significant at P = 0.05

Table 22: Genetic variability for protein content in pulse crops

Crop/No. of genotypes	Mean protein (%)	Range	Genotypes with high protein content
Chickpea/53	23.6	20.7-28.2	ICC 17196 (28.4%), RAJ 52 (26.8%), Vijay, Pusa 329 (26.6%), CSG 8962 (26.3%) PBG 5 (25.8%), Annigeri 1 (25.8%)
Lentil/110	20.96	14.76-27.13	IG 5187 (27.135), T 36 (26.33%), DPL 15 (25.93%)
Pigeonpea/21	21.44	18.63 - 24.63	Banas (24.63%), LRG 38 (23.88%), KPL 43 (23.25%)
Urdbean/26	26.2	20.7 - 28.6	CoBG 653 (28.6%), PU 31 (28.1%), Yakubpur Early (27%)

Values in bracket indicate % protein content.

Enhancing Protein Content in Pulses

In chickpea, seed protein content of 53 genotypes was estimated using kjeldahl N, where protein content varied from 20.69 to 28.21%. Mean protein content in *desi* types was slightly higher (24.81%) as compared to *kabuli* types (23.31%). Wild accessions showed maximum protein content (28.21%).

In lentil, seed protein content of 100 genotypes including landraces and some wild accessions was estimated. Mean seed protein content was 20.96 % and it varied from 14.76% to 27.13 %.

Comparatively less variation for protein content was recorded in a set of pigeonpea released varieties and few landraces, where the protein content varied from 18.31 to 24.63 % with mean of 21.44%. Maximum protein content was recorded in genotype Banas and LRG 38. In urdbean, 28 genotypes were tested for protein content, which varied from 20.7 to 28.6% with mean values of 26.2 %. (Table 22).

Biochemical Characterization of Heat Shock Proteins and Anti-oxidative Defense Mechanism in Chickpea Genotypes

Free radical scavenging activity in seeds of 22 chickpea genotypes were estimated by using 1, 1-diphenyl-2-pycrylhydrazyl (DPPH) radical scavenging assay. Genotype KWR 108 showed maximum level of free radical activity (65.21%), whereas ICC 10685 had minimum free radical scavenging activity (14.51%). The free radical scavenging activity range varied from 20.28 to 65.21% among the genotypes.

Biochemical and physiological response to heat stress was studied among 10 contrasting chickpea genotypes (including susceptible and tolerant genotypes) at normal and late sown conditions. Antioxidant enzymes *viz*., superoxide dismutase (SOD), peroxidase (POX) and glutathione reductase (GR) activity were assayed at flowering stage in leaf tissue. Highest SOD activity was observed in ICC 15614 in late sown condition, whereas in ICC 1205 genotype in normal sown condition. ICC 8950 showed highest POX activity in late sown, whereas ICC 15614 in normal sown condition. Genotype PG 5 showed higher GR activity in late sown, while ICC 8950 showed higher GR activity in normal sown condition. PG 5 maintained higher relative water content, chlorophyll and carotenoid content in late sown as compared to other contrasting genotypes. Under late sown or heat stress condition PG 5 showed higher membrane stability index and lowest heat susceptibility index (%) therefore, PG 5 was less affected by heat stress.

Genotypic Variation in Chickpea Varieties for Nodulation and P-nutrient Acquisition Efficiency

P-use efficiency in 30 different chickpea genotypes was assessed by growing on soil with low and high phosphorus availability. Soil analysis showed that phosphorus deficient soil contained total-P and Olson's-P levels of 790.0 and 7.54 mg/kg soil, respectively as compared to the high-P soil containing 1706.0 mg/kg total-P and 11.62 mg/kg, Olson's-P. Total carbon and organic carbon concentrations in P deficient and high-P soils were also significantly different (Fig. 40). Chickpea genotypes were grown in two blocks with contrasting P-availability and organic carbon content. Plant growth and development was assessed by determining shoot dry weight at three different growth stages. There were significant variations in P-use efficiency and growth among the chickpea genotypes with highest P-use efficiency in genotypes ICC 1194 and ICC 8058, while low use efficiency was recorded in ICC 3230, ICC 15406 and IPC 2009-45.

Root hairs development and its relationship with growth and nutrient uptake were also assessed in six different genotypes (Fig. 41). There were significant differences in both root hairs density and

length among the genotypes. The root hair density and length in chickpea, though important genotypic dependent traits, are not primary determinant for the P-use efficiency.

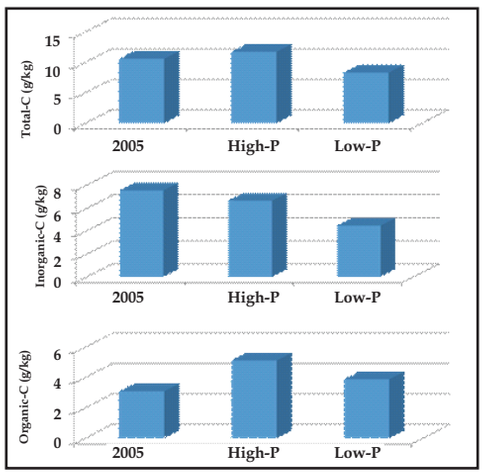


Fig. 40: Total-C and organic carbon content in low and high phosphorus availability soil

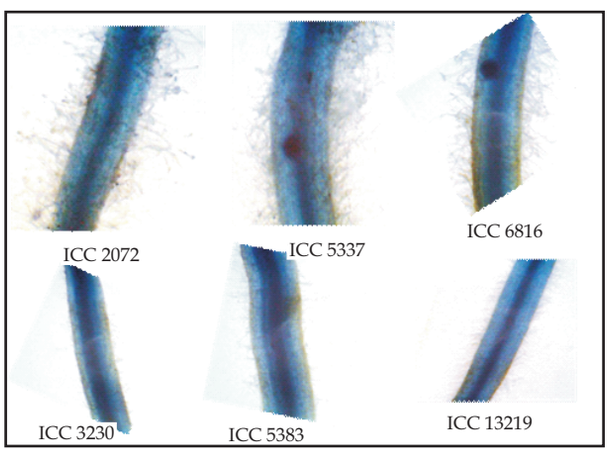
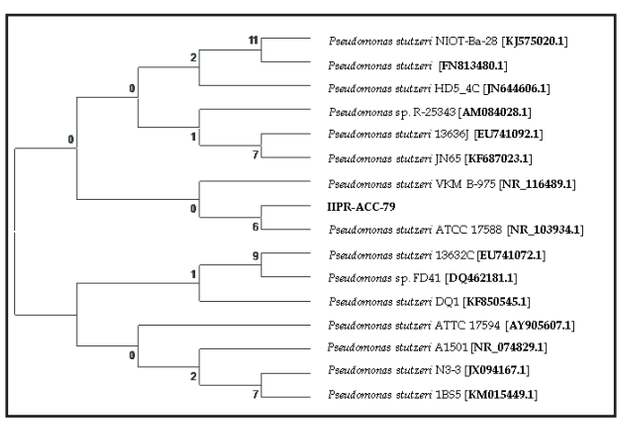


Fig. 41: Root hair development in chickpea genotypes

Development of Microbial Consortium for Drought Stress Management

Bacterial endophytic strains such as NE-138, NE-85, Ne-142, NE-272, NE 77, NE-26 and NE-310 were identified for their plant growth promoting potential. Chickpea was grown in hydroponic system with different concentration of polyethylene glycol to create various levels of stress. The photo-system efficiency under different stress level was identified with chlorophyll fluorometer. Osmotic potential level of -1.25 Mpa was determined as critical point and bacterial isolates (Nodule endophytes 127, 173 and 268) promoting photo-system efficiency at this stress level can be considered as beneficial bacteria. These isolates were screened for plant beneficial traits like production of IAA and ACC deaminase. Under stressed condition, IAA produced by rhizobacteria loosens the plant cell walls thereby facilitating root exudation. Selected bacterial isolates were assessed for their maximum stress tolerance level and ability to produce EPS under no stress and maximum stress level (−0.30 MPa). Exo-polysaccharide fraction from bacterial supernatant was precipitated using three volumes of pre-chilled acetone and dry weight of exo-polysaccharide of selected isolates was in the range of 32.82-81.62 mg/l. 16S-rDNA was amplified by using the primers 27F (5'-AGAGTT TGATCCTGGCTCAG-3') and 1492R (5'-GGTTACCTTGTTACGACTT-3') and sequenced. The DNA sequences were subjected to BLASTn analysis with NCBI data base and the phylogenetic tree indicated that some of the ACC deaminase producing bacterial strains like IIPR-ACC-3 belong to *B subtilis,* while IIPR-ACC-79 belongs to *Pseudomonas stutzeri.*

Field experiment was carried out to test the potential of ACC deaminase producing bacteria on improving grain yield of chickpea, lentil and fieldpea under rainfed condition. IIPR-ACC-68 and IIPR-ACC-16 enhanced grain yield of chickpea and lentil, while IIPR-ACC-16 and IIPR-ACC-10 recorded 19.48% higher grain yield of fieldpea. Total yield enhancement by bacterial inoculation was correlated with higher number of seeds per inoculated plant. Increase in number of pods and seeds per plants inoculated with ACC deaminase producing bacteria and *M. ciceri* strain CR-13 was directly correlated with higher yield.



Phylogenetic relationship of ACC deaminase producing bacterium IIPR-ACC-79



Uninoculated control | ACC deaminase bacteria inoculated

Beneficial effect of ACC deaminase producing bacteria on lentil growth under rainfed condition

Studies on Diversity of PPFM (*Methylobacterium*) in *Vigna* and Fieldpea and Their Potential on Plant Growth Promotion

Total 40 PPFM isolates from *Vigna* sp. and 43 isolates from fieldpea were assessed for their plant growth promoting activities like IAA production and plant biomass enhancement. IAA production potential of the PPFM isolates was quantified under *in vitro* condition. The best three isolates from mungbean (MV-33, MV-11, and MV-1) and fieldpea (MF-8, MF-25, MF-32) were selected for further analysis. Presence of methanol dehydrogenase gene (*mxa* F) in elite PPFM isolates of mungbean, urdbean and fieldpea cultivars were detected by PCR amplification. 16 S rDNA of the PPFM isolates of *Vigna* spp were extracted and diversity profile of the PPFM isolates was studied by RFLP profile. Phylogenetic tree based on 16S rDNA-PCR-RFLP indicated that PPFM isolates are clustered into four groups.

Interactive Effect of Lentil Genotypes-Rhizobium on Biological Nitrogen Fixation

Total 120 lentil genotypes with ten varietal checks were screened for high biological nitrogen fixation. Based on earliness in nodulation early, mid and late nodulation genotypes were identified. Genotypes contrasting in nodulation and biomass were also identified and based on these parameters the genotypes were categorized as excellent, good and poor nodulators with high and low plant biomass (Table 23).

Persistence and Degradation of Post-emergence Herbicides in Soil, Plant and Seeds of Summer and *Kharif* Pulse Crops

Residue level of imazethapyr

Persistence and degradation studies of imazethaypre herbicide were conducted in field and pots. Soil samples from the herbicide treated field of mungbean were collected periodically starting from just after 2 hr of spray and then on a regular interval of 10 days and were immediately processed for extraction of herbicide and cleanup. Cleaned samples of both of the experiments *viz*., field and pot were analyzed *via* HPLC and LCMS. Soil samples collected from field experiments revealed Imazethapyr residue level to the tune of 0.0044, 0.0042, 0.004, 0.0034 and 0.0032 mg/g of soil at intervals of 2 hr, 5th, 15th, 25th, 35th, and 45th days, whereas, in case of pots the residue level was found in range of 0.076 (after 2 hr. of spray) to 0.046 (after 70th day of spray). In both experiments, the observed residual values of the herbicide were found far less at any stage of time than the prescribed MRL value (0.1mg/g) of imazethapyr, however the herbicide was found to persist long in case of pot as compared to field.

Dissipation pattern and effective time

The degradation of imazethapyr was found to follow as per first order kinetic equation *viz*., $[dMi/Dt=K(M_{\alpha}-M_i)]$. Based on obtained residue data of both experiments *i.e*., field as well as pot, it was observed that in NRF field where soil is sandy in nature, 50% of the herbicide got dissipated within a period of 50 days of spray (calculated $T_{1/2}$ =51 days average K = 0.01368), whereas, in pots (containing soil of main farm) the 50% concentration of the herbicide was found to persist up to a period of 118 days (calculated $T_{1/2}$ =118 days, k=6.2X10^{-3}) and 90%

Table 23: Contrasting lentil genotypes in terms of nodulation and biomass

High biomass	Low Biomass
Excellent Nodulators : 7-10 effective nodules in crown root zone (region upto 5cm below the first lateral roots)	
IC-428610, IC-429151, IC-429159, IC-429195, IC-418150, IC-428229, IC-428249, IC-428999, IC-429081,IC-429092, IC-429094, DPL-15	IPL-316, IC-428875, IC-428878, IC-429482, IC-428914, IC-428175, IC-428192, IC-429072
Good Nodulators: 5-7 effective nodules in crown root zone	
IC-428605, IC-429159, IC-428526, IC-429172, IC-429222, IC-429283, IC-428755, IC-428156, IC-428237, IC-428238, IC-428247, IC-429075	IC-428558, IC-428606, IC-428607, IC-428608, IC-428616, IC-428625, IC-428448, IC-428464, IC-428469, IC-429148, IC-429072
Poor Nodulators: 0-2 effective nodules in crown root zone	
IPL-81, DPL-58, IC-428710, IC-428713, IC-428741, IC-428747, IC-428957, IC-429034, IC-428654, IC-428619 ILL-7663	IC-428444, IC-428482, IC-428614, IC-428615, IC-428658, IC-428943

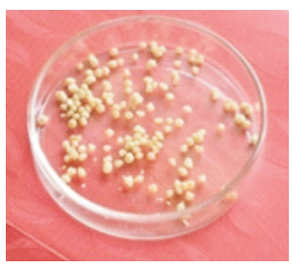
Table 24: Imazethapyr residue and degradation pattern in field and pot experiment

Sampling (at day)	Imazethapyr residue (mg/g soil)						Dissipation pattern					
	In field			In pot			In field			In pot		
	λ_{max} 254	λ_{max} 230	% dissip.	λ_{max} 254	λ_{max} 230	% dissip.	K	$T_{1/2}$ (days)	$T_{eff.}$	K	$T_{1/2}$ (days)	persistance
2hr.	0.0041	0.004	0.00	0.082	0.076	0.0						
5th	0.0038	0.004	5.9				$1.2X10^{-2}$	57	$T_{eff.}$= 24.36 days 25-30d			
10th	-			0.079	0.072	4.4				$4.5X10^{-3}$	153	
15th	0.0029	0.004	18.8				$1.3X10^{-2}$	50				Average K = 0.00589 calculated persistence =393 Days
20th	-			0.078	0.069	6.7				$3.6X10^{-3}$	192	
25th	0.0023	0.003	32.9				$1.5X10^{-2}$	43				
30th	-			0.071	0.064	14.5				$5.2X10^{-3}$	132	
35th	0.0021	0.003	37.6				$1.3X10^{-2}$	52				
40th	-			0.065	0.058	22.1				$6.2X10^{-3}$	110	
45th	0.0018	0.003	44.7				$1.3X10^{-2}$	53				
50th	-	-	-	0.058	0.054	29.1	Average k value= 0.01368 Average $T_{1/2}$=51 Days			$6.8X10^{-3}$	110	
60th	-	-	-	0.051	0.052	34.8				$6.8X10^{-3}$	102	
70th	-	-	-	0.042	0.046	44.3				$7.7X10^{-3}$	90	

herbicide got decayed in 393 days. Compared to pots, fast dissipation of the herbicide in field may be due to faster removal of herbicide by the mechanism of microbial degradation in addition to its removal by leaching and exposed sun light (photo-degradation). Based on dissipation studies and calculated average K=0.01368, the effective period ($T_{effect.}$) in field was calculated as 24.36 d which suggest that once sprayed, the herbicide can only provide protection to crop against weed up to a maximum period of 25-30 days. Residue level at different interval of time and dissipation pattern of imazethapyr in field and pots are given in Table 24.

Granular formulation of imazethapyr

A sustained release granular formulation was prepared by binding the imazethapyr molecules with sodium alginate and making beads of approximately 40-60 mesh size by dropping the mixture of alginate and imazethapyr drop by drop in calcium chloride solution. The developed granular formulation when applied to chickpea field at time of sowing was found to cause no damage to the plants up to its concentration of 200 g/ha and minimal damage at 250 g/ha was recorded after some time. Bioefficacy evaluation was done by recording the density and biomass of major weed flora on 50x50 cm quadrate in field. Phytotoxicity observations on leaf injury on tips/surface, necrosis, wilting, vein clearing, epinasty and hyponasty on chickpea plants were recorded at 40 and 50 DAS in all treatments. In addition to decreased damage to the crop the granules also proved beneficial in reducing pesticide spike concentrations in the environment, prolonging residual activity and reducing the number of applications. Apart from the safety point of view, the granular formulation was found highly effective in reducing total weed population and their biomass by more than 80% as compared to control at single application concentration of 200 g/ha.



The developed granular formulation of imazethapyr

EXTERNALLY FUNDED PROJECTS

National Initiative for Climate Resilient Agriculture

About 100 genotypes each of mungbean, urdbean and pigeonpea were collected in addition to mini-core set of 150 pigeonpea from ICRISAT, exotic collections and wild accessions. All these genotypes were subjected to evaluate under different hot spots/climatically fragile ecosystems during the initial two years. These locations were Kanpur, Durgapura, Ludhiana, Badnapur, Gulbarga and Vamban. Promising lines were identified and a set of 30 genotypes of each crop were further evaluated at the same locations for further two years for

validating their potentials towards higher yield and resilience under diverse climatic conditions. The important research strategies have been made using these sets of germplasm identified under field conditions thereafter towards initiating crossing programme, development of varieties, precision phenotyping for tolerance to various abiotic stresses and deciphering adaptive mechanisms for tolerance to heat, drought, salinity, frost and water-logging and development of agronomic practices to mitigate the stresses. Salient findings are as follow:

Development of precision phenotyping

1 Pollen viability/germination/microsporogenesis/stigma receptivity at high temperature
2 Cellular viability using TTC after 1 h temperature shock at 45-50^{0}C
3 Chlorophyll fluorescence imaging to test their photosynthetic performance under stresses
4 Membrane injury test
5 Thermal induction response (TIR)
6 Antioxidant complex in response to high temperature
7 Mortality frequency under water-logged condition/root hydraulic resistance/chlorophyll retention and presence of arenchymatous cells for water-logging resistance
8 Osmotic adjustment for drought tolerance
9 Water-use efficiency using carbon isotope discrimination sing carbon isotope discrimination
10 Regeneration of meristems after chilling/frost injury
11 Hydralic resistance of roots under sodic soil.
12 Protein /DNA profiling /Molecular/ Biochemical characterization

Identification and Characterization of Photo- and thermo-Insensitive *Vigna* Accessions

Photo-thermo-insensitive and thermotolerant genotype PGRU 95016 of urdbean has been identified. It is characterized by flowering at both 10 and 16 h photoperiod , and at both 25/15^0 and 36/20^{0}C max/min temperature and pollen germination at 43^{0}C.

Identification of drought tolerant genotypes

Based on osmotic adjustment, isotope discrimination (^{13}C/^{12}C) and yield performance under rainfed multilocation trials, pigeonpea genotypes *viz*., JKM 7, JSA 59, RVK 275, Bennur Local, BDN 2008-12, JKM 189 and VKS-11-24-2 were identified as drought tolerant.

Total 40 pigeonpea genotypes were grown under rainout shelter (drought) with 6% soil moisture during podding (at 90 cm depth). The osmotic adjustment in the best performing genotypes was recorded as follows:

Genotype	Osmotic adjustment (MPa)	Degree of drought tolerance
ICP 6971 (mini-core) collection	2.1	Highly drought tolerant
collection		
JSA 59	1.6	Drought tolerant
ICP 348	1.4	Drought tolerant
MAL 13	1.2	Moderate drought tolerant
BAHAR	1.1	Moderate drought tolerant
ICP 14832	0.9	Moderate drought tolerant
BDN 2008	1.25	Moderate drought tolerant
BSMR 853	1.3	Drought tolerant
ICP 13304	1.4	Drought tolerant
ICP 16049	1.5	Drought tolerant
ICP 668	1.6	Drought tolerant
TTB 7	1.0	Moderate drought tolerant

Identification of heat tolerant genotypes

Wild pigeonpea *Cajanas Scarabaeoides* lines were identified which are able to set pod at 47^{0}C and fertile germinating pollen at 47^{0}C.

Physiological and molecular characterization of heat tolerant mungbean

Fluorescence imaging, TTC test and pollen fertility test confirmed heat tolerance in mungbean exotic line EC 398889 which was compared with

highly sensitive line LGG 460. Molecular profiling of 8 *Vigna* accessions was done using 79 SSR markers of which 11 were found polymorphic. From the 11 polymorphic primers, 3 markers showed clear cut differentiation between heat tolerant and susceptible genotypes. The markers exhibited a large amount of genetic variability among different accessions. The marker CEDG 147 distinguished both tolerant and susceptible group of accessions. It amplified at 300 bp in identified tolerant genotype EC 39889 and 285 bp in sensitive genotype LGG 460. Similarly, another marker CEDG 247 also distinguished tolerant genotype EC39889 at 161 bp and sensitive genotype LGG460 at 168 bp. Likewise, marker CEDG 044 was also able to distinguish between tolerant and sensitive genotype in EC39889 at 192 bp and LGG460 at 162 bp, respectively.

Water logging resistance

Water logging resistant of pigeonpea was identified (IPAC 79, MAL 9) based on mortality, Chlorophyll retention and arenchyma cells.

Frost tolerance

Three promising pigeonpea lines *viz.*, IPAC 80, IPAC 75 and ICP 7035 were identified as tolerant against frost/chilling.

Assessment of Symbiotic Nitrogen Fixing Potential and Phosphorus Use Efficiency in Chickpea

Genotypic variations in nodulation of mini-core collection of chickpea

Total 274 mini-core lines including 5 checks (JG 16, Shubra, BG 256, RSG 888 and JAKI 9218) were evaluated under greenhouse conditions in pots filled with pasteurized soil: sand (1:1 v/v) mixture. Seeds were inoculated with *M. ciceri* strain IC-76 before sowing. Nodulation among the lines ranged from 0 to 50 ±7.48 with mean value of 19/plant. Only two per cent of the lines formed high nodulation ranging from 35-50/plant due to inoculation. High nodule number/plant was recorded in ICC 12537, ICC 10945, ICC 4567, ICC 15264, ICC 14799 and ICC 15610, while low number of nodules despite inoculation was observed in ICC 16207, ICC 3512, IG 10309 and ICC13628.

The mini-core lines of chickpea were categorized in 6 categories (nodule rating 1-6; 1= no nodule, while 6 = maximum nodules). Lines with nodule rating of 1 and 2 produced low plant dry weight (0.27 g/plant), while lines with high rating of 5 and 6 produced about 40% higher biomass within 45 days of growth. ICC 15610 produced highest plant dry weight of 0.434 g/plant with nodule number 50/plant. High nodulation along with production of high plant dry weight indicate towards high BNF contribution and P use efficiency of these genotypes while growing with low P supply from soil. A direct correlation was noticed between nodule number and plant dry weight. It is concluded that even under conditions of P deficiency in soil, there was genotypic dependent variations in nodule formation due to inoculation with *M. ciceri* in chickpea (Fig. 42).

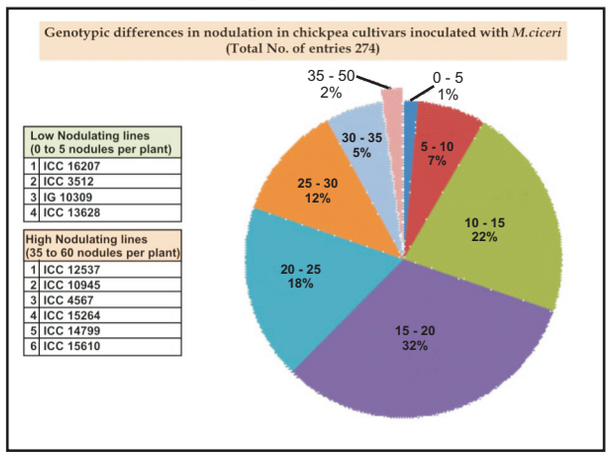


Fig. 42: Genotypic variations in nodulation of mini core collection of chickpea genotypes

Effect of P Fertilization and Mesorhizobial Inoculation on Symbiotic Potential of Selected Chickpea Genotypes

A field experiment was conducted to find out the interactive effect of P-fertilizer and inoculation with *M. Ciceri* in three varieties of chickpea on a soil low in phosphorus. Seed inoculation with *M. ciceri* increased nodule number as well as nodule biomass per plant over un-inoculated control. Improvement in nodulation in terms of increased nodule number/plant was more pronounced in variety Shubhra as compared to JG 16 and JAKI 9218. Seed inoculation along with application of phosphatic fertilizer as DAP increased nodule number/plant from 10.0 in un-inoculated to 17.0 plant in Shubhra. In JAKI 9218 and JG 16 nodule number/plant increased by 25-30% over un-inoculated control. Effect of inoculation along with application of phosphatic fertilizer was more pronounced on nodule mass/plant in Shubhra as compared to other genotypes. Inoculation with *M. ciceri* and P fertilizer application increased shoot dry weight in Shubhra from 1.38 g/plant in un-inoculated to 2.19 g/plant. P-fertilizer application along with inoculation with *M. ciceri* increase grain yield by 40% over control. The grain yield under control was 1104.6, 856.9 and 958.7 kg/ha of three different genotypes and it increased to 1346.0, 1214.0 and 1540 kg/ha in chickpea variety

JAKI 9218, Shubhra and JG 16, respectively. Highest inoculation benefits were however observed only with application of P-fertilizer to the crop along with inoculation with *M. ciceri*. Data revealed that under conditions of P deficiency in soil, beneficial effect of inoculation are more pronounced with application of phosphorus fertilizer at the recommended rate of 60 kg P_2O_5/ha.

Screening of Chickpea Mini-core for Symbiotic Nitrogen Fixing Potential under Field Conditions

Total 215 chickpea mini-core lines along with 10 land races and two checks RSG 888 and BG 256 were sown in field for screening. Nodule number/plant among chickpea mini-core lines ranged from 2.0 to 25 with mean value of 11nodule/plant. Forty four per cent of total lines possess 5-10 nodules/plant, while only 4% of the total population possesses high nodule number (20-25 nodules) per plant and 5% lines had low (0-5/plant) nodulation. Based on nodule formation capacity, these lines were grouped into 5 classes (Nodule number 0-5=1; 5-10=2; 10-15=3; 15-20=4 and 20-25=5). There was positive relationship between nodule formation in the roots with plant dry weight and nutrient uptake (Table 25). As the nodule numbers increased from 4 to 22/plant, plant dry weight, nitrogen and phosphorus uptake also increased. During initial formative growth stage a five fold increase in nodule number/plant resulted into an increase of plant dry weight from 0.13 to 0.19 g/plant only.

At early stage of plant growth, nodule number per plant in check varieties RSG 888 and BG 256 were 12 and 16/plant, respectively as compared to 20 to 25 in eight lines *viz*., ICC 1398, ICC 1422, ICC 1510, ICC 2072, ICC 12328, ICC 6816, ICC 5337 and ICC 11879. ICC 12328 produced highest plant dry weight of 0.32 g/plant with N-uptake of 8.2 mg N/plant as compared to the ICC 3230 and ICC 8607 with plant biomass of 0.08 g/plant and N-uptake of 2.0 mg N/plant.

Higher biomass accumulation and N-uptake was also associated with high uptake of phosphorus of 1.03 mg P/plant as compared to only 0.2 to 0.4 mg P/plant in ICC 3230 and ICC 8607. Nodule number per plant decreased due to low phosphorus in soil as compared to the initial growth stage of 30 DAS. Maximum increase of 250% in nodule number was recorded in ICC 8607 despite phosphorus deficiency in soil. In other lines such as ICC 8621, ICC 7308, ICC 6816, increase in nodule number/plant over earlier sampling date ranged from 100 to 150%.

Among the mini-core lines evaluated under low phosphorus availability in soil, three lines *viz*., ICC 9137, ICC 2580 and ICC 12968 accumulated highest biomass with shoot dry weight of 8.0 to 9.5 g/plant and highest N and P-uptake of 250 to 290 mg N/plant and 21 to 28.7 mg P/plant as compared to less than 1.0 g dry weight/plant produced by inefficient lines with very low uptake of N and P in shoot. There was very high variability for both P-acquisition efficiency as well as N-fixing ability under conditions of phosphorus deficiency in soil. Total N-uptake ranged from 14.2 to 296.7 mg N/plant with mean value of 79.57 mg N/plant. Similarly, P-uptake ranged from 1.79 to 28.73 mg P/plant with mean value of 10.10 mg P/plant. Chickpea lines with high accumulation of nitrogen in shoot under conditions of phosphorus deficiency in soil are considered as P-efficient lines with high BNF potential.

Table 25: Nodulation variation and plant growth in mini-core lines of chickpea after 30 days of plant growth

Nodule rating	Total number of lines	Nodule no. per plant	Total plant weight (g)	Nutrient uptake (mg/plant)	
				N	P
1	11	3.9	0.131	3.28	0.44
2	99	7.8	0.135	3.42	0.47
3	90	12.4	0.180	4.47	0.65
4	18	16.7	0.196	5.12	0.69
5	9	22.5	0.189	4.65	0.57

Note: rating; 1= 0 to 5; 2= 5 to 10; 3= 10 to 15; 4= 15 to 20 & 5= 20 to 25

Social Science

Increasing Pulses Production for Food, Nutritional Security and Rural Livelihoods of Tribal Farming Community through Demonstration and Training

This project is being implemented since August 2011 in 10 selected tribal dominating districts of Madhya Pradesh and Chhattisgarh to bridge the gap between scheduled tribes and general population indicators in all-round socio-economic development in a time bound manner. Community oriented and resource based technological supports are being provided with active involvement, cooperation and collaboration of concerned KVK of district and Zonal Project Directorate Zone VII, Jabalpur (M.P.)

In *kharif* total 262 demonstrations were conducted in tribal areas of M.P. and Chhattisgarh states. Highest yield of urdbean cv. Azad 3 (1200 kg/ha) was recorded in Bastar district of Chhattisgarh with maximum increase of 122.22 %. In pigeonpea, LRG 41, JKM 1892, JT 501 were grown in Kabirdham, Jhabua, Dindori and Badwani and maximum yield was recorded 1500 kg/ha with increase of 17.64% over local check (Table 26).

In *rabi,* total 100 demonstrations were conducted on chickpea, fieldpea and lentil in Kanker, Kabirdham, Balrampur, Dantewada and Baster in Chhattisgarh and Dindori, Badwani, Dhar, Jhabua and Shahdol in M.P. Chickpea varieties like JAKI 9218, Vaibhav, JG 11, JG 63, JG 130 , JG 14 were included in demonstrations. Maximum yield was obtained by JAKI 9218 and Vaibhav varieties in Kabirdham and Balrampur area with 27.16% and 48.6%8 increase in yield respectively. Fieldpea varieties like Paras, Shubhra, IPFDI 1-10 were provided to farmers under demonstration. Maximum increase in yield was obtained 41.82% in Dhar (M.P.). Lentil variety KL 218 and JL 3 were provided to the farmers which gave yield of 975 kg/ha in Dhar (M.P.) with increase of 47.34% over local varieties (Table 27).

Table 26: Performance of *kharif* demonstrations

District/State	Number of farmers	Area (ha)	Crop	Variety	Highest yield (q/ha)	Lowest yield (q/ha)	Average yield (q/ha)	Farmers' plot yield (q/ha)	% increase
Dantewada, Chhattisgh	25	10.0	Urdbean	TAU-2	6.85	5.05	5.95	3.99	49.12
Bastar, Chhattisgarh	40	40	Urdbean	Azad-3	12.00	8.00	10.00	4.50	122.22
Kawadha, Chhattisgarh	12	5.0	Urdbean	PU-31	7.50	5.50	6.72	5.10	31.76
Kanker, Chhattisgarh	25	10.0	Urdbean	TAU - 1	7.10	6.50	6.88	5.49	25.34
Kabirdham Chhattisgarh	12	5.0	Urdbean	PU-31	7.50	5.50	6.72	5.10	31.76
	12	5.0	Pigeonpea	LRG-41	15.00	12.75	14.37	12.20	17.64
Shahdol, M.P.	16	5	Urdbean	PU-35 & LBG-20	3.42	1.86	2.86	1.74	63.70
Dhar, M. P.	25	10	Urdbean	Uttara (IPU 94-1)	7.75	6.25	6.97	4.74	47.15
Jhabua, M. P.	13	05	Urdbean	JU-86	3.88	3.00	3.41	2.46	39.49
	13	05	Pigeonpea	JKM-189					
Dindori, M.P.	25	10.0	Pigeonpea	TJT 501	12.50	10.75	12.00	7.00	71.42
Badwani, M.P.	25	10	Pigeonpea	JKM-189	8.50	7.30	7.90	6.80	15

Table 27: Performance of *rabi* demonstrations

District/State	Number of farmers	Area (ha)	Crop	Variety	Highest yield (q/ha)	Lowest yield (q/ha)	Average yield (q/ha)	Farmers' plot yield (q/ha)	% increase
Kanker, Chhattisgarh	55	22.00	Chickpea	JAKI -9218	11.15	6.75	8.78	6.52	35.00
	30	12.0	Fieldpea	Paras	12.05	8.56	9.80	7.85	25.00
	30	12.00	Lentil	KLS 218	7.45	5.10	6.38	5.22	23.00
Kabirdham, Chhattisgarh	70	28	Chickpea	Vaibhav	15.00	11.00	13.40	10.50	27.61
Balrampur, Chhattisgarh	35	14	Fieldpea	Paras	-	-	8.20	5.90	38.98
	95	38	Chickpea	JAKI 9218	15.00	14.75	14.50	9.92	48.68
Baster, Chhattisgarh	60	24	Chickpea	JG-11	11.00	6.00	8.50	3.00	183.33
	30	30	Fieldpea	Shubhra	14.00	9.00	11.50	5.00	130.00
Dindori, M.P.	110	44	Chickpea	JG 63	14.00	12.50	13.50	8.50	58.82
	40	16	Lentil	Frost tolerar t	6.10	5.00	5.50	3.25	69.23
Badwani, M.P.	25	10	Chickpea	JG-130	10.60	8.60	9.50	7.80	17.89
Dhar, M.P.	25	10	Chickpea	JG-11	15.25	12.25	13.91	9.80	42.06
	16	6.4	Chickpea	JG-130	15.50	13.25	14.70	10.20	44.14
	24	9.60	Chickpea	JAKI-9218	15.25	13.13	14.23	9.92	43.73
	40	16.0	Fieldpea	IPFD 1-10	14.75	12.75	13.53	9.55	41.82
	25	10	Lentil	JL-3	9.75	7.75	8.87	6.03	47.34
Jhabua, M.P.	135	54.0	Chickpea	JG-130	13.50	9.38	11.25	826	36.31
Shahdol, M.P.	115	115	Chickpea	JG-14	17.43	12.71	15.56	11.25	38.31

A study was conducted to know the farmers' perception about technologies provided. Farmers informed that most of the varieties were found suitable in their farming situations (Table 28). The critical inputs showed clear cut difference in yield between improved varieties and local varieties. Local varieties were susceptible to various diseases. The programme is bringing prosperity in tribal areas. Seeds of improved varieties of different pulses are acceptable by tribal farmers of Chhattisgarh and M.P. Tribal farmers also viewed that technological packages (critical inputs as well as practices) demonstrated in pulses are affordable. The taste factor has played very critical role in adoption of pulse production technologies and market value.

Impact Analysis of Transfer of Technology Projects Implemented by IIPR in Uttar Pradesh

Data were collected by using interview, observation and discussion methods from 50 farmers each from adopted villages (Mauhar and Alipur) under ISOPOM project and two non adopted villages *i.e.*, Thanpur and Badahar. The data were analyzed for logical conclusion by using suitable statistical tools. Study revealed that major crops grown were wheat, mustard, urdbean, mungbean, pigeonpea and chickpea. Area of mungbean has increased and cultivated by 72% farmers and 20% farmers were cultivating pigeonpea as well. Chickpea area has gone down and replaced by wheat due to untimely rain and less remunerative price. The Societies formed during project period are still working and facilitating farmers of the area by providing seed and technical knowledge. The benefit of ISOPOM project has gone to other villages also. Majority of farmers (64%) procure seed from IIPR, NSC and other progressive farmers. Inputs are procured from the cooperative society, *Krishi Raksha Ikai* and private dealers. Compost is applied once in three years. Majority of farmers (60%) were still continuing the technologies in same fashion for higher profitability. Technologies have also percolated to the other farmers of villages through farmers to farmer. Majority of farmers sale their produce in local market, NSC and *Mandi*. Overall production and productivity has improved. The common problem in pulse production is blue bull and non-sufficient supply of water in canal. In non-adopted villages farmers are still taking only two crops and not able to cultivate summer mungbean and are following traditional system of pulse cultivation. Non adopted farmers are getting approximately 20-25% less yield than the adopted farmers. Therefore it can be concluded that there is need to provide seed and other inputs in non adopted area for enhancing pulse production and productivity for motivating farmers for cultivation of summer mungbean and other pulses.

Table 28: Perception of tribal farmers about pulses under TSP

Sl. No.	Particular	Chhattisgarh (N=350)			M.P. (N=400)		
		Fully Agree	Partial agree	Not Agree	Fully Agree	Partial agree	Not Agree
1.	Variety suitable for locality	278 (97.42)	67 (19.14)	05 (1.44)	305 (76.25)	83 (20.75)	12 (3.00)
2.	Short duration in comparison to local verity	190 (54.28)	132 (37.71)	28 (08.00)	285 (71.25)	135 (33.75)	30 (7.50)
3.	Disease resistant	332 (94.85)	18 (5.14)	00 (00.00)	348 (87.00)	52 (13.00)	00 (00.00)
4.	Seeds are attractive and bold	295 (84.28)	40 (11.42)	15 (4.28)	305 (76.25)	74 (18.25)	21 (5.28)
5.	Compatible in existing farming situations	185 (52.85)	110 (31.42)	55 (15.71)	207 (51.75)	181 (45.25)	62 (15.50)
6.	Higher yielder and higher net return (B:C ratio)	340 (97.14)	10 (2.85)	00 ()	380 (95.00)	20 (05.00)	00 (00.00)
7.	More demand in local market	195 (47.14)	90 (25.71)	65 (18.57)	221 (55.25)	110 (27.50)	69 (17.25)
8.	Acceptable to tribal farming community	326 (93.15)	24 (6.85)	00 (00.00)	370 (92.50)	30 (7.50)	00
9.	Improved package are affordable	250 (71.42)	30 (8.57)	70 (20.0)	342 (85.50)	38 (09.50)	20 (05.00)
10.	Easily availability of fertilizers, insecticide herbicides etc created confidence towards continuance of technological packages	300 (85.71)	50 (14.28)	00 (00.00)	380 (95.00)	20 (05.00)	00 (00.00)
11.	Taste	258 (73.71)	87 (24.85)	05 (1.42)	308 (77.00)	80 (20.00)	12 (03.00)
12.	Cooking quality	270 (77.14)	80 (22.85)	00 (00.00)	352 (88.00)	48 (12.00)	00 (00.00)
13.	Colour of dal	150 (42.85)	180 (51.42)	20 (05.71)	224 (56.00)	116 (29.00)	60 (15.00)
14.	Market value	190 (44.28)	120 (34.28)	40 (11.42)	262 (65.50)	73 (18.25)	65 (16.25)
15.	Processing value	250 (71.42)	90 (25.71)	10 ()	280 (70.00)	70 (17.50)	50 (12.50)
16.	Suitable for storage	300 (85.71)	50 (14.28)	00 (00.00)	390 (97.50)	10 (02.50)	00 (00.00)

Development of Pulse Based Model Village for Sustainable Rural Livelihood in Central Zone of Uttar Pradesh

Village Seodhari in Patara block of Kanpur Nagar selected for this project has three hamlets *viz*., Salampur, Faror and Tanda. Total number of families in village are 7500, total area is 772 ha where 664 ha (86%) is irrigated, 21 ha (3%) rainfed, barren land 2% and other 9%. Bore well are only source of irrigation. Majority of farmers (72%) come under small category as per land holdings. Soil is categorized as sandy loam to loam. Paddy, maize, sesamum, sorghum, ash guard, chili (green) and onion are grown in *kharif,* whereas wheat, potato, rapeseed, mustard, coriander are grown in *rabi*.

Pigeonpea, mungbean, urdbean, chickpea and fieldpea are grown in all three seasons. Mungbean introduced about six year back in spring/summer season presently occupy about 50 ha under var. PDM

139, IPM 02-3, Meha *etc*. It is considered as low risk crop over other pulses. Urdbean in *zaid* has been introduced recently in 2014. Only green coated urdbean is cultivated in *kharif* season due to good market price. Early pigeonepa (UPAS 120 and Manak) is sown by the end of May to escape insects and diseases at flowering and pod formation. It also helps in timely sowing of wheat. Area under early pigeonpea is reduced due to introduction of hybrid maize and damage by blue bulls. Introduction of hybrid maize restricted mungbean as it was intercropped in *desi* type of maize. Further, increase in irrigation facilities replaced chickpea to wheat as it occupied 80% of land. Before a decade the village was known for fieldpea but root rot and wilt affected he crop and presently it is not under cultivation.

The causes of low productivity were identified as lack of awareness and knowledge of diseases and insects among farmers, lack of quality seed at private shops, weather aberrations, unavailability of farm machinery, low socio-economic status, lack of innovativeness, *etc*. Their explanation and solutions were suggested for increasing pulses area, production and productivity in village. Lack of soil testing facility and deep water table were also concern of farmers. The existing extension system in district was studied. The content of existing pulse promotion schemes was analyzed. The farmers were empowered with meetings in coordination with line department and pulse experts.

Information Communication Technologies (ICT) Mediated Knowledge Management for Pulse Farmers

The project was initiated to develop online knowledge platform for sharing of knowledge base on improved pulse production technologies with farmers in cost effective method. For the knowledge platform, e-books on weed management in pulse crops, seed management, pod borer management, disease and insect pest management in pigeonpea, disease and insect management in urdbean and mungbean have been prepared. .

Development of Web-based Commodity Profile for Chickpea and Pigeonpea

The project envisages to design, develop, test and implement a web-based commodity profile for pulses on the available information related to improved production/protection technologies with the research institutions. This portal will cater information needs of exporters and farmers through production and trade statistics. Another feature of the web-based data management portal will be indexing of *mandi* prices of pulses from regulated market yards (Agmarknet). Policy makers can directly access area, production, productivity trends and futuristic projections based on long-term data analysis. Information related to soil data, weather data, minimum support prices (MSP), breeder seed production, major export destinations and major import sources, and IT Crop Planner/Crop Calendar would be utilized for development of data management portal for pulse crops. Contents on production statistics (area, production and productivity), trade statistics (import and export), MSP, Crop Calendar, *Mandi* prices for chickpea and pigeonpea have been developed and analyzed. A user-friendly structure has been created for digital platform. A home page for the system *viz*., commodity profile for pulses has been designed and linking with the developed contents (Fig.43). A PHP language has been used in developing the system.



Fig. 43. Home page of commodity profile for pulses

Development of User-friendly Analytical Module for Some In-complete Block Design

Sometimes the number of treatments are very large and difficult to maintain within block homogeneity for large number of treatments, therefore incomplete block designs (*e.g.* , augmented, lattice, row column and augmented split plot designs) have been used for conducting experiments having large number of treatments. It is cumbersome to get the data analyzed in convenient way for incomplete block design. To get the data analyzed in simplified and convenient way a user-friendly analytical module has been developed with the facility of interactive user interface for efficient and correct data entry. In this process, a SAS programme for augmented, lattice, row column and augmented split plot designs is connected to data entry user interface. After feeding the data a file will be saved as .sas file and this file may be opened into SAS program editor and using the run command data will be analyzed and output may be saved at desired location.

Analysis of Growth and Instability of Major Pulses in India

This study aims at understanding the growth pattern and stability in production and area of pulses in major producing states. To understand the market structure and situations, it is important to study the growth in production, area and yield. In case of total pulses, there is an increase in instability in production during 2000-10 as compared to previous decade, but the instability in yield kept on fluctuating from 1950 onwards and stood constant at 0.04 in the last two decades *i.e.*, 1990-2000 and 2000-10. It gives an idea that the yield stood still for the last two decades. So it is needed that focus should be on increasing the productivity of pulses. From cross sectional data by tri-decade wise analysis of total pulses, it was observed that although the instability in production and yield has decreased, but in area it increased which brings the inference that still today the farmers decision to grow the pulses is significantly affected by climate or the market led factors which is bringing high instability in area component.

EXTERNALLY FUNDED PROJECTS

Enhancing Lentil Production for Nutritional Security and Sustainable Rice-based Production System in India

This farmers centric collaborative project is being implemented under rainfed pulses based cropping system in Hamirpur district of Bundelkhand region of U.P. In-depth survey was conducted by applying Participatory Rural Appraisal Tools to ascertain farmers' resources, needs, aspiration, constraints, locally adopted cultivars, technological packages, post-harvest techniques, storage, marketing, *etc*. Total 16 villages involving 202 farmers (large, medium, small and marginal categories) of three blocks *viz*., Sumerpur, Maudaha and Gohand were covered. Majority of farmers started sowing of lentil in second week of November under rainfed mono-cropped farming situation, while some performed sowing in mid of December. Seeds of improved varieties (IPL 316, IPL 81, IPL 406, DPL 62) along with Trichoderma, *Rhizobium culture*, pre-emergence herbicides were provided as critical inputs by the Institute and farmers invested in cost of fertilizers, weeding, inter-culture operations themselves. IPL 81 gave an yield of 6-7 q/ha, followed by DPL 62 (5-6 q/ha) and IPL 406 and IPL 316 (3-4 q/ha) in all the adopted villages. Farmers' preferred IPL 81 and DPL 62 for their framing situations. Village wise and variety wise average yield is given in Table 29 indicating the suitability of variety in comparison to local variety.

To ensure seed sufficiency of farmers preferred variety(s) of lentil at village level, participatory seed production of IPL 81, IPL 406, IPL 316, DPL 62) was undertaken in 89 ha area in a compact block of Vidokhar and Ingohata villages. National Seed Corporation and U.P. Seed Certification Agency, Kanpur were actively involved for promotion of formal and informal seed system(s). Registration of all seed growers was done. Total 229 q seed was produced. Farmers' Seed Association 'Vidokhar Kisan Sewa Samiti, Vidokhar, Hamirpur' has been formed as registered seed producer**.** Total 26 members are actively engaged in promotion and continuation in production of quality seeds of preferred varieties of lentil and other pulse crops.

Socio-economic and Technological Empowerment of Pulses Growers of Jalaun and Kanpur Dehat districts of Uttar Pradesh

The project aims at creation of awareness on improved pulses production technologies and development of Model Pulse Villages located in pulse growing regions of selected districts of Uttar Pradesh. It will act as diffusion centers of pulse cultivation technologies to the farming community on a larger scale. Total 113 package demonstrations on improved pulse production technologies including improved planting techniques, seed treatment, weed management, improved varieties and insect pest management were conducted in 52 ha of area in four project villages of Kanpur Dehat and Jalaun districts (Table 30).

Farmers of Silhara and Barai villages achieved yield advantage of 10.51 q/ha in participatory demonstrations conducted on improved pigeonpea technologies. In chickpea, fieldpea and urdbean package technology demonstrations, the participating farmers gained additional yield of 4.1, 1.88 and 1.95 q/ha, respectively (Table 31).

Table 29 : Village wise/Variety wise preformance of lentil

Name of Village	Variety	Area (ha)	No. of demons-trations	No. of farmers	Sowing method	Average yield (q/ha)	Average local variety yield (q/ha)	% increase over local
Mawaijar	DPL 62	10.4	26	26	Normal	5.60	2.50	124.00
Patanpur	IPL 406	12.4	31	24	Normal	3.70	2.45	51.02
	DPL 62	2.0	05	04	Normal	5.32	2.01	164.67
	IPL 81	0.2	01	04	Normal	6.49	2.15	201.86
	IPL 316	0.2	01	-		3.65	2.36	54.66
		14.8	**38**	**32**				
Ingohata	IPL 316	2.0	05		Normal	3.52	2.08	69.23
	DPL 62	3.2	08	13	Normal	5.15	2.18	136.23
	IPL 81	0.4	01		Normal	6.47	2.82	129.43
	IPL 316	0.4	01		Normal	3.40	2.51	49.00
		6.0	**15**	**13**				
Helapur	DPL 62	1.6	04	04	Normal			
	IPL 81	0.4	01		Normal			
		2.0	**05**	**04**				
Bilhari	DPL 62	1.6	04	05	Normal	5.73	2.01	185.07
	IPL 81	0.8	02		Normal	6.49	2.38	172.68
		2.4	**06**	**05**				
Bank	DPL 62	2.0	05	05	Normal	5.45	2.45	122.44
Tendha	IPL 406	6.0	17	18	Normal	3.69	2.65	39.24
	DPL 62	2.8	05		Normal	5.35	2.78	92.44
		8.8	**22**	**18**				
Makraw	DPL 62	5.2	12	25	Normal	5.78	2.15	168.83
	IPL 406	5.6	13		Normal	3.65	2.02	80.69
		10.8	**27**	**25**	Normal			
Vidokhar	IPL 316	3.6	09		Normal	3.68	2.93	25.59
	IPL 406	5.2	13		Normal	3.55	2.70	31.48
	IPL 81	5.2	13	37	Normal	6.38	2.51	251.00
	DPL 62	2.8	07		Normal	5.85	2.60	48.07
		16.8	**42**	**37**				
Banda	IPL 81	1.2	03	10	Normal	6.30	2.36	166.94
	DPL 62	3.2	08			5.87	2.09	180.86
		4.4	**11**	**10**				
Mahajawli	IPL 81		05	06	Normal	6.25	2.00	212.5
	DPL 62		01			5.93	2.45	142.04
			06	**06**				
Maudaha	IPL -81	2.4	06	06	Normal	6.68	2.55	161.94
Kanjauli	DPL 62	2.0	05	05	Normal	5.73	2.69	113.01
Chndakhi	DPL 62	1.2	03	03	Normal	5.85	2.08	181.25
Nadehara	IPL 81	1.6	04	04	Normal	6.30	2.71	132.47
Artara	IPL 81	1.6	04	04	Normal	6.25	2.40	160.41
		89.6	**22**	**22**				
Grand total		**194**	**203**					

Table 30: Details of area (ha) and farmers covered in complete technology package demonstrations

Crop	Variety	No. of farmers	Kanpur Dehat	Jalaun	Total
Pigeonpea	Narendra Arhar-1, IPA 203	23	10	1.9	11.9
Chickpea	JG-16, DCP 92-3, Shubhra	37	15.9	0	15.9
Fieldpea	Prakash, Vikas, Aman, IPF 4-9	22	0	10	10
Mungbean	Samrat, Meha, IPM 205-7, IPM 409-4	22	5	6.6	11.6
Urdbean	IPU 2-43, Uttara	9	2.6	0	2.6
Total		113	33.5	18.5	52.0

Table 31: Yield advantage from improved package technology demonstrations

Crop	With varietal intervention (q/ha)	Control plots (q/ha)	Yield advantage (q/ha)	Incremental returns (Rs./ha)
Chickpea	5.35	1.25	4.10	22550 @ 5500/-
Pigeonpea	18.46	7.96	10.51	95595 (@ 9100/-
Fieldpea	4.01	2.13	1.88	10340 @ 5500/-
Urdbean	2.76	0.81	1.95	11700 @ 6000/-

To strengthen the formal and informal seed system of pulses in the selected districts and to encourage the youth for agriprenuership, two registered seed societies were formed with names "*Barai Kisan Sewa Samiti*" and "*Silhaera Kisan Sewa Samiti*". Total 5 ha area under fieldpea variety Prakash has been registered for seed production for NSC by the registered society "Barai Kisan Sewa Samiti".

Harnessing Modern Communication Technologies for Sharing of Available Knowledge Resources with Pulse Growing Farmers of Uttar Pradesh

This project was initiated to assess the synergetic impact of use of modern communication channels that have the characteristic of reaching a larger space in short span of time and the traditional extension methods that are looked upon as more reliable and credible source of knowledge by the farming community on the pulse growers. Under the traditional extension services component, total 50 need-based participatory demonstrations on recommended varieties of major pulse crops were conducted in 21 ha area in Jalaun and Fatehpur districts of Uttar Pradesh (Table 32). Participating farmers recorded an average yield advantage of 4.1 q/ha and 1.82 q/ha, in case of lentil and chickpea demonstrations, respectively over the local checks.

Farmers participatory demonstrations conducted on improved varieties of lentil and chickpea resulted in yield advantage of 4.1 q/ha and 1.82 q/ha, with economic advantage of Rs. 24600 and 10010 per ha, respectively (Table 33).

Total 14 varietal demonstrations on short duration mungbean varieties (var. Samrat and Meha) were conducted on 9 ha area in Khajuha and Malwa block of Fatehpur in spring/summer season to enhanced system productivity in the traditional paddy- potato, paddy- coriander cropping pattern. The varietal interventions of spring/ summer mungbean resulted in enhancement of gross returns from all the three mungbean inclusive cropping patterns *i.e.*, paddy –potato- mungbean, paddy-coriander-mungbean and paddy- mustard-mungbean cropping pattern in the project villages (Table 34).

Table 32: Details of area (ha) and farmers covered in complete technology package demonstrations conduced at project villages

Parameter	Varietal interventions in Jalaun			Total	Varietial interventions in Fatehpur		
	Dakor Block	Jalaun block			Khajuha block	Malwa block	Total
	Lentil	Chickpea	Lentil		Summer Mungbean		
Variety	IPL-316, DPL-62	JG-16	IPL-316		Samrat, Meha		
No. of demonstrations	12	20	4	36	6	8	14
No. of farmers	12	20	4	36	6	8	14
Area covered (ha)	6.74	3.8	2	12.54	4	5	9

Table 33: Yield advantage (q/ha)and incremental returns of demonstrations on improved varieties of rabi pulse crops

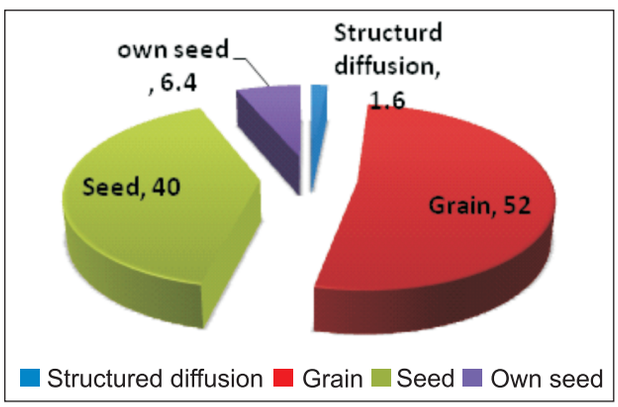
Crop	Varietal interventions		Average	Control plots yield	Yield advantage	Incremental returns
	Dakor Block	Jalaun block				
Lentil	12.26	13.13	12.7	8.6	4.1	24600 (@ Rs 6000)
Chickpea	-	4.72	4.72	2.9	1.82	10010 (@ Rs 5500/q)

Table 34: Economics of varietal intervention of spring/summer mungbean in different cropping patterns

Parameter	Paddy-potato-mungbean		Paddy-coriander-mungbean		Paddy-mustard-mungbean	
	Without intervention	With intervention	Without intervention	With intervention	Without intervention	With intervention
Cost of production	325322	325957	101702	102336	90566	90566
Gross returns	517400	537050	189800	219350	144850	173050
Net returns	192077	211093	88098	117014	54284	82484.2
B:C ratio	1.59	1.65	1.87	2.14	1.60	1.91

Disposal Pattern of Produce of Introduced Improved Mungbean Variety in Project Villages

Disposal pattern of farmers who participated in improved mungbean production technologies in 10 ha area during spring/summer was documented from harvesting of crop to sowing season. Participating farmers disposed about 52% (57 q) of the produce as grain, while about 40% (43.8 q) was disposed as planting material to other farmers through social networks in total 26 villages spread within a radius of 70 km. The participating farmers disposed the produce as seed at average rate of Rs. 10050/q and collectively earned Rs 4,40,190/- as compared to Rs. 389172 from disposal as grain (Table 35). The technological interventions led to strengthening the informal seed system with improved mungbean varieties in and around the project villages.



Disposal pattern of produce of improved mungbean variety

Table 35: Details of additional income from disposal of produce of mungbean variety samrat as seed through farmer to farmer diffusion

Village	No. of farmers	Production (q)	Disposal as (q)							
			Struct. diffusion	Grain	Rate	Income	Seed	Rate	Income	Own seed
Paradan	10	47.72	0.8	25.28	68.71	173698.9	18.3	100	183000	3.34
Faridpur	12	61.85	1	31.65	68.08	215473.2	25.5	101	257550	3.7
Total	12	109.57	1.8	56.93	68.39	389172.1	43.8	100.5	440190	7.04

Regional Station, Phanda, Bhopal

CROP IMPROVEMENT

Genetic Improvement for Plant Type and Grain Yield in Chickpea

Station trials were evaluated for grain yield and their suitability for mechanical harvesting. Important quantitative characters like plant height, growth type, days to 50% flowering, days to maturity, flower colour, primary branches, pods/plant, seeds/pod, seed yield/ plant, plot yield, test weight, *etc*., were recorded.

Trial I: Total 28 entries were evaluated along with 4 checks. Entries *viz*., IPC 2010-142, IPC 2010-181, IPC 2011-76, IPC 2012-49, IPC 2012-228, IPC 2013-21 and IPC 2012-181 were found promising with higher no. of pods/plant, 100 seed weight and seed yield/plant.

Trial II: Total 30 entries were evaluated along with three checks (RVG 203, JG 16 and BG 372). Entries *viz*., IPC 2010-142, IPC 2011-69, IPC 2013-21, IPC 2013-74, IPC 2013-78, IPC 2014-15, IPC 2014-18, IPC 2014-19 and IPC 2014-146 were superior than checks for important economic characters like pods/plant, 100 seed weight, yield/plant and plot yield. These entries were tall type having plant height ranging from 50-62 cm with erect growth habit.

Trial III: Total 22 *desi* genotypes found promising earlier were evaluated and IPC 2011-103, IPC 2011-123, IPC 2011-200, IPC 2006-11 performed better than checks. Except IPC 2006-11, all entries were early flowering and maturing as compared to checks.

Trial IV: Fiftten *kabuli* accessions were evaluated and IPCK 2010-93, IPCK 2011-74, IPCK 2012-229 and IPCK 2013-224 were observed as tall (50-60 cm) and semi-erect with high yield potential than checks.

Generation advancement

F_4 generations of WK 315 x IPC 2004-52, ICCV 1205 x JG 03-14-16, GNG 469 x ICC 5434, ICCV 15614 x JG 03-14-16 and JG 16 x IPCK 2002-19 were advanced to F_5.

Development of Chickpea Genotypes to Mitigate Terminal Heat and Drought Stress for Enhancing Productivity

Thirty two lines were evaluated under irrigated and rainfed conditions. Observations were recorded for 50% flowering, days to maturity, pods/plant, seeds/pod, seed yield/plant, plot yield and test weight. All entries except FLIP 0556, FLIP 0656, Pusa 72, GCP 101, CSG 8962, Pusa 209 and Pusa 372 matured in 115-120 DAS. Seed yield/plant was high in Pusa 261, Digvijay, RVG 202, RVG 203 and ICC 92944. Empty pod percentage was less (≤ 4 %) in JG 130, Pusa 209, PDG 3, CSG 8962 and GL 769. Plot yield was higher in RVG 202, RVG 203, RAU 52, JG 11, Pusa 261, Digvijay, JG 130, JAKI 9218 and ICC 92944.

In addition, 32 entries along with two checks were evaluated under normal and delayed sown for imposing terminal heat during reproductive phase. Under heat stress, PUSA 547, PUSA 72, JAKI 9218 showed negligible reduction in seed weight.



Trials for terminal heat and drought stress tolerance

Generation of breeding material

Seven different crosses *viz*., JAKI 9218 x IPC 2004-52, JAKI 9218 x ICC 4958, Digvijay x IPC- 2004-52, Digvijay x ICC 4958, JG 16 x IPC- 2004-52, JG 16 x IPC 2004-98 and JG 16 x ICC 4958 were attempted.

Identification of Potential Donors and Genetic Analysis of Heat Stress Tolerance in Chickpea

Under normal and heat stress conditions, entries *viz*., K 1058, ICC 16865, Katila, ICCV 07110, JG 315, IPC 09-102 and GNG 1958 performed better. These entries showed early flowering (≤ 55 DAS), early maturity (≤ 95 DAS), yield per plant ≥ 15 g, lower empty pod percentage (≤ 4 %), higher numbers of pods/plant (≥ 65) and good plot yield (≥ 836 g) under heat stress and were better than check ICC 4958 under both situations.

Genetic Improvement for Yield and Disease Resistance in Medium Duration Pigeonpea

Derivatives of wild crosses were advanced to F_5 generation. Selected F_2 plants between the adopted lines and F_3 derivatives of *Cajanas scarabeoides viz*., NDA 1 x WDN 100, Pusa 2001 x Bennur Local, IPAC 79 x WD 5, Maruti x WD 5-1, Maruti x WDN 100, WDBCU 5-2 x WDBCU 5-1 were selfed. Selections were made from F_3 derivatives of *C. scarabeoides*

(IPAC 8 x WDN 2-258, ICP 88039 x IPAC 3, ICP 88039 x WD 3, WDN 1-95 x IPAC 3, IPAC 79 x WD 4, IPAC 79 x WD 5, IPAC 79 x WD 3 and IPAC 70-1 x WDN 2-288). The BC_1F_4 and F_5 populations derived from crosses made among wild and cultivated lines were planted for generating BC_1F_5 and F_6. The F_4 derived through intercrossing of TTB 7, IPAC 80, IPAC 79, BSMR 853, IPA 8F and JKM189 were advanced. The BC_1F_3 and F_4 populations were sown for generation advancement.

IPA 2010-30-5, a line derived from cross UPAS 120 x ICPL 88039 matured in 150 days in the first week of November providing scope for timely sowing of wheat. Selfed seeds of this lines were multiplied for testing at different locations of Malwa region. In preliminary yield trial, 50 rows (4 meter length) of IPA 2010-30-5 sown on ridge gave 16 kg yield (approx. 11 q/ ha).



Field view of IPA 2010-30-5

Generation of breeding material

Cross	Generation
Early3 (determinate, early) x C. scarabeoides (ICP15685)	F_5 & BC_1F_4
UPAS120 x C. Scarabeoides (ICP15761)	F_5
IPAC67 x IPAC68	F_5
IPAC64 x C. cajanifolius (ICP15629)	
IPAC66 x IPA8F	
Maruti x IPAC68	
JAP-10-50 x IPA203	
NDA1 x IPA8F	
UPAS 120 x ICPL 88039	F_6
JKM 189 x BSMR 853JKM 189 x TTB 7	F_6

Genetic Improvement for Yield and Multiple Stresses in Lentil

A station trial of 15 entries and preliminary yield trial of 60 entries was sown. Mapping populations developed from the cross PL 02 x Precoz (160 rows) and L 4603 x Precoz (160 rows) were sown along with the 16 F_3 generations.

Mutation Studies in Lathyrus

To create variability for ODAP content, seeds of Ratan, Mahatewda and Prateek were treated with 10 kR (1000 seeds), 20 kR (2000 seeds) and 30 kR (3000 seeds) of Gamma radiation at NRL, lab at IARI, New Delhi. Very negligible amount of variation and mortality was noticed at germination stage in field. No variation was observed in chlorophyll of the plant in any of the treatment/doses. It was concluded that the dosages were comparatively low and insufficient to create damage like chromosomal aberration .

ICARDA Grasspea nursery

Following IGVT were conducted and observations were recorded and selections were made for further studies:

- Low ODAP Genotypes: 24+01 check
- Early genotypes: 24+01 check
- High biomass genotypes: 24+01 check
- Segregating material: 09+01 check

Genetic Resource Management

Chickpea

Total 430 germplasm accessions were rejuvenated. These lines were characterised for different qualitative and quantitative characters. Early maturity (110-115 DAS) was observed in ICC 306, ICC 11769, ICC 12274, ICC 14968, ICC 16686, ICC 15164, ICC15670, ICC16687, ICC 15623, ICC 15853, ICC 16014, ICC 16022, ICC 16998, ICC319, ICC 331, ICC 335, EC 490038, IC 83565, IC 83653, IC 83677, IC 83801 and IC 83898. Seed yield/plant was recorded high in ICC 1875, ICC 16288, ICC 19388, ICC 16393 and ICC 16595.



View of genetic resource management in chickpea

Screening for wilt resistance

Total 125 germplasm lines were screened for wilt resistance. Out of these, 21 entries *viz.*, **(** EC- 223519, EC-267154, EC-267308, EC-267437, EC-440552, EC-441805, EC-498818, IC-83523,IC-83530, IC-83538, IC-83539, IC- 83542, IC-83556, IC-83558, IC-83748, IC-83750,IC-83751, EC-489919, EC-489991, IC-83570 andIC-83757 were found resistant and 15 *viz.*, EC-267293, EC-267511, EC-441725, EC-489845, EC-489905, IC-83519, IC-83523, IC-83526, IC-83527, IC-83529, IC-83534, IC-83535, IC-83541, IC-83551 and IC-83569 were moderately resistant.

Lathyrus

Total 452 germplasm received from various sources were evaluated for agro-economic traits. Besides, purification of genotypes and single plant selection was done. Variation was observed for flower colour, leaf shape and size, earliness, seed colour, seed shape and seed size. High magnitude of variability was observed for plant height (30-109 cm), number of primary branches (1-5), no. of pods/plant (14-127), seeds/plant (1-6), 100 seed weight (4.8-12.2 g), seeds yield/ plant (2.3-26.6 g), days to 50% flowering (57-77) and days to maturity (85-115). Unique genotypes with white bold seeds (VKS 1723 and EC 5053), green mosaic seeds (RLK 195) and early types (EC 333908 (85d), Sel. 516 (89d) and RLK 116 (111d) were identified.



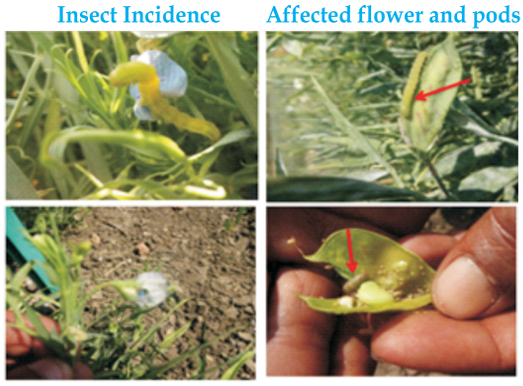
White bold seeds **Green mosaic seeds**

Purification and single plant selection was made in genotypes received from different sources and large variation was observed (Fig. 44).



Fig. 44: Variation within lines for various traits

Insect Incidence **Affected flower and pods**



Insect infestation

CROP PRODUCTION

Enhancing Resource Use Efficiency in Pulse Based Cropping System in Central India

Pigeonpea intercropping in rejuvenated guava orchard

In order to maximum utilization of land in orchards (interspaces between guava trees), pigeonpea var. JKM 189 was grown through dibbling method on raised bed and normal agronomic practices were followed. It was observed that there were no competition for moisture, light and nutrients because roots of guava trees are deeper than pigeonpea crop. The flowering and fruiting season of both the plants are also vary which makes these plants as good companion to each other in the early stages of orchard. Production potential of pigeonpea variety on poor and depleted soil was recorded as 2.67 q/ha. Besides, the level of soil fertility was also increased through nitrogen fixation, litter fall and as a nurse crop (leguminous crop) for trees. It is very useful technology for farmers having orchard at establishment or growth phase. Farmers can opt for intercropping of pigeonpea or cowpea to generate more income from the same piece of land.

EXTERNALLY FUNDED PROJECTS

CRP on Agro-biodiversity in Chickpea

Characterization, regeneration and documentation

Total 962 chickpea germplasm accessions were sown along with two checks *viz*., JG 16 and Shubhra. The characterization of these entries was carried out for different qualitative and quantitative characters like plant height, growth habit, days to flower initiation, days to 50% flowering, days to maturity, flower colour, pigmentation, primary branches, pods/plant, seed/pod, seed yield/plant, plot yield, test weight, *etc*.

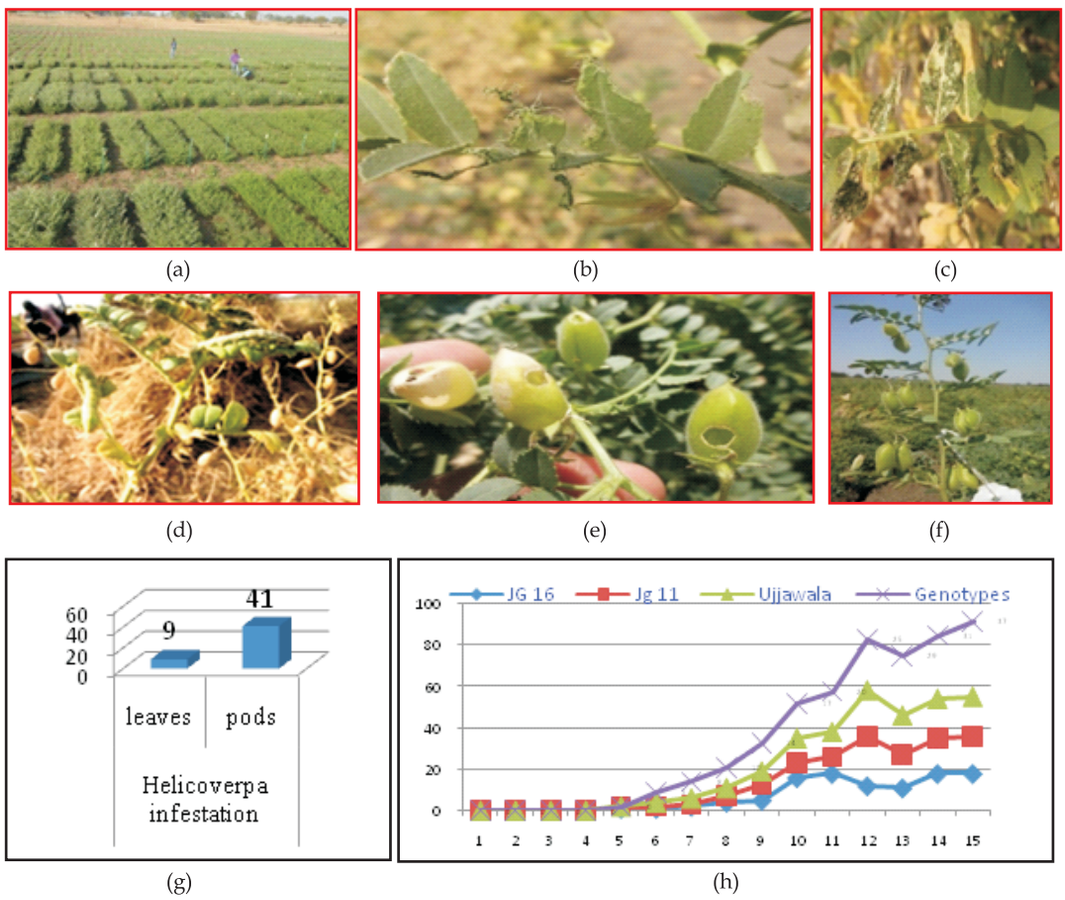


Agro-biodiversity in chickpea

Evaluation for pod borer

Total 1005 chickpea germplasm received from NBPGR were evaluated. Data was recorded on three

major traits *viz*., no. of damaged leaves/plant, no. of damaged pods/plant and no. of larvae/plant to identify the promising genotypes. On the basis of meteorological weeks, pod borer infestation was calculated and it was found that number of leaves damaged (17 nos.) was maximum in 8th meteorological week (March), whereas maximum pod damage (39) was noticed in the 11th week. Maximum no. of larvae (10) was recorded in the 8th week of February. Five accessions *viz*., EC 498782, EC 498773, IC 83336, IC 83797 and IC 83775 showed promising results against pod borer infestation. A unique genotype (EC 498823) with blue flowers, flat stem and spreading growth habit was identified.



Field view of chickpea (b) & (c) damaged leaves (d) Larvae on pods (e) damaged pods (f) Unaffected pods (g) Pods were maximum affected (h) JG 16 is less affected among the entries

CRP on Agro-biodiversity in Pigeonpea

Characterization of germplasm

Total 600 germplasm lines received from NBPGR were sown with 3 national checks and a local check for characterization. Observations were recorded on descriptors traits and agronomic traits *viz*., early plant vigour, plant growth habit, days to 50% flowering, no. of primary branches, flower base colour, flower streaking pattern, stem colour, leaf pubescence, pod hairiness, pod colour, pod shape, pod hairiness, days to 80% maturity, base seed colour, 100 seed weight, seed yield/plant, seed eye width, seed shape, *etc*.. The yield attributes were also recorded (Table 36).

Evaluation for drought tolerance

Twenty medium duration and 10 long duration lines were evaluated under irrigated and rainfed conditions. Among medium duration lines, RVK 275, JKM 189, AKT 9913, ICP 3451, ICP 12654, ICP 14832 and ICP 348 gave higher yield under rainfed condition. ICP 348 (Table 37).

Demonstrations

Five varieties *viz*., IPC 06-77 (18.0 q/ha), IPC 04-01 (18.4 q/ha), IPC 05-62 (21.6 q/ha), JAKI 9218 (23.0 q/ha) and JG 16 (18.5 q/ha) were sown for demonstrating their performance to farmers and visitors.

Table 36: Performance of some useful accessions

Accession	Plot yield (g/5.6 m^2)	Days to maturity (days)	100- seed weight (g)	Plant height (cm)
IC-78341	810.6	140	7.6	60.0
IC-78346	859.8	140	6.7	66.7
IC-78342	837.6	145	8.6	48.3
IC-78344	798.8	150	8.6	53.3
IC-78339	1025.6	145	7.2	71.6
IC-78340	1035	150	7.8	80
IC-78364	985.8	150	8.2	81.6
IC-78347	956.2	150	7.6	75
IC-78340	1452.8	155	8	163.3
IC-78339	1206.2	160	7.5	95
IC-94504	2169.4	175	6.6	135
IC-94496	1820.4	175	8.4	58.3
IC-368966	2457.4	190	8.8	115
IC-56066	2352.6	190	7.5	138.3

Table 37: Performance of some selected medium duration varieties under rainfed situation

Line	Days to 70% maturity	100 Seed wt.	Yield /plot (g)	Estimated yield (q/ha)
RVK-275	192.5	8.4	2102.7	25
JKM 189	190	9.1	1970.9	22.8
AKT-9913	179.5	8.4	1649.9	19.6
ICP-3451	200	6.7	1620.4	19.2
ICP-12654	208	7.1	1612.7	19.1
ICP-348	178	7.8	1608.5	19.1
Bennur Local	177	7	1547.5	18.4
ICP-8840	184	7	1537.4	18.3
ICP-13304	205.5	9.5	1534.6	18.3
JKM- 7	193	8.1	1533.5	18.2
CD at 5%	12.4	1.5	374.7	-

Seed Production

Breeder seed of following varieties was produced:

Variety	Crop	Production (q.)
PDM 139	Mungbean	4.00
Uttara (IPU 94-1)	Urdbean	4.50
Shubhra	Chickpea	20.00
IPL 316	Lentil	14.00
IPL 406		2.50

EXTENSION ACTIVITIES

Pigeonpea

Five front line demonstrations were conducted in Bhopal and Sehore districts of Madhya Pradesh. Seed of varieties *viz.*, TJT 501 and JKM 189 was given to the farmers. They were briefed about complete package of practices as per the AICRP recommendations for Central Zone. Scientists visited their crop at flowering and pod filling stage. The results are given below:

Place	FLD plot yield (q/ha)	Farmers' plot yield (q/ha)	Yield gap with respect to FLD (%)
Phanda	17.0	13.2	22.3
Phanda	12.8	11.0	14.0
Sehore	18.5	14.5	21.6
Mugaliya Haat	22.4	16.0	28.5
Mugaliya Haat	18.0	14.2	21.1
Average of all FLDs	17.7	13.7	22.5

Chickpea

Five front line demonstrations were conducted in Bhopal and Sehore districts of Madhya Pradesh. The farmers were given seed of chickpea variety JG 16. They were also briefed about complete package of practices as per the AICRP recommendations for Central Zone. The scientists visited their crop at flowering and pod filling stage. The results are given below:

Place	FLD plot yield (q/ha)	Farmers' plot yield (q/ha)	Yield gap with respect to FLD (%)
Phanda	14.5	12.5	13.8
Dodi	12.2	10.0	18.0
Dupadiayabhil	11.5	09.5	17.4
Chaudi	14.0	12.5	10.7
JamaniPadali	17.5	15.5	11.4
Average of all FLDs	13.94	12.0	13.9

DEVELOPMENTAL ACTIVITIES

- A new farm shed *cum* building along with threshing floor is complete and was inaugurated by Hon'ble Director General ICAR and Secretary DARE.
- Chain link fencing was done on the highway side and a boundary wall has been erected along the Tumra road.
- A concrete road along with culverts was constructed for movement of vehicles and farm machinery.
- A transformer was fixed and cable line was laid in the campus.
- Fields were re-shaped and marked for easy operation.
- *Kuccha* road was developed along the highway side periphery.
- More than 350 tree saplings were planted and maintained in office premises.
- A new ferti-seed drill *cum* ridger is procured for sowing on ridges.
- The existing pond was deepened.

Regional Centre *cum* Off-season Nursery, Dharwad

Plant Genetic Resources: Collection, Evaluation and Conservation

Evaluation and maintenance

Cowpea

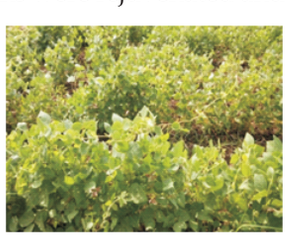
Seventy five accessions from UAS, Bangalore and 4 accessions from ICAR-Research complex, Goa were collected. About 82 accessions of cowpea germplasm were rejuvenated and evaluated for different morphological traits during *kharif/rabi*. Wide range of variation was observed for days to maturity (60-95 days). Entry NBC 24 (60 days) was earliest to mature, followed by EC 458440 (63 days) and EC 394779 (64 days). Entry IC 202777 took more number of days (95 days) to mature, followed by MP 2 (78 days) and EC 170584 (78 days). Character wise promising accessions are as follow:



Character	Promising accessions
Early flowering (< 45 days)	NBC-44, IC-402166, C-198355, C-325, EC-394779
No. of primary branches (>5)	EC-394838, V-578, IC-402175, NBC-30, CB-10
No. of pods/ plant (> 40)	IC-97K499-38, C-720,EC-458442, CB-10, C-720
Pod length (>18 cm)	NB-4, Goa-Cowpea-3, NBC-7, NBC-30, V-578
No. of seeds per pod (> 15)	V-585, NBC-30, V-578, IC-402114, NBC-38
100 seed weight (> 14 gm)	MP-2, NB-4, Alsando-1, IC-202781, C-325
Days to maturity (< 72 days)	NBC-24, NBC-38, EC-458440, EC-394779,

Horsegram

Thirty two accessions were collected from UAS, Bangalore. Total 34 accessions were rejuvenated and evaluated for various traits. Entry TCR 1635 was earliest to mature (73 days), followed by TCR 1493 (74 days) and TCR 1690 (75 days).



Mungbean

About 100 germplasm accessions were rejuvenated and evaluated for different morphological traits. Entry DMG 1133-1 was earliest to mature (64 days), followed by EC 369225 (65 days) and IC 15205 (65 days). Entry GEC 19-21 took more number of days to mature (75 days), followed by Khargaon 2 (72 days) and IPOI 331 (74). The character wise promising accessions are as follow:

Character	Promising accessions
Early flowering (< 40 days)	IC-1608, LM-241, Jalgaon-2, BM-7
No. of primary branches (>3)	IPOI-353, LM-258, INM-446, IC-31401
No. of pods/ plant (> 30)	EC-362096, LM-12, DMG-1105-2, IC-31401
Pod length (>7.5cm)	IC-1608, LM-249, JBT-37/100, DMG-1108
No. of seeds/ pod (> 12)	CN-9058, LA-52, IC-1608, IPOI-353
100 seed weight (> 3.25 gm)	DUS-6-1, EC-369225, IC-470
Days to maturity (< 68 days)	DMG-1133-1, EC-369225, IC-15205, GES-1-4-31

Urdbean

About 100 germplasm accessions were rejuvenated and evaluated for various traits. Entries *viz*., PGRU 95016 (65 days) and IPU 99-79 (66 days) were earliest to mature, followed by PLU 1 (67 days) and PKGU 1 (67 days). Entry IPU 99-200 took more number of days (76 days) to mature, followed by UH 87-7 (73 days) and TU 91-2 (73 days). The character wise promising accessions are as follow:

Character	Promising accessions
Early flowering (< 40 days)	PU-19, UPU-83-3, IC-10703, IPU-99-232
No. of primary branches (>3)	WBU-137-2, PLU-144, NG-2119, NO.7668-43
No. of pods/ plant (> 35)	IC-21001, IC-10703, PLU-328, U-135
Pod length (>5.2 cm)	IPU-99-232, NPU-180, IPU-94-2, TU-99-2, PLU-328
No. of seeds per pod (> 5)	BG-236, IPU-99-232, UH-84-4, IPU-99-95
100 seed weight (> 4.50 g)	IPU-99-40, No.736815, UH-32-3, TU-91-2
Days to maturity (< 75 days)	PGRU-95016, IPU-99-79, UH-218, V-3108, UH-80-38

Maintenance of wild *Vigna* species

About 10 wild *Vigna* species such as *Vigna trilobata* (LRM 2013-24, LRM 2013-30, LRM 2013-32 and LRM 2013-34) *Vigna stipulacea* (LRM 2013-26, LRM 2013-33, LRM 2013-36, LRM 2013-37 and LRM 2013-38) and *Vigna aconitifolia* (LRM 2013-17) were

rejuvenated and evaluated for different morphological traits. About 50 accessions of mungbean and 50 accessions of urdbean were rejuvenated and evaluated for different traits.



Off-season Generation Advancement of Chickpea, Lentil and Fieldpea

Segregating material of chickpea for generation advancement was received from 10 different centers of AICRP on chickpea *viz*., Rahuri, Ludhiana, Sriganganagar, Kota, Sehore, Junagadh, Jabalpur, Coimbatore, Durgapura and Hisar. Off-season generation advancement facility was also used by ICAR-IIPR, Kanpur to advance breeding material in chickpea, lentil and fieldpea. The advanced breeding materials were sent to the respective centers. In addition, 4 F_4 populations of chickpea (derived from JG 11 × ICC 13124, JG 11 × WR 315, BGD 103 × TL-II 109 and BGD 103 × TL-II 112) were advanced during *rabi*.



Breeder/TL Seed Production

Breeder seed production was undertaken under rainfed condition. Total 800 kg breeder seed of mungbean variety IPM 2-14 and urdbean variety IPU 2-43 was produced during *kharif* and 160 kg breeder seed of *kabuli* chickpea varieties and 250 kg truthful labeled seeds of *desi* chickpea variety JG 11 was produced during *rabi* season.



Entries in State MLT

Two promising entries of mungbean (IPM-205-9 and IPM-410-3) and two of *kabuli* chickpea (IPCK 2002-29 and IPCK 2004-29) were entered in state multi-location trials to assess their suitability for cultivation in Karnataka.

CROP IMPROVEMENT

Mungbean

Evaluation of elite breeding lines

Two station trials each comprising of 20 entries were evaluated. In station trial-I, genotype IPM 406-1 recorded highest seed yield (1682 kg/ha), followed by IPM 104-3 (1649 kg/ha) and IPM 9901-8 (1500 kg/ha). In station trial-II, IPM 312-134-135K recorded maximum seed yield (1560 kg/ha), followed by IPM 312-66K-1 (1538 kg/ha) and IPM 544-8 (1504 kg/ha).

Preliminary yield trial

About 48 accessions were evaluated. IPM 14-46-4 was earliest to mature (62 days), followed by IPM 312-394-2 (63 days). Entry IPM 14-28 produced highest seed yield (1907 kg/ha), followed by IPM 14-34-2 (1879 kg/ha) and IPM 14-46-4 (1773 kg/ha) as compared to check IPM 2-14 (1565 kg/ha). Two entries *viz*., IPM 14-32 and IPM 14-37 were found highly resistant to *Cercospora* leaf spot disease.



Generation of breeding material

Two F_2 crosses of mungbean (IPM 2-14 × DGGV 2 and IPM 2-14 × *V. trilobata*) were advanced to F_3.

Chickpea

Evaluation of elite breeding lines

Total 32 accessions of chickpea (*desi*) were evaluated under rainfed condition. IPC 2014-28 was earliest to mature (89 days), followed by IPC 2012-24 (93 days). Entries such as IPC 2006-127 (1027 kg/ha) and IPC 2014-28 (980 kg/ha) produced higher yield as compared to check JG 11 (775 kg/ha). Seed yield was reduced significantly due to drought condition during crop growth period.

Urdbean

Generation of breeding material

Two F_2 crosses (DU 1 × IPU 94-1 and DBGV 5 × DU-1) were advanced to F_3. Eighteen F_3 populations and two F_4 populations of urdbean were sown for generation advancement and selection during *kharif*/*rabi* season. Twelve new crosses were attempted during *rabi* season.

Evaluation of elite breeding lines

Seven advance breeding lines along with three

checks were evaluated. IPU 11-2 was earliest to mature (63 days), followed by IPU 12-30 (65 days). Entry IPU 11-2 produced highest yield (1682 kg/ha), followed by IPU 2-43 (1620 kg/ha) and IPU-12-30 (1453 kg/ha).

Cowpea and Horsegram

Generation of breeding material

Four new crosses *viz*., IC 402172 x EC 394708, EC 458425 x IC 402172, EC 458442 x IC 202777 and EC 394708 x EC 458442 in cowpea and one in horsegram (LRM 2013-03 x CRHG 22) were attempted.

CROP PRODUCTION

Improving Productivity in Pulse Based Cropping System through Resource Conservation and Management

A field experiment was conducted under rainfed condition. There were 16 treatment combinations comprising of four cropping systems (Mungbean-sorghum, maize-chickpea, soybean-chickpea and groundnut-chickpea), two conservation practices (Mulching and no mulching), and 2 fertilizer



management practices (Recommended and farmers practice). Maize-chickpea system recorded highest chickpea equivalent yield of 3867 kg/ha. There was increase by 13% CEY due to mulching in different cropping system.

EXTENSION ACTIVITIES

Participation in the *Kisan Mela*

Scientists of the Center participated in the *Kisan mela* organized by UAS, Dharwad on September 27-30, 2015 and displayed seed samples of IIPR released varieties and various charts related to IIPR released varieties and plant protection measures in pulse crops.



Conduct of FLDs in farmers' fields

Five FLDs were conducted on chickpea (JG 11) in different farmers' field of Dharwad during *rabi* season. During *kharif* and *rabi* seasons scientists of the Centre visited the farmers' field, of different villages (Gambyapur, Narendra, Jamihal) of Dharwad districts and interacted with pulse growing farmers.



DEVELOPMENTAL ACTIVITIES



- Renovation of first floor of sericulture building was completed
- Construction of seed storage *cum* threshing floor is completed



- Installation of bore-well pump was completed
- Chain link fence work and repair of compound wall are in progress
- Bushes/shrubd debris from the farm and surrounding compound wall were removed
- Land leveling work was done in the farm premises.

All India Coordinated Research Projects

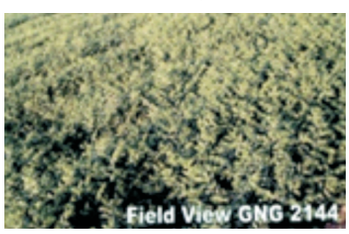
CHICKPEA

Varieties Developed

GNG 2171: This *desi* chickpea variety has been identified for Punjab, Haryana, western U.P., Jammu & Kashmir, Delhi, northern Rajasthan, Himachal Pradesh and Uttarakhand. Its average yield is 2014 kg/ha with yellow coloured seeds (15.9 g/ 100) seed and is suitable for timely sown irrigated conditions of NWPZ. It is tolerant to fusarium wilt disease.



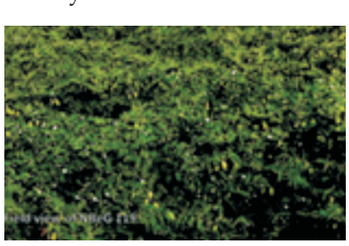
GNG 2144: This *desi* variety has been identified for Punjab, Haryana, Delhi, northern Rajasthan and Uttarakhand. Its average yield is 2281 kg/ha. It is suitable for late sown conditions of NWPZ and is tolerant to fusarium wilt disease.



IPC 2006-77: This *desi* variety has been identified for Madhya Pradesh, Chhattisgarh, Maharashtra and southern Rajasthan. Its average yield is 2065 kg/ha. It is suitable for late sown conditions of central India. It is moderately resistant to fusarium wilt and has light yellow coloured seed of medium size.



NBeG 119: This *kabuli* variety has been identified for Karnataka, Andhra Pradesh and Tamil Nadu. Its average yield is 1882 kg/ha. It has attractive beige coloured seeds with 100-seed weight of 38.8 g.



Genetic Resources

Total 10,972 chickpea germplasm accessions were maintained at 13 centres. These accessions were evaluated for agro-morphological traits.

Breeder Seed Production

Total 7464.28 q of breeder seed of 73 chickpea varieties was produced against DAC indent of 6741.6 q. Some centres produced additional breeder seed to the tune of 238.9 q leading to a total production of 7703.18 q breeder seed.

Research Achievements

- The broad bed furrow with intercropping (one row of intercrop) were found superior in realizing higher productivity in terms of chickpea equivalent yield (CEY) at Durgapura and Kota (chickpea+linseed), Ludhiana (chickpea+linseed), Sehore (chickpea+wheat) and Gulberga (chickpea+safflower) over other methods (flat bed alone, ridge and furrow, and BBF alone).
- Two supplementary irrigations (one each at branching and pod development) had beneficial effect in terms of CEY at Durgapura, Ludhiana and Sehore, while single irrigation at pod development was adequate at Kota and Gulbarga.
- Irrigation schedule at 80% crop evapo-transpiration (ETc) (at par with 100% ETc) resulted in significantly higher chickpea seed and straw yield over 60 % ETc at Rahuri, Junagarh and Bangalore. Irrigation applied at 7 days interval was optimum in terms of productivity and economics at Rahuri and Bangalore, while the interval could be reduced to 5 days at Junagadh.
- Beneficial effect of conventional tillage was recorded at Durgapura, Badnapur and Gulbarga in terms of seed yield and economics. Similarly, INM practice at Durgapura and Gulbarga and recommended dose of NPK at Badnapur were optimum. Recommended pendimethalin herbicide alone was not effective, while twice manual weed control was advantageous in realizing higher yield with effective control of the weeds.
- Pertinent effect of direct seeding of chickpea in untilled field using manual plough+mulching with rice straw (at par with broadcasting seed in standing rice 15 days after 50% flowering *i.e.,* rice relay cropping) was observed at Shillongani. The effect of conventional tillage (seed yield of 1992 kg/ha), followed by reduced tillage (1965 kg/ha) and broadcasting seed, followed by reduced tillage (1949 kg/ha) was evident at

Faizabad. At Imphal, sowing of chickpea with conventional Tillage (two harrowing + planking), followed by line sowing with straw mulch was beneficial.

- Effectiveness of weed control strategy involving pre-emergence application of pendimethalin 30 EC+imazethapyr 2% ready mix combination @ 1.0 kg/ha+one hoeing/HW at 35 DAS (Velor 32 +Hoe/HW) in broad spectrum weed control was confirmed at Ludhiana, Samba, Dholi, Badnapur, Rahuri and Bangalore. At Durgapura, Velor 32 only or pendimethalin CS as PE was adequate to control weeds in chickpea.
- Genotypes RSG 902, GJG 3, GNG 1581, JG 14 and JGK 1 showed very high intrinsic water use efficiency as represented by the ratio of photosynthesis/stomatal conductance (Pn/gs).
- Genotypes Pusa 244, Vijay, Annegiri, CSJD 884, JGK 2 and ICC 4958 showed larger seed size at high temperature than their normal seeds size obtained under cooler temperature. High sucrose synthase activity in grains in these genotypes was found to be the main driving force to enhance the sink efficiency.
- Heat susceptibility index (HSI) was lowest (0.39) in Vijay and JGK 2. This indicated presence of the heat tolerance and better adaptation to warmer environment. Vijay has both drought and heat tolerance.
- Twenty new isolates of mesorhizobia nodulating chickpea were isolated at Ludhiana and screened for plant growth promoting traits and plant infectivity test. Mesorhizobia LGR 14-1, LGR 14-2 and LGR 14-3 were identified as best strains for IAA, siderophore, P- solubilisation, HCN production and cell wall degrading enzymes production with enhanced nodulation and grain yield. Molecular characterization of potential strains revealed the presence of *nif* H, *nod* D and *gyr* B genes. At Sehore centre, four out of 7 isolates showed improved nodulation and grain yield over un-inoculated control.
- Total 123 new isolates of endophytic bacteria were collected from chickpea nodules and root samples at Ludhiana and Hisar. Thirteen isolates were found potential on the basis of plant growth promoting traits. Eleven potential endophytic isolates of root and nodule of chickpea from Pantnagar and Ludhiana centres got accession number from NCBI.
- The PSB strain from Ludhiana along with *Mesorhizobium* (CH 1233) registered highest increase in grain yield (17.0%) over control, followed by PSB strain *Pseudomonas striata* from Gulberga (16%) and strain ORE 35 from Hisar (15.3%). Dehydrogenase activity of soil was significantly high in MR alone and MR+PSB treatment across all the centres in comparison to control.
- **Wilt resistance screening**
  - **Wilt resistant *desi* entries:** GNG 1581, AKG 1108, DKG 964, Phule G 0408, GJG 1209, KGD 2011-1, GJG 0831, IPC 2007-28, IPC 2010-134, GNG 2226, GNG 1958, GL 10023, Phule G 08108, Phule G 124-04 IPCK 2010-124, JG 16, IPC 2010-11
  - **Wilt resistant *kabuli* entry:** IPCK 2009-165
- ***Ascochyta* blight resistance screening**
  - Seven entries viz., GNG 2207, BGD 1082, GNG 2259, GNG 2261, IPCK 2010-92, IPCK 2009-165 and PBG 5 exhibited resistant/moderately resistant reaction at two locations out of five.
- Chickpea accessions with stable resistance for more than two years (no. of years given in parenthesis) against major disease:

Disease	Entries
Wilt	IPCK 2005-74 (5), JG 2001-12 (JG 12) (4), IPC 2008-103 (4), JG 24 (4), HK 05-169 (4), JG 14 (4), JSC 40 (4), JG 2000-04 (3) GJG 0919 (3), IPC 2004-68 (3), GJG 0904(3), GJG 0814(3), IPCK 2004-29 (2), JG 2000-07 (2), JGK 2003-304 (2), GJG 0922(2), GJG 0921(2), BCP 60, IPC 08-11 (2),GLK 28127, CSJK 54 (3), IPCK 06-56 (2), IPC 08-69 (1), SCGPWR 32 (1), SCGPWR 28 (1)
Dry root rot	JSC 37 (6), IPC 2005-28 (5), IPCK 2006-78 (4), CSJ 556 (4), IC 251741 (2) (JG), JG 2003-14-16 (2), JG 24(2), CSJ 826 (1)
Ascochyta blight	GL 23094 (4), GNG 1581 (3), HO 3-45 (3), GLK 24092(3), GLK 26167 (3) IPC 79 (3), IPC 129(3), IPC 93(2), IPC 104 (2)
Botrytis grey mould	HK 94-134 (3), IPCK 2004-29 (2)
Stunt	IPC 2000-06 (5), IPC 2004-52 (4), Phule G 07112 (4), NDG 10-11(1)

- **Chickpea accessions with multiple diseases resistance**
  - ❖ Wilt, dry root rot : GNG 2226, IPC 2007-28, IPC 2010 134
  - ❖ BGM, Stunt : CSJK-72
  - ❖ Dry Root Rot, Collar rot : AKG 1106
  - ❖ Wilt, Dry root rot, Collar Rot : IPC 2010-134
  - ❖ Wilt, Collar rot, Ascochyta blight : DKG 964
- Chickpea seeds with rough seed coat and light brown colour seem to be less preferred by bruchids than smooth and whitish brown colour seed coat.
- Application of neem soap 5%+Rynaxypyr 18 g a.i+Indoxacarb 15.8 EC @ 62g a.i./ha reduced pod borer damage and gave maximum yield at Ludhiana. Treatment Dipel+Acephate in combination with Rynaxypyr and Indoxacarb were found more effective in reduction of pod borer incidence and gave higher yield at Hisar.

Front Line Demonstrations

- One hundred ninety one demonstrations were conducted on production potential of high yielding varieties. The overall mean grain yield of high yielding varieties was 1231 kg/ha against 1155 kg/ha of old/local varieties.
- Two hundred eighty one demonstrations were conducted on package technology. By applying package technology 1517 kg/ha of yield was obtained against 1231 kg/ha by farmers' practice.
- Three hundred sixty three demonstrations were conducted under Tribal Sub-plan in tribal areas and an average yield of 1337 kg/ha was obtained, which was 19.1% higher than yield obtained through traditional practices and varieties.

PIGEONPEA

Promising Entries

Early (120-140 days) genotypes *viz*., SJP 102, RKPV 451-01 (IVT in NWPZ), SJP 102 (IVT in SZ), mid-early (141-160 days) genotypes *viz*., PT 04-378, PT 0705-3-1-1, GRG 177, NTL 30 (IVT in CZ), Medium (161-180 days) genotypes *viz*., TRG 59, GRG 2013, RVSA 7-17, GJP 1401, RPS 2007-10, CRG 2012-25, WRG 252 (IVT in SZ), and late (181-270 days) genotypes *viz*., Pusa 151, DA 15-2, BAU PP 09-27, Pusa 153 (IVT) were found promising.

Breeder Seed Production

Total 734.15 q breeder seed of 34 varieties was produced against the DAC indent of 266.35 q.

Research Achievements

- Mechanised cultivation of pigeonpea under raised bed system with intercropping of soybean and urdbean registered higher pigeonpea equivalent yield and economy.
- Plant spacing of 90 x 30 cm is ideal for pigeonpea-urdbean intercropping for higher grain yield and economy.
- Pigeonpea equivalent yield was significantly higher with CoRG 9701, AL 201 and UPAS 120 with soybean intercropping (2:4) and AL 201 with soybean intercropping (1:6).
- Optimum row spacing for short duration pigeonpea varieties was 45 cm at Nagaland and 60 cm at Tripura.
- Early sowing on 15 September or 1 October registered significantly higher grain yield in *rabi* pigeonpea at Lam and Warangal. Early sowing in September registered higher grain yield at Dholi and Faizabad. Delay in sowing reduced pigeonpea grain yield gradually.
- Application of 125% recommended dose of fertilizers (RDF) recorded higher grain yield in pigeonpea+mungbean intercropping (1:1).
- Application of recommended dose of fertilizers along with foliar spraying of 1% urea+0.25% Zn+0.25% B at 50% flowering, followed by indoxacarb spray at flowering and one systemic insecticide spray after 15 days of first spray recorded significantly higher grain yield at all centres of NEPZ.
- Giving three supplemental irrigations (50 DAS, flowering and pod development stage) registered higher grain yield at Lam, Warangal, Dholi and Faizabad, which was at par with two irrigations during flowering and pod development stage.
- Additional yield of 1490 kg/ha and 494 kg/ha was recorded with drip irrigation over rainfed at Gulbarga and Badnapur, respectively.
- Under drip irrigation system, higher grain yield and benefit cost ratio was obtained with irrigation at 50% PE and dripper spacing of 120 x 60 cm.
- Adoption of all management practices *in toto* (INM+IWM+IPM) registered higher grain yield in all zones except NEHZ, where adoption of

INM+IWM recorded higher yield.

- Application of Pusa hydrogel along with organic residue mulching recorded higher grain yield and economics in Lam, Warangal, Gulbarga, Bengaluru, Berhampur and Badnapur.
- At Coimbatore, application of vermicompost along with Pusa hydrogel at 2.5 kg/ha and at Vamban, FYM at 5 t/ha along with pusa hydrogel at 2.5 kg/ha, followed by foliar spray of 2% KH_2PO_4 at flowering and 2% KNO_3 at pod development stage registered higher grain yield.
- Direct sowing of Manak at plant spacing of 20 cm registered higher grain yield and economy as peripheral crop at Berhampur.
- At Bengaluru and S.K. Nagar, tank mix application of indoxacarb and TNAU pulse wonder at 5.0 kg/ha, followed by rynaxipyr application at 15 days later registered significantly higher grain yield and benefit cost ratio. Tank mix application of rynaxipyr and TNAU pulse wonder at 5.0 kg/ha, followed by indoxacarb application at 15 days later registered significantly higher grain yield at Kanpur.
- Total 35 rhizobial strains were isolated from different centers. At Kalaburagi out of 25 rhizobial isolates only three isolates were able to tolerate up to 50°C. At Varanasi out of ten isolates only five were able to grow at temperature of 40°C. Isolate RA 15-10 showed maximum nodulation at 35°C.
- Among six efficient rhizobial strains CPR 9, GRR 12-21and RA 13-2 recorded maximum grain yield at Coimbatore, Kalaburagi and Varanasi, respectively.
- Combined application of *Rhizobium* and endophytic rhizobacteria POE-7 performed better by registering highest grain yield at Coimbatore and Varanasi.
- Combined application of biofertilizers along with FYM and Ammonium molybdate performed better than their individual application.
- Combined inoculation of PSB and *Rhizobium* increased nodulation and grain yield of pigeonpea as compared to individual inoculation. At Coimbatore and Kalaburagi numerically superior yield was registered with PS-1 (Coimbatore) and PSB-GLB-11 (Kalaburagi).
- Among different PGPR strains, GPGR 25, CRB 2 and LP 13 performed better at Kalaburagi, Vamban and Varanasi, respectively.
- In combined application with *Rhizobium,* the KRB strains *viz*., KRB 3 and KRB 4 performed better at Kalaburagi and Varanasi, respectively, whereas KRB 2 performed better at Coimbatore and Vamban.
- Out of 227 germplasm entries screened for resistance against pod borer, 45 entries were categorized as resistant or moderately resistant and were selected for further screening for confirmation of resistance.
- An overall increase in benefit cost ratio of 1: 3.14 in IPM over either farmer's practice or untreated control was recorded at most of the centres.
- Genotypes CoRG 7 and LRG 151 were found to be promising based on insect pest infestation.
- Genotype ICPL HaRL 4985-11 had lowest damage by pod borer *Helicoverpa* at most of the centres.
- Lambda cyhalothrin 5 EC (25 g a.i./ha) and deltamethrin 2.8 EC (500 ml/ha) treatments were found effective in management of blister beetles.
- Among sequential application of insecticides for management of pod borers and sucking pests, Chlorantraniliprole 18.5 SC @ 30 g ai /ha > flubendiamide 2 WG @ 50 g a.i./ha >Dimethoate 30 EC @ 600 g *a.i.*/ha were found most effective.
- Significant negative correlation was observed between relative humidity and larval population of *M. vitrata.*
- Gram pod borer *H. armigera* population was positively correlated with increase in temperature.
- The activity of *Maruca* starts in 35th SW and reaches its peak during 45th standard week.
- Entries Asha, BRG 3, BRG 15-2, BRG 15-3, BRG 15-4 3, BSMR 243, BSMR 736, BSMR 853, GRG 2013, IPA 8F, KDPV 1935, LRG 151, LRG 170, MA 6, NTL 30, NTL 740, KPL 44, and TDRG 107 were found most promising and exhibited R to MR reaction to wilt at more than 60% locations. ICRISAT genotypes *viz*., ICP 11376, ICPL 12728, ICPL20095, ICPL 20124, ICPL 20136, ICPL 87051, ICPL 96053, ICPL90061, ICPL 99048 and ICPL99095 showed R to MR reaction to wilt at 5-7 locations out of 9 locations.
- Entries Bahar, BRG 3, BRG 5, BRG 15-4, BSMR 243, DAS 15-1, IPA 8F, MA 6 and MAL 13 showed resistant reaction to sterility mosaic at 5-6 locations out of 7 locations. Whereas, ICRISAT genotypes, ICPL11376, ICPL 12739, ICP 99044,

ICP 99048, ICP 99055, ICP 990044, IC99091 and ICPL 9099 were found promising and exhibited resistant reaction at majorly of the locations.

- Etries *viz*., AL 2025, AKTE 12-02, AKTM 10-12, CRG 2012-30, KDPV 1935, LRG 151, LRG 160, MAL 13, SJP 702, TRG 59, WRGE 252 and WRP 1 recorded resistant reaction against *Phytophthora* stem blight at two centers out of four.
- Three entries *viz*., AKTE 12-02, LRG 160 and IPA 8F recorded resistant reaction against Macrophomina stem blight at one location. IPA 15F and MAL 43 showed moderately resistant reaction at Coimbatore and Varanasi.
- Seven entries *viz*., Bahar, BDN 2, CRG 2012-25, IPA 8F, IPA 15 F, MA 6 and PA 443 showed resistant reaction against leaf spot at Coimbatore.
- Six genotypes *viz*., IPA 9F, IPA 16F, IPA 2012-1, VKG-17/18, JBT-41/30 and AKTM 1012 were found highly resistant or resistant against *M. javanica*
- Two genotypes IPA 16F and AKTM 1012 gave resistant or moderately resistant reaction against *M. ingcognita* at three locations out of 5 test locations.

Front Line Demonstrations

- Front line demonstrations were organized in 289 ha area on five components *viz*., intercropping with soybean, transplanting, IPM, planting on ridges and package technology (integration of all the components).
- Intercropping of pigeonpea with soybean (2:4) resulted in 34.2% more grain yield than farmers practice (Sole crop) in 22 ha demonstrations.
- Transplanting method resulted in 211% more grain yield than normal sowing with 584% higher net return in 5 ha demonstrations.
- Insect (Pod borers) management was found most beneficial and recorded 16.3% higher grain yield with 37.9% higher net return in 36 (ha) demonstrations.
- Planting on ridges recorded 19.5% higher grain yield as compared to flat sowing in 10 ha demonstrations.
- Integration of all components of production technology enhanced productivity by 25.5% with 33.8%, higher net return in 193 ha demonstrations.

MULLaRP

Varieties Developed

DGGV 2 : This mungbean variety developed from the cross Chinamung x TM 98-50 has been released and notified for *kharif* season in Karnataka. It has average yield of 1200 kg/ha.

BGS 9 : This early maturing and bold shining green seeded mungbean variety is moderately resistant to powdery mildew and gives yield up to 14 q/ha. It is released and notified for *kharif* cultivation in Gujarat.

Shalimar Mung 2: This mungbean variety has been developed from the cross PS 7 x Larkipora Local. It gives average yield of 1000 kg/ha. The variety has been released and notified for *kharif* season in Jammu and Kashmir.

DGGS 4 : This mungbean variety has been developed from the cross SL 4 x TM 98-50. It gives average yield of 968 kg/ha in North Hill Zone with 26% yield advantage over the check variety KM 2241. The variety has been identified for *kharif* season in Tripura, Manipur and Arunachal Pradesh.

DBGV 5: This urdbean variety has been developed from the cross TAU 1 x LBG 20. It gives average yield of 1210 kg/ha. It is large seeded variety and matures in 82-84 days. It has been released and notified for *kharif* season in Karnataka.

Vallabh Urd: This urdbean variety has been released and notified for *kharif* season in western Uttar Pradesh, Punjab, Haryana Rajasthan and Uttarakhand.

MDU 1: This urdbean variety has been developed from the cross ADB 2003 x VBG 66. It gives average yield of 1200 kg/ha. It is large seeded variety and has good battering quality. It has been released and notified for *kharif* season in Tamilnadu.

KPU 405: This urdbean variety has been developed from the cross RBU 1012 x M 1-1. It has average yield of 942 kg/ha in North West Plain Zone during spring season. It is resistant to MYMV. It has been identified for release for spring season in western Uttar Pradesh, Punjab, Haryana Rajasthan and Uttarakhand.

RVL 31 : This lentil variety is a high yielding (1800-1900 kg/ha), early maturing, large seeded and wilt resistant with very good biomass. It is developed from selection of local collection from Shajahpur. It has been released for cultivation in Madhya Pradesh.

Shalimar Masoor 2 : This large seeded lentil variety has been developed from selection from EC 3109. It is moderately resistant to rust and gives yield up to

13 q/ha. It is suitable for Kashmir Valley up to the altitude of 1850 msl.

KLB 2008-4 (Kranti) : This large seeded lentil variety has been developed from the cross LG 362 x DPL 62. It has average yield of 1800 kg/ha and matures in 115-120 days. It has been released and notified for U.P. state.

KLS 09-3 (Krish): This small seeded lentil variety has been developed from the cross L 9-12 x WBL 58. It has average yield of 1800 kg/ha and matures in 105-110 days. The variety has been identified for release for U.P. State.

RFP 2009-1: This tall fieldpea variety with pink flower has been developed from the cross Rachna x EC 334160-1. It has average yield of 1969 kg/ha in Central Zone and found suitable for rice fallow. It is moderately resistant to powdery mildew disease and matures in 109 days. The variety has been released for Chhattisgarh and Bihar.

IPFD 11-5 : This dwarf fieldpea variety has been developed from the cross (DDR 16 x HUDP 7) x DDR 16. It has average yield of 2246 kg/ha in Central Zone and has shown an yield advantage of 14.3% over the check variety Prakash. It is resistant to powdery mildew disease and matures in 109 days. It has been identified for Madhya Pradesh, Chhatisgarh, Bundelkhand region of U.P. and Gujarat.

Shalimar Pea 1: This dwarf fieldpea variety has been developed from selection of KPFD 8. It matures in 210-215 and has yield potential of 13-14 q/ha in Kashmir Valley up to the altitude of 1850 msl. It is released and notified for J&K.

Pre-breeding Efforts

- Total five interspecific crosses were attempted with the use of *Vigna umbellata, V. sublobata, V. sylvestris and V. trilobata* for developing pre-breeding material for improvement of mungbean and urdbean.
- Eight inter-specific crosses were attempted for mungbean x urdbean introgression.
- Eight fresh crosses were made using wild (*Lens orientalis*) and cultivated species. Ten crosses involving *Lens orientalis* and *L. erviodes* as wild species were advanced in subsequent generations. These are IPL 220 × ILWL 145 (*L. orientalis*), DPL 62 × ILWL 106 (*L. orientalis*), IPL 406 × ILWL 242 (*L. orientalis*), IPL 406 × IG136653(*L. orientalis*), DPL 15 ×IG136667 (*L. erevoides*), IPL 533 × IG136656 (*L. erevoides*), IPL 220 × IG136667 (*L. erevoides*), IPL 220 ×ILWL 11, (*L. orientalis*), IPL 406 × IG136667 (*L. erevoides*), and IPL 406 × ILWL 356. Total 80 single plants selected from 260 F_3 progenies for different plant types were sown from cross made between cultivated (DPL 58) and *Lens orientalis* (ILWL 118) species. These lines have been recorded for earliness, leaf size, plant height seed size and biomass to study the range of variability.

Promising Entries

Based on the yield data, several entries out yielded the best check by more than 5% in IVT and 10% in AVTs (Table 38). The mean yield (kg/ha) of the promising entries as well as best check has been indicated in parenthesis.

Quality Breeding and Biofortification

Phenol content ranged from 0.86 to 22.65 (mg/g), antioxidant from 0.95 to 12.14 (micromole/g) and flavonoids 1.98 to 16.85 (mg/g) as reported by IARI, New Delhi. Total 195 lentil genotypes were evaluated for grain Fe and Zn concentration. At IIPR Kanpur, minerals rich advanced breeding line IPL 220 was evaluated in AVT 2 and has been validated for higher Fe and Zn content.

National Crossing Programme

To develop pool of segregating material, a national crossing programme was organized at 11 centres for lentil, 10 centres for fieldpea and two centres for lathyrus. A large number of crosses were attempted in lentil at IARI, New Delhi (49), PAU, Ludhiana (34), ARS, Sehore (24), NDUAT, Faizabad (18), CSAUAT, Kanpur (18), GBPUAT, Pantnagar (17), IIPR, Kanpur (16), BAU, Ranchi (6) and RARI, Durgapura (3). Similarly, a large number of crosses were attempted in fieldpea at CAU, Imphal (21), IIPR, Kanpur (20), CCS HAU, Hisar (18), GBPUAT, Pantnagar (15) , IGKVV, Raipur (11), RARI, Durgapura (10), NDUAT, Faizabad (7), BAU, Ranchi (6) , BHU, Varanasi (6) and ARS, Shillongani(5). In lathyrus, two centres *viz,* CAU, Imphal and ARS, Kota attempted 21 and 13 crosses, respectively.

Breeder Seed Production

Total 856.76 q breeder seed of mungbean (48 varieties), 378.39 q of urdbean (41 varieties), 311.59 q of lentil (35 varieties) and 637.33 q of fieldpea (24 varieties) was produced against the indent of 931.96 q, 424.36 q, 258.90 q and 464.47 q, respectively.

Registration of Varieties

During the year, total 6 varieties of fieldpea and lentil were registered with PPV and FRA.

Research Achievements

- In mungbean + pigeonpea intercropping system, 1:1 row ratio with 100 % recommended dose of phosphorus (RDP) at Dharwad and 5:1 row ratio with 150 % RDP at Lam was better for higher mungbean equivalent yield.

Table 38 : Promising entries in different trials

Trial	Zone	Genotype
Mungbean *(Kharif)*		
AVT 2	NHZ	GM 04-2 (5.3%), KM 2241ch. (696 kg/ha)
AVT 1	NHZ	NVL 516 (45%), IPM 410-3 (23%), RMG 1028 (21%), DGG5 (20%), Pusa 1371 (11%), KM 2241 ch. (696 kg/ha)
IVT	NHZ	HUM 27 (13%), GM 11-02 (5%), KM 2241 ch. (1030 kg/ha)
	NWPZ	MH 810 (5.5%), ML 2333 (5.2%), Pusa 1472 (4.7%), ML 818 ch. (752 kg/ha)
	NEPZ	Pusa 1472 (10%), MH 810 (9%), SGC 20 (9%), IPM 02-3 ch.(958 kg/ha)
Urdbean *(Kharif)*		
IVT	NHZ	DKU 11 (28%), TU 67 (14%), NDUK 13-6 (12%), KU 96-7 (8%), Uttara ch. (826 kg/ha)
	NEPZ	MU 44 (6%), Uttara ch. (1263 kg/ha)
	CZ	KU 96-7 (6%), DKU 11 (6%), NUL 7 ch. (1314 kg/ha)
	SZ	KU 96-7 (6%), Vamban 7 ch. (938 kg/ha)
Urdbean *(Rabi)*		
AVT 2	SZ	LBG 787 (9%), CoBG 653 ch. (944 kg/ha)
IVT	SZ	CoBG 10-06 (19%), LBG 792 (10%), VBG 10-031 (8%), CoBG 653 (973 kg/ha)
Lentil		
IVT (Large seed)	NHZ	LL 1374 (1374 kg/ha), LL 1375 (1219 kg/ha), RL 3-5 (1187 kg/ha), IPL 333 (1178 kg/ha)
	CZ	L4727 (1439 kg/ha), L 4726 (1335 kg/ha), RVL 13-5 (1256 kg/ha), RKL 14-20 (1174 kg/ha), RKL 24C-59 (1007 kg/ha)
	NWPZ	PL 194 (1514 kg/ha)
IVT (Small seed)	NWPZ	PL 175 (1490 kg/ha), LL 1320 (1435 kg/ha)
AVT 1 (Extra early)	CZ	L 4717 (1091 kg/ha)
IVT (Extra early)	CZ	L 4735 (1144 kg/ha), KLS 14-1 (1158 kg/ha), L 4737 (1094 kg/ha)
Fieldpea		
AVT 1 (Tall)	CZ	Pant P 243 (1902 kg/ha)
IVT (Tall)	NHZ	KPF 1023 (1631 kg/ha), VL 60 (1432 kg/ha), VL 61 (1385 kg/ha)
	NEPZ	IPF 2014-13 (1599 kg/ha)
	CZ	IPF 2014-16 (1816 kg/ha), Pant P 269 (1605 kg/ha), KPMR 936 (1598 kg/ha)
AVT 2 (Dwarf)	CZ	IPFD 12-2 (2401kg/ha), Pant P 195 (2279 kg/ha)
IVT (Dwarf)	NHZ	IPFD 13-2 (1251 kg/ha)
	NWPZ	Pant P 250 (2554 kg/ha), IPFD 2014-11 (2194 kg/ha),Pant P 247 (2173 kg/ha), NDP 14-11 (2133 kg/ha)
	CZ	IPFD 2014-2 (2120 kg/ha), Pant P 250 (2115 kg/ha), IPFD 2014-11
Lathyrus		
AVT 1	NEPZ	BK 14-1 (1498 kg/ha)
IVT	NEPZ	DLY 13-7 (1295 kg/ha)
Rajmash		
IVT	CZ	RKR 1038-1 (1684 kg/ha), RKR 1009 (1677 kg/ha), RKR 1011 (1666 kg/ha)

- Pre-emergence application of pendimethalin 30 EC+imazethapyr 2 EC (ready mix) @ 0.75 kg/ha *fb* hand weeding at 25-30 DAS was found better for controlling weeds in mungbean at different centres.
- Foliar spray of salicylic acid 100 ppm or complex NPK (19:19:19) at flowering proved better for higher grain yield at Kota. At Ludhiana, foliar application of TNAU Pulse wonder @ 5 kg/ha or DAP 2% at flowering and 15 days later or complex NPK (19:19:19) at flowering proved better for higher grain yield
- Nutrient+weed+pest management recorded significantly higher grain yield of mungbean and urdbean, followed by nutrient+weed management. Individually weed followed by nutrient and pest management practices were major yield enhancing factor. Optimum seed rate of 30 kg/ha with 125 % recommended dose of fertilizer+25 kg $ZnSO_4$+2% urea spray twice at Akola and 15 kg/ha with 100 % RDF at Badnapur was found better.
- In urdbean+maize intercropping system, 1:1 row ratio at Coimbatore, Dharwad, Keonjhar and Pantnagar and 2:2 row ratio at Dholi and Vamban and weed management practice of pendimethalin 30 EC @ 0.75kg/ha+one hand weeding at 25 DAS and at Dholi and Keonjhar, pendimethalin 30 EC @ 0.75 kg/ha *fb* imazethapyr @ 75 g/ha at 20-25 DAS gave significantly higher urdbean/maize equivalent yield.
- Pre-emergence application of pendimethalin 30 EC+imazethapyr 2 EC @ 0.75 kg/ha *fb* manual weeding at 25-30 DAS recorded higher urdbean yield.
- Integrated crop management practices *i.e.*, nutrient (half dose through organic sources+ half through inorganic sources)+weed (pendimethalin 30 EC @ 0.75-1.0 kg /ha as PE *fb* one hand weeding at 30-60 DAS)+pest (seed treatment with thiram 3 g/kg or captan 2 g/kg or carbendazim 1 g/kg *fb* spray of monocrotophos/dimethoate + propiconazole 25 EC @ 500 ml/ha) recorded significantly higher grain yield and net return of lentil, fieldpea and rajmash, followed by nutrient+weed practices over control. Individually, weed followed by nutrient management practices were major yield enhancing practices.
- Recommended dose of fertilizer RDF (20-17-16-20 kg NPKS/ha)+25 kg $ZnSO_4$+ seed inoculation with *Rhizobium*+*PSB*+*PGPR* and seed treatment with 1.0 g ammonium molybdate/kg seed recorded significantly higher grain yield and net return of lentil, followed by RDF (20-17-16-20 kg NPKS/ha)+seed inoculation with Rhizobium culture + PSB+PGPR+1.0 g ammonium molybdate/kg seed over no inoculation.
- Use of recommended dose of nitrogen *i.e.*, 15 kg/ha along with seed inoculation with *Rhizobium*+sodium molybdate produced higher grain yield of lentil under rice fallow system.
- Two foliar sprays of 20 ppm salicylic acid at flower and pod initiation effectively manage moisture stress with higher yield of lentil under moisture stress condition, which was equally at par with 2% urea spray.
- Recommended dose of fertilizer RDF (20-17-16-20 kg NPKS/ha)+25 kg $ZnSO_4$+seed inoculation with *Rhizobium*+*PSB*+*PGPR* and seed treatment with 1.0 g ammonia molybdate/kg seed recorded significantly higher yield and net return of fieldpea, followed by RDF (20-17-16-20 kg NPKS/ha)+seed inoculation with Rhizobium culture+PSB+ PGPR+1.0 g ammonium molybdate/kg seed over uninoculated control.
- Lathyrus seed inoculated with sodium molybdate @ 0.5 g/kg with 30 cm rice stubble height and sown as relay cropping after rice harvest of either early or medium duration variety gave higher grain yield over 10 and 20 cm rice stubble height.
- In mungbean, thermo-tolerant *Rhizobium* strains LMR 14, MOR 8, CMR 4 (909 kg/ha) and AKMR 12-01 (893 kg/ha) significantly improved nodulation and yield over uninoculated control.
- In urdbean, *Rhizobium* strains PUR 34, UP 4 and WUR 12-01 significantly improved nodulation and grain yield over uninoculated control. *Rhizobium* strain PUR 34 recorded maximum yield (1136 kg/ha) and number and dry weight of nodules.
- *Rhizobium* strain LRB 2 co-inoculated with KRB 1 significantly increased nodulation and yield (1178 kg/ha), followed by LR 63-01+KRB 1 (1167 kg/ha) in lentil.
- *Rhizobium* co-inoculated with ACC-deaminase producing PGPR strains improved nodulation and grain yield of lentil. Among the PGPRs, LLRACC-3(Ldh) and IIPRRACC1 (Kanpur) when inoculated with *Rhizobium* (LLR 12) significantly increased grain yield by 8.3% and 10.1%, respectively over *Rhizobium* alone.
- Isolate BHUPR 14-5 showed highest growth in terms of O.D at 25^0C (1.14) and at 15^0C (0.78). *Rhizobium* strain HUPR 74 when co-inoculated

with KRB1 recorded maximum nodulation (33.4 nodules/plant) and yield (1824 kg/ha) in fieldpea. *Rhizobium* co-inoculated with LFP 10 significantly improved nodulation and grain yield (1695 kg/ha).

- In fieldpea, ACC-deaminase producing strains IIPRACC 3 and LLRACC 2 exhibited maximum grain yield when co-inoculated by *Rhizobium* strain.
- Mungbean entries CoGG 10-10 and ML 2333 showed multiple resistance to MYMV, ULCV, PM, MYMV and anthracnose.
- Seed treatment with imidacloprid 5g/kg+carbendazim (2g/kg)+foliar spray of imidacloprid 0.05% at 25 DAS+foliar spray of tubuconazole+trifloxystrobin (0.1%) recorded lowest incidence of foliar leaf spots and viral diseases coupled with increase in yield in mungbean.
- Urdbean entry DKU 4 showed multiple resistance to MYMV, Anthracnose, WB and MB, while DKU 11 and Vamban 7 showed reistance to MYMV and ULCV at most of the locations.
- Foliar and viral diseases of urdbean were effectively managed by seed treatment with imidachloprid, followed by foliar sprays of carbendazim, imidachloprid and tebuconazole + trifloxystrobin (0.1%).
- Lentil entries IPL 332 and IPL 194 showed multiple resistance to rust and wilt. Entry IPL 576 showed multiple resistance to rust, wilt and stemphyllium blight and IPL 315 to rust, Ascochyta blight and stemphyllium blight. Entries DPL 15 and IPL 176 were resistant to wilt and stemphyllium blight, whereas PL 157, KLB 13-6, RKL 24C-59, LL 1316, VL 524 and DPL 62 were resistant to rust and stemphyllium blight. Entries DKL 57 and VL 525 were resistant to rust and Ascochyta blight, whereas, LL 1375 and NDL 14-21 were resistant to Ascochyta blight and Stemphyllium blight.
- Among the NGSN, lentil entries PL 211, 212, 214, 215 and 216 showed multiple resistance to wilt and rust.
- Fungicides amistar and tebuconazole were effective for lowering the disease severity of rust in lentil.
- Among NGSN entries Pant P 306, 308 and 313 showed high level of resistance to rust and powdery mildew in fieldpea.
- Fieldpea genotype RFPG 67 showed resistance to powdery mildew and RFPG 79 showed multiple resistance to powdery mildew and Ascochyta blight.
- Rajmash entries RKR 1011, RKR 1038-1, RKR 1036 and Arun were resistant to BCMV.
- Mungbean entries IPM 2-14, TMB 45, KM 2342, ML 2333, DGG 1 and DGG 6 were found promising against whitefly and jassids. Entries DGG 1, DGG 6, ML 2333,KM 2342, LGG 486, SGC 20, Pusa 0672 and Pusa 1472 were found promising against stem fly .
- For control of sucking pests in mungbean, seed treatment was effective only for initial 40- 45 days. New insecticides, Thiamethoxam @ 0.3 g/l and Clothianidin 0.1 g/l were observed best treatments with least infestation of pest and high crop yield.
- Among *rabi* mungbean genotypes tested at Vamban, Coimbatore and Lam against sucking pests like stem fly and pod borers, entries *viz*., IPM 05-17,CoGG 10-10, IPM-410-2, GM 11-02 and DGG 6 were found promising.
- In advance stage screening trials, mungbean entries PKVAKM 4, IPM 410-3 and VGG 05-009 were found promising against sucking pests, defoliators and pod borer at Vamban and Berhampur (O).
- Entries AKU 11-8, DKU 11, KUG 715, KUG 725 AKU 10-2, GH 1 and Pant U31 were found promising against whitefly and jassids. Entries VBG 11-6, MH 066, AKU 10-1, AKU 10 -2 and CoBG 10-6 were found promising against stem fly.
- Entries TU 68 and TU 80 were found tolerant to bruchids.
- Novaluron @ 37.5g a.i. and profenophos (50 EC) @ 625g a.i./ha were most effective insecticides for management of defoliators in urdbean.
- Among urdbean genotypes tested at Vamban, Coimbatore, Berhampur and Lam against sucking pests, stem fly and pod borers, entries *viz*., KUG 715, NUL 244, TU 94-2, CoBG 653, COP 759 and IPU-10-23 were found promising.
- At Vamban, among newer chemicals tested against sucking pest (whitefly), its population was lowest in Imidacloprid seed treated plots, followed by plot with any one spray of Thiamethoxam @ 0.3g or Acetamiprid @ 0.3g/l water.
- Seed treatment with Imidacloprid 600 FS @ 3 ml/kg seed+ Carbendazim 2 g/kg+Rhizobium+PSB intercropped with mustard proved effective in control of aphids and pod borer. Bio-rational spray of NSKE 5% at 40 DAS and spray of Indoxacarb 14.5 SC @ 50 g

a.i. /ha at 50% flowering stage resulted in 13.4-27.0% increase in yield of lentil.

- Bio-rational insecticides Rynaxypyr 18.5 SC @ 25.0 g and Indoxacarb 14.5 SC @ 60.0 g and Emmamectin benzoate @ 10 g a.i./ha were most effective against pod borer complex *w.r.t.* larval population, pod damage and yield of fieldpea at Ranchi, Durgapura, Faizabad and Shillongani.
- Bio-rational spray of NSKE 5% at 40 DAS and spray of Indoxacarb 14.5 SC @ 50 g a.i./ha at 50% flowering stage resulted in 14.59-28.31% increase in yield of fieldpea at different locations *viz*. Dholi (19.0%), Varanasi (26.05%), Durgapura (14.89%), Ranchi (17.54%), Pantnagar (85.00% fieldpea + mustard), Faizabad (26.19%) and Shillongani (16.71%) with CB ratio varied form 1: 1.84 to 1: 2.0 at various locations.
- Leaf miner damage in rajmash at Varanasi varied from 26.16 to 45.12%. Lowest leaf minor damage was recorded by entry 405 and entries 228, 336 and HUR 137 were at par with it.
- Mungbean variety IPM 2-14 was resistant against *Meloidogyne incognita* at two locations and moderately resistant at other two locations out of eight locations and GM 04-02, HUM 1, HUM 27, KM 2342, RMG 1028, RMG 1030 were observed resistant in preliminary screening against *M. javanica*.
- Carbofuran 3G 0.5 kg a.i./ha in combination with seed treatment with carbosulfan 1% v/w gave better plant growth parameters, reduced nematode multiplication and increased the yield in mungbean infected with *M. incognita*.
- Urdbean entry VBG 11-016 was found resistant against *M. incognita* at four location and moderately resistant at one location out of eight locations, while MU 44 and NUL 205 were observed resistant in preliminary screening against *M. javanica*.
- In preliminary screening, two lentil entries HUL 57 and PL 165 were found resistant and IPL 220, DKL 50, L 4710, RKL 607-1, LH 84-8, IPL 332 and IPL 81 were found moderately resistant against *M. incognita* at two locations. Entries *viz*., L 4710 L 4076 IPL 332 and DPL 15 were observed as resistant and KLS 218 DKL 37 KLB 13-6 IPL 81were observed moderately resistant against *M. javanica*.
- Fieldpea entries *viz*., Vikash, HFP 529 and IPFD 12-2 were found resistant and Rachna, RFPG 79, IPFD 13-2, HFP 530 B, Pant P 222, HFP 4, Pant P 195 and IPFD 13-04 were found moderately resistant against *M. incognita* at two locations. Entries IPF 13-14, Adarsh and IPFD 12-2 were observed resistant and RFPG 79, Ambika, Pant P 243, IPFD 13-2, HFP 530 B and HFP 4 were observed as moderately resistant against *M. javanica*.
- Carbofuran 3G @ 1.5 kg a.i./ha reduced maximum nematode population and increased grain yield as compared to other treatments, followed by soil application of neem cake @ 500 kg/ha + seed treatment with carbosulfan 25 DT @ 0.1% in fieldpea

Front Line Demonstrations

- During *kharif*, 85 demonstrations conducted on package technology in mungbean recorded 27.38% higher grain yield and 37.55% increase in net returns over local farmers practices.
- In rice-fallow, package technology depicted 19.44% higher grain yield and 25.32% increase in net economic benefit over local varieties in mungbean.
- During *kharif*, 110 demonstrations conducted on package technology in urdbean recorded 32.69% higher grain yield and 38.19% increase in net returns over local varieties.
- During *rabi*, urdbean demonstrations conducted on package technology recorded 20.45% higher grain yield and 23.53% increase in net returns over local varieties.
- In rice-fallow, package technology depicted 18.26% higher grain yield and 25.64% increase in net return over local varieties in urdbean.
- Total 161 frontline demonstrations conducted on full technology packages in lentil, fieldpea and lathyrus resulted in 34%, 33% and 29% increase in yield, respectively. The average monetary gains with improved technology were 55% (lentil), 37.76% (fieldpea) and 34.30% (lathyrus).

Demonstrations under Tribal Sub-plan

- Package technology exhibited 27.23% higher grain yield and 34.82% increase in monetary advantage over local varieties in urdbean.
- Package technology recorded 26.29% increase in grain yield and 35.14% in net return in mungbean.
- Total 216 demonstrations (65 on lentil, 78 on fieldpea, 33 on rajmash and 20 on lathyrus) were conducted by seven AICRP centres on package technology. Improved technologies recorded 26%, 34% and 29% increase in yield in lentil, fieldpea and lathyrus, respectively.

ARID LEGUMES

Variety Developed

CRHG 22: This variety of horsegram has been developed through induced mutation through gamma rays irradiation and identified for rainfed areas of Andhra Pradesh, Tamil Nadu, Telangana, Karnataka and Kerala. It has semi-compact and semi-erect plant type with moderate plant height. Its seed colour is black. Its mature in 94-101 days. Its average yield is 800-900 kg/ha. It is moderately resistant to anthracnose, yellow mosaic virus and cercospora leaf blight.

Promising Entries

Entry GC 901 of cowpea out yielded best check RC 101 by more than 5% in North zone and in South zone, 14 entries gave 5% higher yield against the best check GC 3. In horsegram, 3 entries in North zone and 2 entries in South zone gave more than 5% higher yield than the best checks. In mothbean, 3 entries gave higher yield than the best check RMO 257.

AVT-2 entry, Phule CP-05040 gave 11.9% higher yield than the best check RC 101 on the basis of weighted mean over years and locations. In South zone, AVT-2 entry, PCP 0306-1 gave 14.2% higher yield than the best check GC 03 and Phule CP-05040 gave 3.6% higher yield than the best check GC 03 on the basis of weighted mean over the years and locations. In horsegram, two entries CRGH 23 and CRGH 22 gave 14.1 and 13.4% higher yield, respectively than the best check CRGH 19 on the basis of weighted mean over the years and locations.

Breeder Seed Production

Total 271.73 q breeder seed of guar (19 varieties), 14.32 q of cowpea (8 varieties), 35.7 q of mothbean (7 varieties) and 3.7 q of horsegram (7 varieties) was produced against the indent of 341.06 q, 38.75 q, 95.25 q and 75.6 q, respectively.

Research Achievements

- At Bangalore, economics of cowpea cultivation showed that higher net return (Rs. 38,871) was recorded with genotype KBC 4 coupled with 45 cm spacing and application of full package. The highest B:C ratio (2.71) was in KBC 4 + 45 cm spacing + full package, followed by KBC 4 + 30 cm spacing + full package and the least (2.43) was in DC 15 + 30 cm and control (1.16). At Pattambi, DC 15 (991 kg/ha) and DCS 47-1 (925 kg/ha) were significantly superior in grain yield than Kanakamony and Goa local. Full POP is significantly superior in grain yield (1002 kg/ha) than Zero POP.
- DC 15 and DCS 47-1 of cowpea with 30 and 45 cm row spacing were significantly superior in grain yield than other treatments. DC 15 with full POP (1172 kg/ha), DCS 47-1 with full POP (1054 kg/ha) and Goa local with full POP (923kg/ha) were significantly superior in grain yield than other treatments.
- Maximum seed yield of clusterbean was recorded with two irrigations applied at vegetative and 50% flowering stage. Similar trend was observed for dry fodder yield. 50% flowering and seed development stages are most critical for irrigation in clusterbean. At Hanumangarh, one irrigation at vegetative state and another at development state gave highest yield of 927 kg/ha, while one irrigation at grain development state gave 902 kg/ha.
- At Sardarkrushinagar, intercropping clusterbean + pearlmillet (2:2) and sole pearlmillet (2:1) being at par and recorded significantly higher clusterbean equivalent yield (552 kg/ha) and (519 kg/ha), respectively.
- At Gwalior, highest clusterbean equivalent grain yield (1531 kg/ha) and B.C. ratio (4.17) were obtained with sole clusterbean, followed by clusterbean+ pearlmillet intercropping (2:1 row ratio). In weed management practices, higher clusterbean equivalent grain yield (1614 kg/ha) was recorded in two interculture at 25 and 45 DAS, followed by application of Pendimethalin @ 1.5 kg a.i/ha PE spray + one interculture at 25 DAS.
- On the basis of three year pooled data, the results showed that highest clusterbean equivalent seed yield (1845 kg/ha) and B.C. ratio (6.76) were obtained with sole clusterbean, followed by clusterbean+pearlmillet intercropping (2:1 row ratio). Results on weed management practices revealed that the higher clusterbean equivalent seed yield (1570 kg/ha) and B:C ratio (4.98) was recorded in two interculture at 25 and 45 DAS, followed by the application of Pendimethalin @ 1.5 kg a.i/ha PE spray + Imazethapyr @ 40 g a.i./ha at 25 DAS.
- At Bangalore, foliar spray of 2% urea at vegetative growth stage recorded significantly higher pod number/plant, 100 seed weight and seed yield (21.1, 8.1 and 1632 kg/ha, respectively), followed by foliar spray of 1% urea at vegetative growth stage (19.9, 7.4 and 1576 kg/ha, respectively) and mulching @ 3 t/ha (19.4, 7.6 and 1565 kg/ha, respectively). Significantly lower yield parameters and yield were recorded with foliar spray of growth retardant (Maleic hydrazide) at vegetative stage (9.9, 7.2 and 832 kg/ha, respectively). This treatment recorded

maximum days to 50% flowering (77.7 days) and maturity (105.3 days).

- Foliar spray of 2% urea at vegetative growth stage recorded highest net returns and B:C ratio (Rs. 33,831/ha and 2.45, respectively), followed by 1% urea and normal planting at recommended spacing (Rs. 31, 891/ha, 2.37 and Rs. 31,001/ha and 2.37, respectively). Foliar spray of growth retardant (Maleic hydrazide) at vegetative stage recorded negative net returns and B:C ratio because of significantly lower yield (832 kg/ha) and high cost of cultivation (Rs. 33,241/ha).
- At Gwalior, application of Imazethapyr + Imazamox @ 40 g/ha at 3-4 leaf stage (20 DAS) gave highest seed yield (2073 kg/ha) of clusterbean, net monetary return and BCR (6.67), but at par with Imazethapyr @ 40 g/ha at 3-4 leaf stage (20 DAS). Significantly lower seed yield (1044 kg/ha) was noted in weedy check (No weeding) treatment.
- At Bangalore, post-emergence application of Imazethapyr+Imazamox @ 40 g/ha at 3-4 leaf stage recorded significantly superior yield (1685 kg/ha) with better weed control efficiency (66%). This was followed by one hand weeding at 3-4 leaf stage (1434 kg/ha and 63.7%). against lower yield with weedy check treatment (1039 kg/ha).
- At Bathinda, application of Imazethapyr @ 40g/ha at 20 DAS or Imazethapyr+Imazomox @ 40 g at 20 DAS provided maximum productivity as compared to other treatments.
- At Hanumangarh, application of Imazethapyr + Imazomox a.i. @ 40 g/ha at 3-4 leaves stage gave highest yield of 1142 kg/ha as against 783 kg/ha weedy check. Second highest yield was obtained by post-emergence application of Imazethapyr @ 40 g/ha at 3-4 leave stages.
- At Pattambi, application of Imazethapyr + Imazamox @40 g/ha at 3-4 leaf stage gave highest grain yield which was at par with hand weeding and all other herbicide application except Fenoxaprop-p-ethyl@50 g/ha.
- Disease intensity of MYMV and crinkle virus was higher as compared to previous years in 25 villages of Bikaner district. The disease intensity of MYMV on mothbean varied from 10 to 35%. The disease severity of leaf crinkle virus was 5 to 25%. In clusterbean, bacterial blight was a common disease and its intensity ranged from 10 to 25%. Root rot incidence ranged from 5 to 20% and maximum in Gusaisar and Jetsar villages.
- Weather conditions favoured development and spread of bacterial leaf blight in clusterbean and average disease intensity was 30-40%. Root rot infection was 15%. Powdery mildew was observed with 25% severity. Weather conditions were highly congenial for development of bacterial blight and viral diseases of cowpea.
- Minimum incidence of BLB was observed in clusterbean entry HG 13-1 at Bikaner and CAZG 13-1 at SK Nagar, however in entries HG 13-1, GAUG 1106 and HG 126 incidence was 5% only. Maximum root rot incidence was recorded in HG 126 and minimum in HG 2-20 (C) against root rot. At Durgapura, six genotypes *viz*., HG 2-20 (C), RGr 13-2, RGr 14-3, RGC 1033 ©, HG 563 (C), RGr 14-5 showed resistant reaction against BLB and root rot complex under field conditions.
- In cowpea, no incidence of root rot/web blight was observed in Goa cowpea 3, KBC 8, PGCP 28 at Bikaner and at SK Nagar. Minimum incidence was recorded in GC 13 (GC 1002). In mothbean, 5 entries were found moderately resistant against MYMV and all entries were moderately resistant against crinkle virus. In horsegram, 9 entries were moderately resistant against cercospora leaf spot.
- For managing bacterial blight in clusterbean under epiphytotic conditions, two sprays of streptocycline 500 ppm (SS)+streptocycline 250 ppm+copper oxychloride (0.2%) at 15 days interval were best and gave yield of 1259 kg/ha at Bikaner, 507 kg/ha at SK Nagar, 945 kg/ha at Durgapura and 1481 kg/ha at Hanumangarh.
- For management of root rot in mothbean through bioagents, *T. harzianum*+*P. fluorescens* seed treatment (4+4 g/kg seed)+soil application of *T. harzianum*+*P. fluorescens* (1.25 +1.25 kg in 50 kg FYM/ha) was best treatment which gave 1127 kg/ha yield.
- Seed treatment with carbendazim 50%, WP (2g/kg seed) and soil application of *T. harzianum* @ 1.5 kg/ha gave highest yield (643.73/ha) with only 6.33% disease incidence of root rot in cowpea.
- Total 200 germplasm accessions of clusterbean were evaluated against BLB disease and 139 accessions were found moderately resistant and 60 were average infected.
- Incidence of jassids varied from 1.0 to 2.0, while incidence of whitefly was in the range of 1.4 to 2.4 at Bikaner. Incidence of whitefly was 2.0 to 2.4 in Baaskantha and Sabarkantha. In clusterbean, incidence of jassids varied from 1.11 (Raisur and Gusaissar Village) to 2.1 (Thawaria Village). Incidence of whitefly ranged from 1.1 (Gajsekhdesar Village) to 2.2 (Raisur and

Lakhasar Village). In Gujarat, incidence of whitefly was higher in magnitude in Banaskantha and Sabarkantha Distt. In Palakkad district of Kerala, the intensity of aphid was in the 5-10 aphid / leaf. Pod borer incidence ranged from 5-10%.

- At Bikaner, minimum incidence of jassid was observed in TPTC 29, however, in case of whitefly, it was minimum in RC 101(C) and aphid population was minimum in KBC 4 and PGCP 27. At SK Nagar, the incidence of pod borer was high in GC-1110 in IVT (N+S) entries and PCP 0306-1 in AVT-II (S) entries. As regard to leafhopper and whitefly incidence, it was minimum in entry HG 14. At Pattambi, no incidence of aphid was observed in IVT+AVT entries. No incidence of pod borer was observed in GC 901, TPT C29, RC 101(C), GC 13-1(GC 1002), KBC 6, Pant Lobia 3, PGCP 28 and DC 15.
- At Bikaner, jassid and whitefly population was minimum in clusterbean genotype HG 126 for both insects in AVT-I and IVT entries. At SK Nagar, minimum population of leafhopper was observed in HG 126 however, whitefly population was minimum in RGr 14-4.
- At Bikaner, jassid population was minimum in mothbean genotype Jadia-100-10 and whitefly population was minimum in RMO-225-1-6 and Jadia-100-10 in AVT-I + IVT. At SK Nagar, minimum population of whitefly was observed in RMO-225-1-6.
- Eight genotypes of mothbean were screened against bruchid, *Callosobruchus chinensis* (L.) in the laboratory. Entry Jadia 100-10 had minimum oviposition (34.89 eggs/female) and minimum adult emerged (15.56/female) which was statistically at par with RMO-225 (C).
- Seed treatment with Thiamethoxam 35 FS @ 5 g/kg seeds resulted in minimum population of jassids in mothbean, followed by Fipronil 5% SC @ 4 ml/kg seeds at Bikaner.
- Highest yield of mothbean was obtained with seed treatment with Fipronil 5% SC @ 4 ml/kg seeds at Bikaner .
- Seed treatment with Thiamethoxam 35 FS @ 5 g/kg seeds significantly reduced whitefly population (0.32/leaf) in mothbean, which was at par with Imidacloprid 600 FS @ 5 g/kg seeds and Fipronil 5% SC @ 4 ml/kg seeds. For effective and economical management of whitefly, treatment of mothbean seed with Fipronil 5% SC @ 4 ml/kg seed or Imidacloprid 600 FS @ 5 g/kg seed is recommended .
- In guar, mean value of carbohydrate per cent was maximum in the CAZG-13-1 (38.55%), endosperm content was maximum in RGr-14-2 (37.86%), mean value of crude protein content was highest in RGr-14-3 (31.94%), maximum mean value of gum content was observed in RGr-13-2 (30.52%) and maximum mean value of viscosity was observed in national check RGC-1066 (2800cp).
- In cowpea, mean value of crude protein content was maximum in the Goa Local (29.43%), minimum tannin content was in the Phule -CP-05040 (0.18 mg/g), fat content was maximum in the KBC 8 (3.38%), digestibility was maximum in the KBC-9 (90.10%) and minimum cooking time was observed in genotype GC-901(42.0 min.).
- In horsegram, mean crude protein content was maximum in VLG 39 (29.20 %) and minimum cooking time was observed in CRHG 23 (101 min).
- In horsegram, mean protein content was highest in national check CZM-2 (21.44%), digestibility was maximum in RMO-40-30 (88.40%.), minimum tannin content was in national check RMO-257 (0.43 mg/g) and content was maximum in RMO-257 (5.0%).

Front Line Demonstrations

- In 41 demonstrations, 20% increase in yield (791 kg/ha) was recorded with high yielding varieties with improved technology against yield of local practices (617 kg/ha).
- In guar, 67 demonstrations were conducted and overall mean grain yield was 876 kg/ha which was 31.8% higher than yield of farmers' variety (592 kg/ha).
- In mothbean, 18 demonstrations were conducted on high yielding varieties and overall mean yield was 408 kg/ha which was 34.6% higher than yield of local practices (303 kg/ha).
- In horsegram, 15 demonstrations were conducted on production potential of variety PHG 9. Mean yield was 446 kg/ha, with 27% yield increase over control plots (351 kg/ha).

Intellectual Property Right

A special project on National Agricultural Innovation Fund (NAIF) funded by Indian Council of Agricultural Research, New Delhi is operational at the Institute. Dr. Bansa Singh, Principal Scientist is Project Investigator of this project.

Objectives of Project

- To guide the scientists in respect of protecting their inventions and other IP's.
- Active assistance in preparation and drafting of Memorandum of Understandings (MoU's).
- To create awareness about IPRs in the Institute.
- To provide prior art search/ patent search to scientist/ researchers of the Institute.
- To procure and provide latest books dealing with different aspects of Intellectual Property Rights.
- Database management of Institute IP's *i.e.*, registered varieties and germplasm, success stories, contract research, *etc.*

Human Resource Development in IPR

NAIF promotes and provides financial support to scientist/researchers to attend various trainings/ seminars on Intellectual Property Rights.

IP Secured

Type of IP Secured	Title of Work	Type of work	Application/Registration no.
Copyright	An Expert System for Identification and control of diseases/ insect-pests in pulse crops	Computer Software	4184/2016-CO-L
Trademark	PulsExpert Diagnostic Expert System For Pulse Crops	Logo	3229366

Transfer of Technology

For effective dissemination of new pulse production technologies among the farmers and other stakeholders, following training and extension activities were organized during 2015-16:

Activity	Date	No. of participants	Participants
State level Training for Extension Personnel under ATMA, Lucknow	12-16 October, 2015	37	Deputy Director (Training) State Consultants (NFSM), B.T.Ms of different districts of U.P.
	27-31 October, 2015	26	Deputy Director (Training) State Consultants (NFSM), B.T.Ms of different districts of U.P.
Training of farmers			
Uttar Pradesh	27 January , 2016	44	Farmers of Jalaun U.P
	4 February, 2016	47	Farmers of Jalaun U.P
	9 February, 2016	30	Farmers of Jalaun U.P
	24-25 February, 2016	21	Farmers of Fatehpur U.P.
	28-29 March, 2016	46	Farmers of Urai Jaloun U.P.
Other States	7-11 December, 2015	24	Farmers of Hazaribagh (Jharkhand)
	4-6 January, 2016	21	Farmers of Bhopal (M.P.)
Jai Kisan Jai Vigyan Week and Farmers-Scientist Interaction	29 December, 2015	41	Farmers of Kanpur Dehat U.P.
Field day at Hamirpur	16 March, 2016	215	Farmers of Hamirpur U.P.
Participation in Agril. Exhibition & Kisan Mela			
Exhibition organized on the occasion of Foundation Stone Laying of ICAR-IARI Barahi, Jharkhand	27-28 June, 2015	-	Farmers, Entrepreneurs
Agro-climatic Zonal Level-Virat Kisan Mela Organized by State Agriculture Department at CSAUA & T, Kanpur	23-25 February, 2016	980	Farmers, students, Entrepreneurs
Krishi Unnati Mela at IARI, New Delhi	19-21 March, 2016	-	Farmers, Extension Personnel, Scientists, Students etc.
Kisan Mela at IIVR, Varanasi	30 January, 2016	-	Farmers, Extension Personnel, Scientists, Students etc.
Kisan Mela at Muzaffarnagar, U.P.	26-28 June, 2015		Farmers, Extension Personnel, Scientists, Students etc.
Agricultural exhibition in Motihari, Bihar	20-21 August, 2015		Farmers, Extension Personnel
Exposure visit of farmers at IIPR, Kanpur	09/04/2015	15	Farmers of Sagar, M. P.
	02/05/2015	17	Farmers of Bhopal M.P.
	13/07/2015	20	Farmers of Shivpuri M.P.
	06/08/2015	30	Farmers of Anoopur, M.P.
	09/08/2015	42	Farmers of Bhind (M.P.)
	19/08/2015	60	Farmers of Anoopur, M.P
	08/09/2015	10	Farmers of Damoh M.P.
	09/09/2015	90	Farmers of Anoopur, M.P

Activity	Date	No. of participants	Participants
	07/10/2015	16	Farmers of Singarouli (M.P.)
	17/12/2015	13	Farmers of Jabalpur M.P.
	10/09/2015	25	Farmers of Dindori M.P.
	11/09/2015	26	Farmers of Chhatarpur M.P.
	14/09/2015	10	Farmers of Damooh, M.P.
	19/09/2015	14	Farmers of Anooppur, M.P.
	19/09/2015	26	Farmers of Shivpuri, M.P.
	03/11/2015	09	Farmers of Tikamgarh M.P.
	03/11/2015	50	Farmers of Shivpur ,M.P.
	20/11/2015	06	Farmers of Bhind,M.P.
	23/11/2015	19	Farmers of Shohratgarh Maharashtra
	17/12/2015	14	Farmers of Jabalpur,M.P.
	17/12/2015	17	Farmers of Fatehpur U.P.
	18/12/2015	28	Farmers of Jabalpur, M.P.
	23/12/2015	13	Farmers of Vidhisha, U.P.
	24/12/2015	25	Farmers of Bhind M.P.
	29/12/2015	07	Farmers of Bhind M.P.
	02/01/2016	11	Farmers of Satna M.P.
	19/01/2016	19	Farmers of Syopur M.P.
	04/01/2016	64	Farmers of Anooppur M.P.
	12/01/2016	25	Farmers of Bhopal M.P.
	12/01/2016	25	Farmers of Syopur, M.P.
	20/01/2016	25	Farmers of Rajgarh M.P.
	25/01/2016	23	Farmers of Shahdol M.P.
	28/01/2016	30	Farmers of Karouli Rajasthan
	09/01/2016	40	Farmers of Basti, U.P.
	01/02/2016	40	Farmers of Dumaraia M.P.
	10/02/2016	13	Farmers of Rajgarh (M.P.)
	12/02/2016	22	Farmers of Bhopal M.P.
TV Talk	-	04 (Live telecast)	Doordarshan Kendra, Lucknow
Radio Talk		01	AIR, Lucknow

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1. Annual Report 2014-15
2. *Varshik Prativedan* (Annual Report - Hindi) 2014-15
3. Pulses Newsletter Vol. 26, Nos. 1, 2, 3 and 4
4. *Rajbhasha Patrika: Dalhan Alok-2015*
5. Primer on Modern Tools of Plant Biotechnology
6. *Bharat Main Dalhan Utpadan Badhane Ki Prodyogiki*
7. *Bundelkhand Main Chana Utpadan Ki Unnat Takaniki*
8. *Arhar Ke Pramukh Rogon Evam Keeton Ka Prabhandhan*
9. *Mung Aur Urd Ke Pramukh Rogon Evam Keeton Ka Prabandhan*
10. *Dalhani Fasalon Main Beejopchar Takanik*
11. *Bundelkhand Kshetra Hetu Masoor Ki Utpadan Takaniki*
12. Quality Seed Production of Arid Legumes
13. Improved Varieties of Pulses for Madhya Pradesh
14. Mungbean-Summer Cultivation in India (Pocket Guide)
15. Lentil Cultivation in India (Pocket Guide)
16. Fieldpea Cultivation in India (Pocket Guide)
17. *Agrim Pankti Pradarshno ke Dwara Unnat Dalhan Utpadan Praudyogikiyon ka Sarvjanikaran.*

Training and Capacity Building

Deputation Abroad



Dr. N.P. Singh, Director attended 'Meeting of Senior Managers/Policy Makers' held at ICARDA, Lebanon on June 1-4, 2015.

Dr. N.P. Singh, Director attended 4th Regional Coordination Meeting on "Strategic Partnership towards Enhancing Food and Nutritional Security in South Asia and China" held at Kathmandu, Nepal on February 27–29, 2016.



Dr. N.P. Singh, Director, and Drs. Jagdish Singh, P.S. Basu and S.K. Singh attended meeting on "Expert Consultation on the Promotion of Pulses for the Multiple Benefits in Asia" held at Bangkok, Thailand on June 29-30, 2015.



Dr. N.P. Singh, Director and Dr. S.K. Chaturvedi attended 'Tropical Legumes-III Launching and MLE Planning Workshop' held at Nairobi, Kenya on August 17-22, 2015.



Dr. Ummed Singh was deputed to participate in International Conference on 'Innovative approaches in applied sciences and technologies' held at Kasetsart University, Bangkok, Thailand on February 1-5, 2016.

Dr. D.N. Gawande was deputed to attend training on 'Food Legume Improvement' organised by International Centre For Agriculture Research In The Dry Areas (ICARDA), at Terbol Station in Lebnon on May 18-26, 2015.

Participation in Trainings/Meetings, *etc.*

Important meetings attended by Dr. N.P. Singh, Director :

- National Seminar on 'Harmonizing biodiversity and climate change: Challenges and opportunity' (NSBC- 2015) held at CAIRI, Port Blair on April 18-19, 2015.
- Interactive meeting of ICAR Directors held at New Delhi on May 14-16, 2015.
- Meeting of International Mungbean Research Network held at ICRISAT, Hyderabad on June 15, 2015.
- National Conference of Krishi Vigyan Kendras (KVKs) held at Patna on July 25-26, 2015.
- Brain storming meeting on pulses, held at PAU, Ludhiana on August 31- September 3, 2015.
- XXII Zonal Workshop of KVKs held at Ujjain on September 9-11, 2015.
- Special Meeting on 'Promotion of pulses in NEH Region' held at CAU, Imphal on September 29-30, 2015.
- Brainstorming session on 'Quality seed production' held at Directorate of Groundnut Research, Junagadh on October 19, 2015.
- Workshop on 'Preparing road map for agricultural development in agro-climatic zone-western plateau and hills' held at DSR, Indore on November 4, 2015.
- DUS workshop at PPVFRA, held at New Delhi on November 23, 2015.
- Second Meeting of 'Indian grain storage working group' held at NASC Complex, New Delhi on November 21, 2015.
- Workshop on 'Agricultural development issues of central plateau & Hill Region' held at IGFRI, Jhansi on November 30, 2015.
- Workshop on 'Human-Wildlife conflict in agro-pastoral context' held at NBAIR, Bangalore on December 12, 2015.
- Directors' Conference of ICAR Institute held at New Delhi on January, 23-24, 2016.
- National Workshop on 'Pulses development: Challenges and opportunities in central and southern states' held at CIAE, Bhopal on February 4, 2016.
- Second Annual Review Meeting of the NASF Project held at NASC Complex, New Delhi on February 10, 2016.
- Workshop on 'Prospects of climate resilient agriculture in Uttar Pradesh' held at Yojna Bhawan, Lucknow on March 9, 2016.
- 'India Consultation Meeting' held at NASC Complex, New Delhi on March 22, 2016.

Trainings/Meetings, *etc.* attended by scientists

Dr. S.K. Chaturvedi attended 'Joint ICAR-ICRISAT partnership projects review and planning meeting' held at ICRISAT, Patancheru on April 4, 2015.

Dr. S.K. Chaturvedi attended 'U.P. Agricultural Science Congress' held at SHIAT, Allahabad on June 14-16, 2015.

Dr. S.K. Chaturvedi attended 'Review meeting of ICAR-ICARDA collaborative projects' held at NASC Complex, New Delhi on July 10-11 , 2015.

Dr. S.K. Chaturvedi attended 'Indo-US collaborative research on chickpea- initiative meeting' held at NRCPB, New Delhi on July 10-11, 2015.

Dr. S.K. Chaturvedi attended 'Round table discussion on achieving 30 million tonnes of pulses by 2020' held at NASC Complex, New Delhi on January 6, 2016.

Dr. S.K. Chaturvedi attended 'Special Meeting on promotion of research and development in pulses for NEH states' held at Central Agril. University, Imphal on September 28-29, 2015.

Dr. S.K. Chaturvedi attended meeting on 'Environment risk assessment of GE plants' held at New Delhi on September 15-17, 2015.

Mr. S. Gurumurthy attended NAE training on 'Phenotyping for drought adoptive traits' held at UAS, Bangaluru on January 18-23, 2016.

Dr. Alok Das attended two workshops on 'Finalization of various SOPs for biosafety compliance' held at New Delhi on May 27-28, 2015 and September, 23 2015 under ICAR's New Programme on Biosafety Awareness and Compliance Readiness at Pilot Scale.

Dr. Alok Das attended Training Workshop on 'Monitoring of confined field trials of regulated GE plants' held at New Delhi on May 25-26, 2015.

Dr. Alok Das attended Training Workshop on 'Environmental risk assessment (ERA) of GE plants' held at New Delhi on September 15-17, 2015.

Dr. Alok Das attended Training Workshop on 'Dossier preparation of GE plants' held at New Delhi on February 25, 2016.

Dr. Alok Das attended 'AGRI-SEARCH 2050' held at NASC, New Delhi on May 18, 2015.

Drs. K.R. Soren, Jitendra Kumar and Alok Das attended *Rabi* Pulses Scientists' Meet, held at IIPR, Kanpur on February 19-20, 2016.

Dr. C.S. Praharaj participated in a special meeting *cum* workshop on 'Promotion of pulses in NEH region' held at CAU, Imphal on September 28-29, 2015.

Dr. C.S. Praharaj participated in a special meet on 'Preparation of road map for middle gangetic plains' held at ICAR-Research Complex for Eastern Region, Patna, Bihar on October 7, 2015.

Drs. C.S. Praharaj, S.S. Singh and Narendra Kumar participated in Review Meeting on 'Mitigating abiotic stress and enhancing resource use efficiency in pulses in rice-fallow' held at DWR, Jabalpur on 13-14 March, 2016.

Dr. C.S. Praharaj participated in Brain Storming Session on Promotion of Pulses held at PAU, Ludhiana on August 31, 2015.

Dr. C.S. Praharaj participated in 'Cluster Demonstration Programme in Pulses and Oilseed' held at BCKV, Kalyani, Kolkata on December 8-9, 2015.

Dr. C.S. Praharaj participated in 'Cluster Demonstration Programme in Pulses' held at IIPR, Kanpur on 18-19 November, 2015.

Dr. Krishna Kumar attended 6th International Conference on Plant Pathology held at NASC Complex, Pusa, New Delhi on February 23-27, 2016.

Dr. Mohd. Akram attended 4th Uttar Pradesh Agriculture Congress organized by UPCAR, Lucknow held at CSAUAT, Kanpur on March 2-4, 2016.

Dr. Purushottam attended 'SAC review and planning meeting' held at KVK, Kannauj on August 18, 2016 and at KVK, Mainpuri on August 26, 2016.

Dr. Hemant Kumar attended 21 days CAFT training on 'Recent advances in statistical genetics and genomics' at IASRI, New Delhi on March 4-24, 2016.

Dr. Devraj attended first workshop on 'Nodal Officers of KRISHI Portal' held at NASC Complex, New Delhi on August 4-5, 2015.

Dr. Devraj, attended training workshop on 'Usage of unified messaging solution' held at IVRI, Izzatnagar, Bareilly on December 22, 2015.

Dr. A. Pratap attended Brainstroming Session on 'Promotion of pulses in non-traditional niches; summer cultivation' held at ICAR-IIPR, Kanpur, February 9-10, 2016.

Dr. A. Pratap attended International Mungbean Network Meeting held at ICRISAT, Hyderabad on June 15, 2015.

Dr. A. Pratap attended high level NICRA planning and review meeting held at CMFRI, Kochi on August 13-14, 2015.

Dr. A. Pratap attended 'Review and planning meeting of CRP on molecular breeding' held at IARI, New Delhi on January 21, 2016.

Dr. A. Pratap attended planning-*cum*-inception meeting on 'ACIAR funded International Mungbean Improvement Network Project' held at IIPR, Kanpur on 22-23 February, 2016.

Dr. A. Pratap attended 10th Review Meeting of DUS Test Centres held at MPKV, Rahuri on February 26-27, 2016.

Dr. A. Pratap attended 'State level research advisory committee meeting' held at Lucknow on August 28, 2015.

Dr. A. Pratap participated in 21 days Summer School on 'Novel genomic tools and modern breeding approaches for enhancing productivity and nutritional quality of pulse crops' held at IIPR, Kanpur on September 5-25, 2015.

Dr. Jitendra Kumar attended Review Meetings of 'Foreign aided projects', held at ICAR, New Delhi on May 12, 2015 and on December 21, 2015.

Dr. Jitendra Kumar attended meeting on 'Review and Planning of HarvestPlus Challenge Program (Lentil Biofortification)' held at NAAS Complex, New Delhi on October 5, 2015.

Dr. Jitendra Kumar attended Annual Review and Planning Meeting of DAC-ICAR-ICARDA on Collaborative Projects under National Food Security Mission (NFSM)-Pulses, held at NASC, Pusa Campus, New Delhi on July 10-11, 2015.

Dr. Jitendra Kumar attended 'Brain storming session on promotion of pulses in Indo-Gangetic plains of India' held at PAU, Ludhiana on September 3, 2015.

Dr. D.N. Gawande attended training on 'Tracking Lentil Improved Cultivar Adoption' held at RAK, College, Sehore on January 23, 2016.

Dr. Archana Singh attended workshop on 'Krishi Manthan' held at Bhopal on October 31, 2015.

Dr. Archana Singh attended 'Soil health day celebration programme' held at IISS, Bhopal on December 5, 2015.

Dr. Archana Singh attended a 'Workshop on Pulses' held at CIAE, Bhopal on February, 3-4, 2016.

Drs. M.S. Venkatesh and Revanappa participated in the workshop on "Innovative/best practices in NeGP-Agriculture and allied sectors" held at UAS, Dharwad on July 30 to August 1, 2015.

Dr. Revanappa attended 10th Annual Review Meeting of ICAR Seed Project "Seed Production in Agricultural Crops" held at CCARI, Goa on August 24-25, 2015.

Dr. Venkatesh participated in National Conference on Soil Science held at UAS, Bangalore on December 5-8, 2015.

Dr. Revanappa attended the CAFT-ICAR training held at TNAU, Coimbatore on January 28 to February 17, 2016.

Trainings/Meetings, etc. attented by Technical and Administrative staff

Mr. R.S. Mathur, ACTO attended training on 'Advanced level training in soil testing , plant analysis and water quality' held at IARI, New Delhi on October 13- November, 2015.

Mr. Panchoo Lal, Administrative Officer attended training on 'Management and development programme on public procurement' held at NIFM, Faridabad on November 30-December 5, 2015.

Trainings/Courses organized

- A 21 days summer school on 'Novel Genomic Tools and Modern Breeding Approaches for Enhancing Productivity and Nutritional quality of Pulses crops' was organized on September 5-25,2015.
- A farmers training programme on "Farmers participatory seed production techniques in *Rabi* pulses" was organized on December 17, 2015.
- A farmers training programme on "Farmers Participatory Seed Production Techniques in *Rabi* Pulses" was organized at ICAR-IIPR Regional Research Station, Phanda, Bhopal on February 24, 2016.
- An eight days training course on 'Production and popularization of biological control agents to enhance pulse production' was organized on February 22-29, 2016.

Fund allocation and utilization

Total Rs. 5.00 lakh fund was allocated for HRD during 2015-16 and Rs. 4.95 lakh were utilized.

Awards/Recognition



ICAR-IIPR has bagged the Best Performance Award in Breeder Seed Production (ICAR Institute category) for the year 2014-15 during 10th Annual Review Meeting of ICAR Seed Project, "Seed Production in Agricultural Crops" held at ICAR-Central Costal Agricultural Research Institute, Goa on 24-25 August, 2015.



Dr. S.S. Singh, Head, Division of Crop Production was awarded with prestigious Rajeev Gandhi Rashtriya Gyan-Vigyan Hindi Maulik Pustak Lekhan Puraskar for his book "Sametik Krishi Pranail: Ek Vrihad Drishtikon' in Prosthan Shreni by Hon'ble President of India in a function held at New Delhi on September 14, 2015.



Dr. Aditya Pratap received Lal Bahadur Shastri Outstanding Young Scientist Award-2014 at ICAR Foundation Day, held at Patna on August 25, 2015.



Dr. Ummed Singh, Senior Scientist was awarded First Prize in the Oral Presentation in National Seminar on 'Agriculture Resource Management for Sustainability and Eco-Restoration', held at ICAR-CIAH, Bikaner on March 11-13, 2016.

Dr. Ummed Singh, Senior Scientist was awarded SERS Fellow-2015 by the Scientific and Educational Research Society, Meerut (UP) on February 4, 2016 in International Conference held at Kasetsart University, Bangkok, Thailand.

Dr. Ummed Singh, Senior Scientist was awarded Best Oral Presentation in International Conference on 'Innovative approaches in applied sciences and technologies' held at Kasetsart University, Bangkok, Thailand on February 1-5, 2016.



ICAR-IIPR, Kanpur team bagged First Prize in Best Poster Award Category for the poster entitled "Intellectual Property Rights in context of food security in India" authored by Sunil Tripathi, Bansa Singh and R.K.Mishra in National Symposium on 'Transforming Indian Agriculture towards Food and Nutritional Security (IAFNS-2016)' held at ICAR-IGFRI, Jhansi on February 20-21, 2016.



ICAR-IIPR, Kanpur got Third Prize in Best Poster Award Category for the poster entitled "Indian legislation to protect different Intellectual Properties in context of agriculture" authored by Sunil Tripathi, Bansa Singh and N.P. Singh in 3rd Uttar Pradesh Agricultural Science Congress organized by Uttar Pradesh Council of Agricultural Research, Lucknow held at SHIATS, Allahabad on June 12-14, 2015.

On-going Research Projects

CORP IMPROVEMENT

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
1.	CRSCIIPRSIL 201201100062	Genetic improvement for plant type and grain yield in chickpea	-	Dr. S. K. Chaturvedi	Dr. P R Sabale Dr. D. N. Gwande
2.	CRSCIIPRSIL 01202700078	Genetic improvement for yield and resistance to multiple diseases in blackgram	-	Dr. P. K. Katiyar (w.e.f. June. 2015) Dr. G.P. Dixit (till May. 2015)	Dr. Revanappa Dr. Mohd. Akram
3'	CRSCIIPRSIL 201202300074	Genetic improvement for yield and disease resistance in pigeonpea	**Coordinator: Dr. Dibendu Datta**		
			Genetic improvement for yield and disease resistance in long duration pigeonpea	Dr. Farindra Singh	Dr. Dibendu Datta Dr. R. K. Mishra
			Genetic improvement of yield and disease resistance in medium duration pigeonpea	Dr. Dibendu Datta	Dr Abhishak Bohra Dr D. N. Gawande
	CRSCIIPRSIL 201200900060		Genetic improvement for yield and disease resistance in short duration pigeonpea	Dr. Abhishek Bohra	Dr. R. K. Mishra
4.	CRSCIIPRSIL 201200100052	Pulse Genetic resources management and on-line information retrieval	**Coordinator : Dr. Farindra Singh**		
	CRSCIIPRSIL 201202400075		Pigeonpea	Dr. Farindra Singh	Dr. Sateesh Naik
	CRSCIIPRSIL 201200800059		Chickpea	Dr. Biswajit Mondal	Dr. D. N. Gawande (IIPR RS Bhopal)
	CRSCIIPRSIL 201200100052		Blackgram	Dr. P. K. Katiyar	Dr. Revanappa (IIPR RC Dharwad)
	CRSCIIPRSIL 201200100052		Greengram	Dr. Aditya Pratap	Dr. Revanappa (IIPRRS Dharwad)
	CRSCIIPRSIL 201200500056		Lentil	Dr Jitendra Kumar	Dr. D. N. Gawande (IIPR RS Bhopal)
	CRSCIIPRSIL 201200500061		Fieldpea	Dr. A. K. Parihar	-
	CRSCIIPRSIL 201202500076		Rajmash	Dr. T. Basawaraj	
	-------		Lathyrus	Dr. Archana Singh (IIPRRS Bhopal)	
	-------		Cowpea & Horsegram	Dr. Revanappa (IIPR RC Dharwad)	
	CRSCIIPRSIL 201500300119		Development of web-based commodity profile for chickpea and pigeonpea	Dr. Devraj	Dr.Uma Sah
5.	CRSCIIPRSIL 201200200053	Genetic improvement of mungbean for yield enhancement and resistance to multiple stresses		Dr. Aditya Pratap	Dr. Revanappa Dr. T. Basawaraj (wef June, 2015) Dr. Mohd. Akram

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
6.	CRSCIIPRSIL 201200400055	Genetic improvement for yield and multiple stresses in lentil		Dr. Jitendra Kumar	Dr. Naimuddin
7.	CRSCIIPRSIL 201200700058	Development of chickpea genotypes to mitigate terminal heat and drought stress for enhancing productivity	Identification and genetic inheritance study of heat stress tolerance in chickpea genotypes	Dr. D. Gawande	Dr. P.S. Basu
8.	CRSCIIPRSIL 201200600057	Combining *Fusarium* wilt and dry root rot resistance in chickpea by integrated breeding approach	-	Dr. A. K. Srivastava (wef Dec., 2015) Dr. D.N. Gawande (upto Dec. 2015)	Mr. U.C. Jha Dr. P. R. Saabale
9.	CRSCIIPRSIL 2012001000061	Genetic improvement for plant type and grain yield in fieldpea	-	Dr. A.K. Parihar	Dr. G.P. Dixit
10.	CRSCIIPRSIL 201400100096	Improving seed quality of major pulses	**PI : Dr. Amrit Lamichaney**		
			Enhancing field emergence and seed storage of extra-large seeded *kabuli* chickpea	Dr A. Lamichaney	Dr. P.K. Katiyar Dr. Vijay Laxmi
			Measures to overcome pre-harvest sprouting of mungbean	Dr A. Lamichaney	Dr. P.K. Katiyar Dr. Vijay Laxmi
11	CRSCIIPRSIL 201500200118	Management of plant genetic resources and genetic enhancement for grain yield and resistant to multiple diseases in cowpea and horsegram	-	Dr. Revanappa (IIPRRS Dharwad)	-
12	CRSCIIPRSIL 201500400124	PGR Management and improvement of grasspea for low ODAP	-	Dr. Archana Singh (IIPRRS Bhopal)	Mr. N.L. Meena
13	CRSCIIPRSIL 201500700123	Identification of potential donors and genetic analysis of heat tolerance in chickpea (Development of chickpea varieties tolerant to heat stress)	-	Mr. Udai Chand Jha	Dr. D. N. Gwande Mr. S. Gurumurthy

PLANT BIOTECHNOLOGY

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
14.	CRSCIIPRSIL 201400300097	Genomics enabled improvement in pulse crops	**Coordinator : Dr. K.R. Soren**		
			Marker-assisted gene pyramiding for pod borer resistance and drought tolerance in elite chickpea	Dr. K.R. Soren	Dr. Alok Das Dr. Shanmugavadivel P. S. Dr. Sujayanand, G.K. Dr. Biswajit Mondal
	CRSCIIPRSIL 201300200081		Prospecting alleles for enhanced drought tolerance in chickpea and pigeonpea	Dr. Alok Das	Dr. K.R. Soren Dr. Shanmugavadivel P.S.
	CRSCIIPRSIL 201401700111		Molecular dissection of response to terminal heat in chickpea	Dr. Shanmugavadivel P. S.	Dr. K.R. Soren Dr. S.K. Chaturvedi Dr. S. Gurumurthy

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
15.	CRSCIIPRSIL 201500100120	Gene discovery and transgenic technology for pulses improvement	**Coordinator : Dr. Alok Das**		
			Genetic engineering for development of pod borer resistant chickpea using multigene approach	Mr. K. Aravind Kumar	Dr. Alok Das Dr. Sujayananad G.K Ms. K. N. Poornima
	CRSCIIPRSIL 201401800112		Molecular insight into *Fusarium* interaction in chickpea	Ms. K.N. Poornima	Dr. P.R. Saable

CROP PRODUCTION

S No.	IIPR Code	Project name	Sub-project	Principal Investigator	Associate
16.	CRSCIIPRSIL 201201600067	Efficient management of water for higher productivity in pulses	-	Dr. C.S. Praharaj	Dr. Ummed Singh
17.	CRSCIIPRSIL 201300300083	Enhancing resource use efficiency in pulse systems in Indo-Gangetic plains	-	Dr. Ummed Singh	Dr. S.S. Singh Dr. C.S. Prahraj Dr. K.K. Hazara
	CRSCIIPRSIL 201500100120		Assessment of soil plant nutrient dynamics for strategic nutrient management in pulse based cropping system	Dr. K. K. Hazra	Dr. S. S. Singh
18	CRSCIIPRSIL 201300300082	Development of RCT and weed management strategies for enhancing pulses productivity	-	Dr. Narendra Kumar	Dr. Lalit Kumar Dr. S. Paulraj Dr. C.P. Nath Dr. V.P. Singh (DWSR)
19	CRSCIIPRSIL 201400500099	Long-term effect of pulses in cropping systems on soil health and crop productivity in Indo-Gangetic plains	–	Dr. S.S. Singh	Dr. C.S. Praharaj Dr. Narendra Kumar Dr. Ummed Singh Dr. K.K. Hazara Dr. Dhyaneshwar Borase
20	CRSCIIPRSIL 201400600100	Enhancing resource use efficiency in pulses based cropping systems in central India	–	Dr. C.S. Praharaj	Dr. S.S. Singh Dr. Ram Lal Jat Dr. R.P. Singh (RAK, Sehore) Dr. R. Elanchezhian (IISS, Bhopal) Dr. Abhay Sirale (IISS, Bhopal)
21.	CRSCIIPRSIL 201400700101	Enhancing resource use efficiency of pulse based cropping system in peninsular India	–	Dr. M.S. Venkatesh	--

CROP PROTECTION

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
22.	CRSCIIPRSIL 201300700086	Studies on the host plant resistance and bio-ecology of key nematode pests of pulses along with their eco-friendly management	-	Dr. Bansa Singh	Dr. R. Jagdeeswaran
23		Pest complex infesting pigeonpea and their eco-friendly management	**Coordinator : Dr. S. K. Singh**		
	CRSCIIPRSIL 201300800087		Bio-ecology of borer complex and sucking pests infesting medium and long duration pigeonpea and their management	Dr. S.K. Singh	Dr. Sanjay Bandi
	CRSCIIPRSIL 201301000089		Eco-friendly management of spotted pod borer, *Maruca vitrata* Fabricius in short duration pigeonpea	Dr. Sujayanand, G.K.	Dr. S. K. Singh
24.	CRSCIIPRSIL 201201200063	Variability among geographical isolates of *Fusarium oxysporum* f. sp. *lentis* and management of lentil wilt	-	Dr. Naimuddin	Dr. Mohd Akram
25.	CRSCIIPRSIL 201300900088	Diversity analysis, identification of resistant donors and management of *Rhizoctonia bataticola* causing dry root rot in chickpea	-	Dr. P.R. Saabale	Dr. Naimuddin Dr. Manjunath
26.	CRSCIIPRSIL 201400900103	Diagnosis and monitoring of viruses infecting pulse crops and identification of resistant sources against yellow mosaic in *Vigna* spp.	-	Dr. Mohd. Akram	Dr. Naimuddin
27.	CRSCIIPRSIL 201401000104	Bio-intensive management of major diseases of pigeonpea	-	Dr. R.K. Mishra	Dr. Naimuddin
28.	CRSCIIPRSIL 201401100105	Potentials of fungal bio-agents for management of parasitic nematodes of pulses	-	Dr. R.Jagadeeswaran	Dr. Banasa Singh

BASIC SCIENCE

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
29.	CRSCIIPRSIL 201401900113	Improving protein content in pulses	-	Dr. Jagdish Singh	Dr. Biswajit Mondal Dr A. Bohra Dr. A. K. Parihar
30.	--	Quantification of biologically active components in pulses having potential impact on human health	-	Dr. Jagdish Singh	Dr. Jitendra Kumar
31	CRSCIIPRSIL 201401300107	Quantification of bio-active components of mungbean and enhancement of nutritive value by processing	-	Mr. N.L. Meena	-

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
32.	CRSCIIPRSIL 201201300064	Physiological approaches to mitigate abiotic stresses in pulse crops	Identification and physiological evaluation of chickpea germplasm for combined tolerance to drought and heat for improving yield under changing climate	Dr. P.S. Basu	Dr. Jagdish Singh Dr. S. K. Chaturvedi
	CRSCIIPRSIL 201402000114		Drought induced leaf senescence in chickpea- Amelioration through PGRs	Mr. S. Gurumurthy	Dr. P.S. Basu
	CRSCIIPRSIL 201402100115		Physiological basis of salt tolerance in coastal blackgram genotypes	Mr. S.K. Meena	Mr. S. Gurumurthy Dr. S. S. Singh Dr. M. S. Venkatesh
33.	CRSCIIPRSIL 201301100090	Physiological response of mungbean to photo-thermo-periods and identification of insensitive genotypes for different photo-thermal regimes	-	Dr. Vijay Laxmi	--
34.	CRSCIIPRSIL 201301300092	Studies on the diversity of PPFM (*Methylobacterium*) in *Vigna* and fieldpea and their potential on plant growth promotion	-	Dr. S. Paulraj	Dr. M. Senthilkumar
35.	CRSCIIPRSIL 201401200106	Phosphorus acquisition efficiency of chickpea genotypes and its improvement through P-solubilizing microorganisms	-	Dr, Mohan Singh	-
36.	CRSCIIPRSIL 201401400108	Persistence and degraded products of post-emergence herbicides in soil, plant and seeds of summer and *kharif* pulses	-	Dr. Lalit Kumar	Dr. Narendra Kumar Dr. Sobha Sondia (ICAR-DWR, Jabalpur)
37.	CRSCIIPRSIL 201401500109	Development of microbial consortium for drought stress management in chickpea	-	Dr. M. Senthilkumar	Mr. Nand Lal Meena
38.	CRSCIIPRSIL 201401700116	Biochemical characterization of heat shock proteins (HSPs) and antioxidative defense mechanism in chickpea genotypes	–	Mr. Nand Lal Meena	Mr. Gurumurthy S. Ms. Pornima
39.	CRSCIIPRSIL 201402300117	Interactive effect of lentil genotypes - *Rhizobia* on biological nitrogen fixation	–	Mr. Dnyaneshwar Borase	Dr. M. Senthil kumar Dr. S. Paulraj

SOCIAL SCIENCE

S No.	IIPR Code	Project	Sub-project	Principal Investigator	Associate
40.	CRSCIIPRSIL 201301600095	Enhancing pulses production for food, nutritional security and livelihoods of tribal farming community through demonstration and training	-	Dr. S.K. Singh (upto 2-2-2016)	Dr. Rajesh Kumar Dr. Uma Sah
41.	CRSCIIPRSIL 201301400093	Impact analysis of transfer of technology projects implemented by the IIPR in Uttar Pradesh	-	Dr. Rajesh Kumar	Mr. Deepak Singh
42.	CRSCIIPRSIL 201301500094	Development of user-friendly analytical module for some incomplete block designs	-	Mr. Hemant Kumar	Dr. Dev Raj
43	CRSCIIPRSIL 201202200073	Analysis of growth, consumption pattern and prices of major pulses in India	Analysis of growth and instability in major pulses of India	Mr. Deepak Singh	Dr. Dev Raj (wef Sept.. 2014)
44.	CRSCIIPRSIL 201401600110	Information communication technology (ICT) mediated knowledge management for pulse farmers	-	Dr. Uma Sah	Dr. S.K. Singh (upto 2-2-2016) Dr. Devraj
45	CRSCIIPRSIL 201500500121	Development of pulse based model village for sustainable rural livelihood in central zone of UP	-	Dr. Purshottam	Dr. Rajesh Kumar

Externally Funded Projects

CROP IMPROVEMENT

S No	Project	Funding Agency	Principal Investigator	Associate
1.	Development of lentil cultivars with high concentration of iron and zinc	ICARDA	Dr. N.P. Singh	Dr. Jitendra Kumar
2.	Evaluation of lentil germplasm for heat tolerance and herbicide tolerance	ICARDA	**Focal Person :** Dr. N.P. Singh **PI:** Dr. Jitendra Kumar	
3.	Generation advancement and development of new genotypes through pre-breeding in lentil and *kabuli* chickpea	DAC-ICARDA-ICAR	**Coordinator :** Dr. N.P. Singh **PI** (Lentil) : Dr. Jitendra Kumar **PI** (*Kabuli* Chickpea) : Dr. S.K. Chaturvedi	Mr. Udai Chand Jha
4.	Developing chickpea cultivars suited to mechanical harvesting and tolerant to herbicides	NFSM	Dr. S.K. Chaturvedi	Dr. Ummed Singh Dr. Narendra Kumar
5.	Seed production in agricultural crops	DAC	Dr. P.K. Katiyar	Amrit Lamichaney
6.	ICAR (NSP) crops	DAC	Dr. P.K. Katiyar	Amrit Lamichaney
7.	Development of thermo insensitive and high yielding cultivars in greengram through AB-QTL approach	UPCAR	Dr. Aditya Pratap	–
8.	CRP on Agro-biodiversity 1. CRP on Agro-biodiversity: Pigeonpea 2. CRP on Agro-biodiversity : Chickpea-sub project (characterization, regeneration, distribution and documentation) 3. CRP on Agro-biodiversity- Chickpea-sub project 2 (detailed evaluation)	ICAR	 Dr. Dibendu Datta Dr. D. Gawande Dr. Archana Singh	 Dr. Archana Singh Dr. D. Gawande Dr. Archana Singh Dr. D. Gawande Dr. G. K. Sujayanand
9.	Harnessing favourable QTL of wild and exotic germplasm for yield contributing traits in lentil using advanced backcross QTL analysis	DBT (DST)	Dr. Jitendra Kumar	Dr. Aditya Pratap
10.	Genomic data analysis for identification of economically important markers and viral diagnostics in pulses	Centre for Agril. Bioinformatics (IASRI)	Dr. Abhishek Bohra	Dr. K. R. Soren Dr. M. Akram
11.	CRP-Molecular breeding for improvement of tolerance to biotic and abiotic stresses, yield and quality traits in crops-chickpea	ICAR	Dr. Aditya Pratap	Dr. S.K. Chaturvedi Dr. K. R. Soren Dr. P.S. Basu Dr. P.R. Saabale
12	Multiplication and distribution of mungbean mini-core germplasm	ACIAR	**Coordinator** : Dr. N.P. Singh **PIs:** Dr. Sanjeev Gupta Dr. Aditya Pratap	–-
13.	Development of photo-thermo insensitive and yellow mosaic resistant pre-breeding lines in mungbean and urdbean	ICAR (Extramural Research Project)	Dr. Aditya Pratap	Dr. P.K. Katiyar Dr. Basavaraja Dr. Revanappa Dr. Mohd. Akram
14.	Widening of genetic base in pigeonpea through pre-breeding efforts for developing next generation wilt resistant and photo-insensitive early pigeonpea	ICAR (Extramural Research Project)	ICAR-IIPR PJTSU-RARS, Warangal SDAU, S K Nagar VNMKV-ARS, Badnapur NAU-Navsari	Dr. Farindra Fingh (Centre PI)

PLANT BIOTECHNOLOGY

S No	Project	Funding Agency	Principal Investigator	Associate
15.	Development of pod borer resistant transgenic in pigeonpea and chickpea (Phase II : Core Group 1)	NFBSFARA(ICAR)	Dr. N.P. Singh	Dr. S.K. Chaturvedi Dr. K.R. Soren Dr. Alok Das Dr. Sujayanand, G.K
16..	Transgenic in chickpea and pigeonpea for pod borer resistance	NPTC-TG (ICAR)	Dr. Alok Das	Dr. Sujayanand, G.K.
17.	Functional genomics in chickpea	NPTC-FG (ICAR)	Dr. K.R. Soren	Dr. S.K. Chaturvedi
18.	Utilizing chickpea genome sequence for crop improvement	DAC (NFSM)	**Project Coordinator (India):** Dr. N.P. Singh **PI:** Dr. K. R. Soren	Dr. S.K. Chaturvedi Dr. D. N. Gawande Dr. P. R. Saable
19.	Incentivizing research in agriculture	ICAR-CRRI	Dr. K. R. Soren	Dr. B. Mandal Dr. S.K. Chaturvedi Dr. S. K. Meena
20.	Genetic mapping of *Fusarium* wilt and SMD in pigeonpea	NPTC-G (ICAR)	Dr. P. G. Patil	Dr. Abhishek Bohra Dr. P. R. Saable

CROP PRODUCTION

S No	Project	Funding Agency	Principal Investigator	Associate
21.	Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices	NFBSFARA (ICAR)	Dr. S.S. Singh	Dr. C.S. Praharaj Dr. Narendra Kumar Dr. P.S. Basu Dr. Senthilkumar Dr. M.S. Venkatesh Dr. K.K. Hazra

CROP PROTECTION

S No	Project	Funding Agency	Principal Investigator	Associate
22.	Crop pest surveillance and advisory project (CROPSAP)	RKVY, Maharashtra	Dr. Shiva Kant Singh	-
23.	Outreach programme on "Phytophthora, *Fusarium* and *Ralstonia* diseases of horticultural and field crops"– *Fusarium* wilt of pigeonpea and chickpea	ICAR (through IISR Calicut)	Dr. Naimuddin	Dr. K.R. Soren Dr. P.R. Saabale
24.	Studies on climate volatility and its impact on pests of pulses at micro level in varied agro-ecosystem of Uttar Pradesh	UPCAR	Dr. S. K. Singh	-
25.	Characterization and development of bio-pesticides from native microbes for the managements of Bihar hairy caterpillar in pulse crops	UPCAR	Dr. Sujayanand, G. K.	-
26.	Developing strategic and holistic pest management modules in legume based cropping system and its authentication	DST (SERB)	Dr. Jewesh Kumar **Mentor** : Dr. S.K. Singh	-

BASIC SCIENCE

S No	Project	Funding Agency	Principal Investigator	Associate
27.	Alleviation of moisture-deficit stress in groundnut, soybean, chickpea and pigeonpea by application of endophytic bacteria	ICAR (Extramural Research Project)	Dr. M. Senthilkumar	-

SOCIAL SCIENCE

S No	Project	Funding Agency	Principal Investigator	Associate
28.	Enhancing lentil production in eastern and North-eastern states for nutritional security and sustainable rice based production system in India (Hamirpur)	DAC-ICARDA-ICAR	Dr. S.K. Singh (Upto 2.2.2016)	–-
29.	Network project on "Market Intelligence"	NCAP, ICAR	Mr. Deepak Singh	–
30.	Harnessing modern communication technologies for sharing of available knowledge resources with pulse growing farmers in Uttar Pradesh	UPCAR	Dr. Uma Sah	Dr. S. K. Singh (upto 2-2-2016) Dr. Devraj Dr. S. K. Dubey (ATARI-Zone-IV)
31.	Socio-economic and technological empowerment of pulse growers of Jalaun and Kanpur Dehat district of Uttar Pradesh	DBT	Dr. Uma Sah	Dr. Narendra Kumar Dr. Hem Saxena (upto 31-8-2015) Dr. S. K. Singh (upto 2-2-2016) Dr. P. R. Saabale

INSTITUTE MEGA- PROJECTS

S No	Project	Funding Agency	Principal Investigator	Associate
32.	Implementation of PVP legislation (DUS test)	PPV & FRA (DUS) Chickpea Pigeonpea MULLaRP	 Dr. G.P. Dixit Dr. I.P. Singh Dr. Sanjeev Gupta	 Dr. A.K. Srivastav Dr. Farindra Singh Dr. A.K. Parihar
33.	National Innovations on climate resilient agriculture (NICRA)	ICAR	**Coordinator** :Dr. N.P. Singh **PI:** Dr. Sanjeev Gupta	Dr. P.S. Basu Dr. Aditya Pratap Dr. Dibendu Datta Dr. G.P.Dixit
34.	Long term measures taken to increase production of pulses and proposal for creation of buffer stock of pulses through support scheme and price stabilization fund	ICAR & DAC & FW	**Coordinator :** Dr. N.P. Singh	Dr. P. K. Katiyar Dr. Krishna Kumar Dr. R.K. Mishra Dr. Senthil Kumar M.

Institute Management Committee

As on 31.3.2016

Dr. N.P. Singh Director Indian Institute of Pulses Research, Kanpur	Chairman
Mr. T.C. Sharma Finance and Accounts Officer PDFSR, Modipuram, Meerut	Member
Dr. Ram Awatar Sharma Principal Scientist CAZRI, Jodhpur (Raj.)	Member
Dr. C. Bhardwaj Principal Scientist IARI, New Delhi	Member
Dr. S. Natarajan Principal Scientist IARI-RBGRC, Aduthurai (TN)	Member
Dr. Rama Shankar Katiyar Billhor, Kanpur Dehat (U.P.)	Member
Mr. Shiv Poojan Singh Chandel Mirzapur (U.P.)	Member
Dr. A.N. Sharma Principal Scientist Directorate of Soybean Research, Indore	Member
Mr. Vijay Kumar Dy. Director (PP) Govt. of U.P., Lucknow	Member
Mr. Panchoo Lal Administrative Officer IIPR, Kanpur	Member Secretary

Research Advisory Committee

As on 31.3.2016

Dr. J.H. Kulkarni Former Vice-Chancellor UAS, Dharwad	Chairman
Dr. U.P. Singh Ex. Head, Division of Genetics & Plant Breeding IAS, BHU, Varanasi	Member
Dr. R.K. Jain Joint Director (Education) IARI, New Delhi	Member
Dr. V.V. Ramamurthy Ex- Principal Scientist (Entomology) IARI, New Delhi	Member
Dr. B. Venkateswarlu Vice-Chancellor MAU, Parbhani (MS)	Member
Dr. Anupama Singh Senior Research Officer Dept. of Post-harvest Process and Food Engineering GBPUA&T, Pantnagar	Member
Dr. B.B. Singh Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
Dr. N.P. Singh Director Indian Institute of Pulses Research, Kanpur	Member
Dr. Mohan Singh Principal Scientist, Division of Basic Science Indian Institute of Pulses Research, Kanpur	Member Secretary

Institute Research Council

As on 31.3.2016

Dr. N.P. Singh Director Indian Institute of Pulses Research, Kanpur	Chairman
Dr. B.B. Singh Assistant Director General (O&P), ICAR Krishi Bhavan, New Delhi	Member
All Scientists of the Institute	Member
Dr. P.S. Basu Principal Scientist, Division of Basic Science IIPR, Kanpur	Member Secretary

Important Committees of the Institute

As on 31.3.2016

1. **Monthly Review Committee**
   Chairman : Dr. N.P. Singh, Director
   Member Secretary : Dr. Naimuddin
   All Project Coordinators
   All Heads of Divisions
   All Scientists
   Editor
   Finance & Accounts Officer
   Administrative Officer
   Asstt. Admin. Officer (Admin.)
   Asstt. Admin. Officer (Stores)
   Chairmen of Various Committees
   Architect
   Secretary, IJSC
   I/Cs of Various Activities

2 **Farm Advisory Committee**
   Chairman : Dr. S.S. Singh
   Member Secretary : Dr. Narendra Kumar
   All HoDs
   Dr. P.K. Katiyar, I/c Seeds
   I/c Farms
   I/c Security

3. **Estate Managamant Committee**
   Chairman : Dr. Mohan Singh
   Member Secretary : Mr. D.N. Awasthi
   Dr. S.K. Singh (Ento.)
   Dr. Rajesh Kumar
   Mr. Omkar Nath
   Administrative Officer
   Finance & Accounts Officer
   Mr. S.K. Garg
   Mr. R.M. Pal

4. **Publication Committee**
   Chairman : Dr. N.P. Singh, Director
   Member Secretary : Mr. Diwakar Upadhyaya
   Dr. P.S. Basu
   Dr. G.P. Dixit
   Dr. Naimuddin
   Dr. Jitendra Kumar

5. **Purchase Advisory Committee**
   Chairman : Dr. Jagdish Singh
   Member Secretary : Asstt. Admin. Officer (S)
   Dr. Shiv Sewak
   Dr. Narendra Kumar
   Dr. K.R. Soren
   Dr. M. Senthil Kumar
   Finance & Accounts Officer
   Administrative Officer

6. **Institute Technology Management Committee**
   Chairman : Dr. N.P. Singh, Director
   Member Secretary : Dr. Bansa Singh
   Dr. S.K. Chaturvedi
   Dr. Jagdish Singh
   Dr. S.S Singh
   Dr. S.K. Singh (upto 2.2.2016)
   Dr. Dibendu Dutta
   Dr. M.S. Venkatesh
   Ex-Officio Members:
   Dr. Sanjeev Gupta,
   Dr. I.P. Singh
   Dr. G.P. Dixit

7. **Resource Generation and Farm Produce Price Fixation Committee**
   Chairman : Dr. S.K. Chaturvedi
   Member Secretary : Dr. Ummed Singh
   Dr. Narendra Kumar
   Dr. Dev Raj
   Finance & Accounts Officer
   Administrative Officer
   Dr. (Mrs.) Uma Sah, I/c Library

8. **Prioritization, Monitoring and Evaluation Cell**
   Chairman : Dr. N.P. Singh, Director
   Member Secretary : Dr. Aditya Pratap
   Dr. (Mrs.) Uma Sah
   Dr. M. Senthil Kumar
   Dr. Mohd. Akram
   Dr. (Mrs.) Archana Singh (RS, Bhopal)
   Dr. Alok Das
   Mr. Deepak Singh (upto 2.1.2016)
   Dr. Revanappa (RS, Dharwad)
   Mr. Diwakar Upadhyaya
   Dr. Omkar Nath
   Mr. Kanhaiya Lal
   Mr. Hasmat Ali

9. **Library Committee**
Chairman : Dr. N.P. Singh, Director
Member Secretary : Dr. (Mrs.) Uma Sah
All HoDs
Finance & Accounts Officer
Administrative Officer

10. **Institute Biosafety Committee**
Chairman: Dr. N.P. Singh, Director
Member Secretary : Dr. Alok Das
Dr. Amaresh Chandra (DBT Nominee)
Dr. Jonaki Sen, IIT, Kanpur
Dr. Mohd. Akaram
Dr. Sujayanand, G.K.
Dr. Senthil Kumar
Dr. P.K. Singh (GSVM Medical College, Kanpur)

11. **Academic & HRD Committee**
Chairperson: Dr. (Mrs.) Hem Saxena (Upto 31.8.2015)
Member Secretary : Dr. Naimuddin
Dr. Rajesh Kumar
Dr. Alok Das
Dr. Ummed Singh
Mr. Jitendra Kumar

12. **Germplasm & Genotype Identification Committee**
Chairman : Dr. N.P. Singh, Director
Member Secretary **:** Dr. Farindra Singh
Dr. Shiv Sewak
Dr. S.K. Singh (Ento.)
Dr. Jitendra Kumar
Dr. Mohd. Akram

13. **Consultancy Processing Cell**
Chairman : Dr. Basa Singh
Member Secretary : Dr. R.K. Mishra
Dr. Rajesh Kumar
Dr. Farindra Singh
Dr. A.K. Parihar
Mr. Shanmugavadivel, PS

14. **Institute Joint Staff Council**
Chairman : Dr. N.P. Singh, Director
Member Secretary : Mr. Panchoo Lal, AO
Dr. G.P. Dixit
Dr. C.S. Praharaj
Dr. Rajesh Kumar
Dr. P.K. Katiyar
F&AO
Mr. R.K. Singh
Mr. K.A. Chaturvedi (Member, CJSC)
Mr. Yashwant Singh (Secretary IJSC)
Mr. Bachchoo Singh

15. **Grievance Cell**
Chairman : Dr. C.S. Praharaj
Member Secretary : Administrative Officer
Dr. Jitendra Kumar
Dr. (Mrs.) Archana Singh (RS, Bhopal)
Dr. Omkar Nath

16. **Vehicle Maintenance Committee**
Chairman : Dr. C.S. Praharaj
Member Secretary : Dr. Omkar Nath
Dr. Naimuddin
Dr. Ummed Singh
Dr. Revanappa (RS, Dharwad)
Mr. D.N. Gawande (RS, Bhopal)
Finanance & Accounts Officer
Administrative Officer
Asstt. Admin. Officer (S)

17. **Computer/ARIS Cell & Instrumentation Committee**
Chairman : Dr. Mohan Singh
Member Secretary : Dr. Dev Raj
Dr. M. Senthil Kumar
Dr. Hemant Kumar
Mr. A.K. Parihar
Mr. D.K. Sharma

18. **Guest House Management Committee**
Chairman : Dr. S.K. Singh (upto 2.2.2016)
Member Secretary : Administrative Officer
Dr. Ummed Singh
Dr. Alagu P. Solai
Dr. K.R. Soren

20. **Sports Committee**
Chairman : Dr. Rajesh Kumar
Member Secretary: Mr.K.N.Gupta (Upto 31.10.2015)
Dr. Ummed Singh
Dr. (Mrs.) Vijay Laxmi
Dr. R. Jagdeeswaran
Dr. M.P. Singh
Mr. Yashwant Singh, Secretary, IJSC

21. *Rajbhasha* Implementation Committee

Chairman : Dr. N.P. Singh, Director
Member Secretary : Mr. Diwakar Upadhyaya
All HoDs
Dr. R.K. Mishra
Dr. Purushottam
Dr. Hemant Kumar
Dr. R.K. Srivastava

22. Women's Cell & Saxual Harassment Committee

Chairperson : Dr. (Mrs.) Hem Saxena
(Upto 31.8.2015)
Member Secretary : Dr. (Mrs.) Uma Sah
Dr. (Mrs.) Vijay Laxmi
Dr. P.K. Katiyar

23. Technical Advisory Committee

Chairman : Dr. P.S. Basu
Member Secretary: Dr. Alok Das
Dr. Mohd. Akram
Dr. Lalit Kumar
Dr. Senthil Kumar
Dr. Sujayanand, GK

24. Results Framework document Committee

Chairman : Dr. N.P. Singh, Director
Nodal Officer : Dr. Mohd. Akram
Co-Nodal Officer : Dr. M. Senthilkumar
Dr. S.K. Chaturvedi
Dr. Jagdish Singh
Dr. S.S. Singh
Dr. (Mrs.) Hem Saxena (Upto 31.8.2015)
Finanance & Accounts Officer
Administrative Officer

25. Coordination Committee

Chairman : Dr. C.S. Praharaj
Dr. Omkar Nath
Mr. Rajendra Kumar Nigam

26. Local Purchase Committee

Chairman : Dr. Bansa Singh
Dr. Rajesh Kumar
Dr. Ummed Singh
Administrative Officer
Finance & Accounts Officer
Indenter

27. Incharges

Dr. Aditya Pratap, Nodal Officer, HYPM
Dr. (Mrs.) Uma Sah, Convener, Seminars
Dr. S.K. Singh, I/c Photography
(Upto 2.2.2016)
Dr. Narendra Kumar, I/c Farms
(New Research Campus)
Dr. Ummed Singh, I/c Farms (Main Farm)
Dr. P.K. Katiyar, I/c Seeds & Farms
Dr. Jitendra Kumar, I/c Cold Module
Dr. S.K. Garg, I/c Farm Machinary & Seed
Processing Machines
Mr. D.N.Awasthi, I/c Estate Management
Mr. S.K. Garg, I/c Maintenance of Power Supply
& Other
Farm Related Works
Mr. Shukadeo Mehto, I/c Vehicle
Mr. Vijendra Singh, I/c Horticulture
(Upto 29.2.2016)
Mr. Omkar Nath, I/c Security
Mr. R.M. Pal, I/c Electricity
Mr. Shiv Saran Singh, Care Taker, Guest House
& I/c Sanitation
Mr. A.B. Singh, Farm Manager, Main Farm
Mr. S.P.S. Chauhan, Sr. Farm Manager,
New Research Farm

IIPR- Regional Center *cum* Off Season Nursery, Dharwad

1. Tender, Technical/ Farm Produce Price Fixation/Purchase Committee

Chairman : Dr. M.S Venkatesh
Member Secretary : Dr. Revanappa
Dr. B.S. Patil (IARI-RRS)
Dr. Jayanath Bhat (IARI-RRS)
Dr. (Mrs.) Ganajakshi Math
(MULLaRP Sch. UAS)
Dr. Vinod Kumar (IGFRI-SRRS)

2. Seed, Security & Farm Development Committee

Chairman : Dr. M.S Venkatesh
Member Secretary : Dr. Revanappa
Dr. Shiv Kumar (IGFRI-SRRS)
Dr. Suma Mogali (MULLaRP Sch. UAS)
Dr. Jayanath Bhat (IARI-RRS)

IIPR-Regional Station, Phanda, Bhopal

1. **Purchase Committee**
   Chairman : Dr. (Mrs.)Archana Singh
   Member Secretary : Dr. D.N. Gawande
   Dr. R.P. Singh (MULLaRP, College of Agriculture, Sehore)

2. **Seed/ Grain Auction Committee**
   Chairman : Dr. (Mrs.) Archana Singh
   Member Secretary : Dr. D.N. Gawande
   Dr. S.C. Gupta (College of Agriculture, Sehore)

3. **Incharges**

   Dr. (Mrs.) Archana Singh, I/c Sanitation & Land Scaping
   Dr. D.N. Gawande, I/c Farm
   Dr. D.N. Gawande, I/c Vehicle
   Mr. Mayank Mishra, I/c Security
   Mr. Arvind Kumar Yadav, Farm Manager

Panorama

Union Minister of Agriculture and Farmers Welfare Visited IIPR

Hon'ble Union Minister of Agriculture and Farmers Welfare Shri Radha Mohan Singh visited ICAR-Indian Institute of Pulses Research, Kanpur on March 13, 2016 to give impetus to activities in the International Year of Pulses-2016. His proclivity was to stimulate scientific community and pulse growers for increasing pulse production in the country to eradicate malnutrition. Dr. Trilochan Mohapatra, Secretary DARE and Director General, ICAR, New Delhi and Dr. J.S. Sandhu, Dy. Director General (CS) also accompanied the Minister during the visit. Hon'ble Minister and the dignitaries were given a warm welcome by Dr. T. Mohapatra, DG, ICAR and Dr. N.P. Singh, Director of the Institute. Hon'ble Minister laid the foundation stone of Scientists Apartments in the Institute. He visited the experimental fields and took ardent interest in development of new varieties, particularly the hybrids and transgenic containment facility.



In his welcome address, Dr. Mohapatra presented before the Hon'ble Minister the pulse production scenario in the country, keeping in foreground the importance and significance of International Year of Pulses. He highlighted the achievements of the Institute in development of new high yielding varieties and matching crop production technologies.



In his address, Hon'ble Minister called upon the scientists to develop short duration varieties of pulse crops to foster multiple cropping systems. He stressed upon developing high yielding varieties insulated with pest and disease resistance keeping in mind the changes in climate and seasons. He called for minimizing the post-harvest losses. At this occasion, a farmers' friendly bulletin on Unnat Dalhan Utpadan Prodikiyon ka Sarwajanikaran was also released by the Hon'ble Minister.

Addressing the pulse growers the Hon'ble Minister said that the cultivable area is shrinking due to urbanisation and industrialization, while the population of the country is increasing. So the farmers and the scientists should go with hand-in-hand to produce sufficient food for the growing population. In this endeavour Govt. will provide all help and assistance to make the country self sufficient in pulses. Hon'ble Minister honoured Sri Rajendra Prasad Savita, farmer of village Vidokhar, Distt. Hamirpur with Pandit Deen Dayal Upadhyaya Krishi Antyoday Puraskar.

While delivering vote of thanks to the Hon'ble Minister, other dignitaries and farmers present, Dr. N.P. Singh assured all that with immense support of the Government and massive scientific and technical strength, the production of pulses will achieve all targets. He also assured that in the International Year of Pulses, scientists and pulse growers will leave no stone unturned to make the country self reliant.

Institute Foundation Day Celebrated

ICAR-Indian Institute of Pulses Research celebrated its 23rd Foundation Day on Saturday, September 5, 2015. Dr. J.S. Sandhu, Deputy Director General (CS), ICAR, New Delhi, was the Chief Guest at the occasion. Vice-Chancellor, CSA University of Agriculture & Technology, Kanpur and Banda University of Agriculture & Technology, Banda, Dr. S.L. Goswami was Guest of Honour. Dr. P.K. Agrawal, ADG (NASF) and Dr. P.K. Chakrabarty ADG (PP) were also present at the occasion. Dr. N.P. Singh, Director, IIPR welcomed the honorable guests.



Speaking on the occasion, Dr. J.S. Sandhu said that in comparison to year 1950, the production of crops has increased by five times but still people are suffering from malnutrition. He expressed concern over changing climate scenario and the bad affects of rising pollution levels over the fields. He added that if the hybrid quality of seeds and production techniques are made available to the farmers, the production of pulse crops is likely to go up by 30%. Dr. S.L. Goswami expressed concern over the difficulties that farmers are facing in getting high quality of seeds and advanced production techniques. He said that if the farmers are made a part of the various research based programmes and the same research is applied in their fields they will surely get better results.

Dr. N.P. Singh, while delivering his address briefed about the various activities going on in the Institute. He also highlighted the achievements of the Institute. Dr. Singh informed that scientists of the Institute have identified heat tolerant varieties of chickpea and lentil, and large seeded lentil that will be shortly available for cultivation. He also said that research on development of pod borer resistant transgenic chickpea and pigeonpea is going in the right direction and yielded promising results. On this occasion, a new publication on 'Primer on Modern Tools of Plant Biotechnology' was released.

At this occasion, Dr. Aditya Pratap, Senior Scientist was felicitated for getting ICAR's Lal Bahadur Shastri Outstanding Young Scientist Award-2014 and Dr. Shallu Thakur, Research Associate for getting ICAR's Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agriculture and Allied Sciences-2014.

During the function, Dr. G.P. Dixit and Dr. Mohd. Akaram were awarded the Best Scientist Award for 2014 and 2015, respectively. Dr. Omkar Nath and Mr. Kanhaiya Lal were awarded as Best Worker for 2014 and 2015, respectively in Technical Category. Sh. Rajendra Kumar Nigam and Sh. Shiv Saran Singh in the Administrative Category and Sh. Devi Prasad and Sh. Yashvant Singh were awarded as Best Worker in Skilled Supporing Staff Categories,



for the respective years. Vote of thanks was proposed by Dr. S.K. Chaturvedi, Head, Crop Improvement Division. The programme was conducted by Dr. Aditya Pratap and Dr. (Mrs.) Uma Sah.

Director General, ICRISAT Visited IIPR

Dr. David J. Bergvinson, Director General, International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Hyderabad visited the Institute on September 25, 2015 and discussed various IIPR-ICRISAT collaborative research programmes. Dr. B.B. Singh, Assistant Director General (O&P), ICAR, Dr. Rajeev Varshney, Research Programme Director, Grain Legumes, ICRISAT, Dr. N.P. Singh, Director, IIPR and Dr. K.C. Bansal, Director, ICAR-NBPGR were present at the occasion. Dr. N.P. Singh presented a brief about the Institute and explained various activities as well as significant





achievements including those of the IIPR-ICRISAT collaborative projects. Dr. Bergvinson took keen interest in the Institute activities and got acquainted with various research programmes and was highly appreciative of the research efforts, infrastructure and scientific strengths of the Institute and desired to have more fruitful collaborations. He also visited Institute facilities including the laboratories, museum, containment facilities, *etc*. He exhorted to strive more for global food and nutritional security and desired that as agricultural scientists, we all should live to the expectations of poorest of the poor. Dr. Bergvinson left with a very high opinion about the Institute and expressed deep sense of gratitude for making his visit to IIPR successful.

Deputy Director General (CS) Visited IIPR

Dr. J.S. Sandhu, Deputy Director General (Crop Science) visited ICAR-IIPR, Kanpur on June 7, 2015. He visited breeding, agronomical and plant protection experimentation trials. He suggested several researchable points mainly related to summer mungbean. While addressing the scientists, he emphasized upon active involvement of scientists in providing need based information on pulses technologies to the farming community. A field trip was arranged to show performance of demonstrations at farmers' fields at Barahpur village





of Kanpur Dehat. Dr. Sandhu along with Dr. N.P. Singh, Director and scientists of the Institute visited demonstration plots. A large number of farmers of nearby villages were also present at the occasion. Dr. Sandhu keenly observed the performance of mungbean varieties, interacted with the farmers and appreciated the efforts. He observed that summer mungbean cultivation could be a huge success and could help tremendously in diversification of rice-wheat system. Dissemination of technologies for summer mungbean cultivation among the farmers will boost its cultivation in many regions of northern India. Dr. Sandhu appreciated the efforts of Institute in conductance of mungbean demonstrations in compact block and popularization of proven technologies to the farmers.

Annual Group Meets of AICRPs

❖ Annual Group Meet on Mungbean and Urdbean under AICRP on MULLaRP was held at Birsa Agricultural University, Ranchi on May 22-24, 2015. Dr. George John, Vice-Chancellor of the University inaugurated the meet. Dr. B.B.Singh, Assistant Director General (O&P), ICAR presided the inaugural session. Dr. N.P. Singh, Director, IIPR while presenting a glimpse of the production



enhancement in pulses, gave insights on the unprecedented challenge to be faced by the pulse scientists which targets increasing pulses production by 1 m t/year by taking 19 m t as a base. Dr. Singh stressed on short duration genotypes, sharing of the material generated across research stations and MYMV and powdery mildew diseases as current issues.

Dr. George John illustrated a set of newer agricultural challenges like climatic adversities which will further be aggravated by the increasing emergence of insect/pest and disease problems. Dr. B.B. Singh called upon the scientists for aggressive efforts for accelerating transfer of technologies to farmers, preparation of a roadmap for pulses improvement, development of short duration and photo-thermo insensitive genotypes in pulses.

Dr. Sanjeev Gupta, Project Coordinator (MULLaRP), while presenting a brief report of the project, apprised about the major achievements and constraints in mungbean and urdbean crops. He emphasized that plant types need to be changed inducing photo-thermo insensitivity and high harvest index. A session on Inter-Project Linkages was also held in which role of global cooperation on mungbean improvement was discussed and programmes for such collaborations were formulated. In later sessions, results of *kharif* 2014 were discussed and technical programme for *kharif* 2015 was finalized.

❖ Annual Group Meet on Chickpea and *Rabi* MULLaRP and a Brain Storming Meeting on 'Promotion of Pulses in Indo-Gangetic Plains of India' were held at Punjab Agricultural University, Ludhiana on August 31 to September 3, 2015. The meeting was inaugurated by Dr. B.B. Singh, Assistant Director General (O&P), ICAR. Dr. B.S. Dhillon, Vice-Chancellor, PAU, was the Chief Guest of the function. More than 250 delegates from different parts of the country attended the Meet. Dr. N.P. Singh, Director, IIPR Kanpur presented overall progress made in pulses research and development. He also expressed his serious concern over deficit pulse production in the country due to unseasonal rains in the last year.

Dr. B.S. Dhillon, in his opening remarks, expressed concern over lack of sufficient genetic variability in pulses. He emphasized upon climate change as an additional threat and need to adopt technologies suited to changes in the climate. Dr. B.B. Singh expressed urgent need to reorient research towards development of new plant types and utilization of new genetic resources. Dr. G.P. Dixit and Dr. Sanjeev Gupta presented the Project Coordinators' report of AICRP on chickpea and MULLaRP, respectively.



Dr. B.B. Singh mentioned that the brain storming session's primary objective is to rehabilitate the pulses in Indo-Gangetic plains, which could be possible through tailor made varieties having resilience to changing climate and efficient crop management. Deliberations were made by eminent scientists along with representatives from ICRISAT, ICARDA, BISA and AVRDC (WVC) on various issues related to crop diversification and genetic enhancement, resource conservation and mechanization for promotion of pulses in IGP.

❖ Annual Group Meet of All India Network Research Project on Arid Legumes was held on June 8-9, 2015 at ICAR-Central Arid Zone Research Institute, Jodhpur. About 70 delegates from cooperating centres of SAUs, ICAR Institutes, State Department of Agriculture and Seed Agencies attended the group meet. While welcoming the dignitaries and delegates Dr. R.K. Bhatt, Director, ICAR-CAZRI, Jodhpur emphasized the importance of arid legumes in farming system and changing



scenario of climate. Dr. Shiv Sewak, Nodal Scientist (Arid Legumes) presented the progress report for 2014-15 and mentioned his concern over deficit in breeder seed production of mandate crops of arid legumes. Dr. B.B. Singh, Visiting Professor, GB PUA&T, Pantnagar emphasized the need of short duration varieties. Mr. S.K. Sharma, Secretary, Guar gum Manufacturers Association of India urged the scientists to develop guar varieties with large endosperm to extract more gum. Dr. B.B. Singh, ADG (O&P) in his Chairman's remarks envisaged that arid legumes would be the future crops with global warming situation. Dr. N.P. Singh, Director, ICAR-IIPR, Kanpur expressed his views about the research and development of pulses in general and of arid legumes in particular. He emphasized the need to develop high yielding, disease resistant varieties and protection and production technologies to increase the productivity and production of these crops.

❖ Annual Group Meet of AICRP on MULLaRP (Mungbean and urdbean) and Arid Legumes (Cowpea and guar) was held at IIPR, Kanpur on November 28-29, 2015. About 70 delegates from SAUs and cooperating centres participated in the Group Meet. Dr. N.P. Singh, Director, IIPR in his welcome address expressed happiness over promotion of pulses in new niches specially in spring, summer and rice-fallow conditions and specifically mentioned the success of short duration varieties of mungbean. He called upon the scientists to exert more for development of new technologies to reduce the gap between potential and harvested yield. Dr. A.K. Tiwari, Director, Pulses Development, Bhopal advocated cultivation of summer mungbean and urdbean. He raised high hope for cultivation of cowpea and desired that its potential should be fully exploited.

Dr. Sanjeev Gupta, Project Coordinator, MULLaRP projected tremendous scope of horizontal and vertical increase in production of mungbean and urdbean and specifically increasing production and productivity of rice fallow pulses. He emphasized upon development of short duration, machine harvestable varieties having multiple resistance to diseases and insect pests. He also presented the summary of progress of summer/spring mungbean and urdbean during last season. Dr. Shiv Sewak, Nodal Officer, Network Research Project on Arid Legumes, presented the summary of progress in arid legumes during the last spring/summer seasons.

Dr. B.B. Singh, ADG (O&P) in his chairman's remarks desired that early duration varieties are the need of the hour and special trials should be



conducted for extra early genotypes across the locations. He exhorted that other short duration pulses such as cowpea should also be promoted for increasing area under pulses, while newer areas under rice fallow should be brought under mungbean and urdbean cultivation. Later, results of previous season were discussed and technical programme for the next season was finalized.

World Soil Day Celebrated

World Soil Day was celebrated at the Institute on December 5, 2015. Shri Devendra Singh Bhole, Hon'ble Member of Parliamant, Akbarpur Parliamentary Constituency, Uttar Pradesh was the Chief Guest for the function. Around 250 farmers from 7 districts of Uttar Pradesh, besides staff members of the Institute participated in the function. Dr. Ummed Singh highlighted the importance of World Soil Day and Soil Health Cards. While welcoming the Chief Guest and participants, Dr. N.P. Singh, Director stressed upon the need for large scale soil/plant testing and development of soil health card (SHC) so as to provide a requisite boost to both production and productivity of staple crops including pulses. In this direction, he called for large scale adoption of balanced and integrated nutrient management, enhancing efficiency of fertilizer use, and use of soil health cards for managing both soil and crops efficiently.

The Chief Guest Shri Devendra Singh Bhole in his special remarks, said that farmers are the soul of



the nation and urged the need to make the farmers self-sustained and self sufficient. He said that agriculture still continues as a major livelihood to a significant portion of population in the country. He promised to extend all his support and cooperation for soil health improvement programme. Total 311 SHC were prepared for distribution to farmers. The meeting ended with a vote of thanks by Dr. S.K. Singh, Principal Scientist, Social Science.

Inauguration of Building at Regional Station, Phanda, Bhopal

On February 24, 2016 inauguration of Farm Services Building and foundation stone laying ceremony of Laboratory-cum-Administrative Building at Regional Station of ICAR-IIPR (Kanpur), at Phanda, Bhopal, was solemnized by the Secretary, DARE and Director General, ICAR, Dr. T. Mohapatra and DG, ICARDA, Dr. Mahmaud Solh, in presence of Dr. J.S. Sandhu, DDG (CS), Dr. B.B. Singh, ADG (O&P), ICAR and Dr. N.P. Singh Director, IIPR. Dr. N.P. Singh, while welcoming the guests and dignitaries, elaborated the importance and scope of the new Research Station at Phanda in catering the research needs of central India.

Dr. Mohapatra, DG ICAR emphasized on achieving the target of 21 million ton pulses production by 2020 to make the country self sufficient. He was much concerned about the strengthening the communication network between the researchers and farmers for dissemination of technologies to the farmers. He appreciated the efforts of ICAR-IIPR scientists towards development of new varieties of pulses and eradication of malnutrition.



Dr. Mahmoud Solh, DG ICARDA conveyed his gratitude to ICAR for needful collaboration and support for development and spread of new varieties in pulses. Dr. J.S. Sandhu desired that the deficit in pulses production should be compensated within a time span of 2-3 years to fulfil the dream of Hon'ble Prime Minister. Dr. B.B. Singh emphasized on production of sufficient quality seed of pulses through farmers participatory approach and purchasing the seed under buy-back policy. A farmers' training programme on seed production technique in pulses was also organized at this occasion.

Rabi Pulses Scientists' Meet organized

Rabi Pulses Scientists' Meet was organized at ICAR-Indian Institute of Pulses Research, Kanpur on February 19-20, 2016 to provide an opportunity to researchers to share information on basic and applied aspects of pulses research and to share breeding material and genetic resources. Total 43 scientists including scientists from ICRISAT and ICARDA participated in the meet. Dr. N.P. Singh, Director



IIPR, highlighting its importance, suggested to take advantage of the meet to explore areas for future collaborations and called for providing feedback on material received and its utilization. Dr. S.K. Chaturvedi, Head, Crop Improvement and Convener extended warm welcome to the participants and presented his views on resetting research priorities in *rabi* pulses. Dr. P.M. Gaur of ICRISAT highlighted accelerated breeding with special reference to transfer hot spot QTLs to impart drought tolerance. Dr. Kiran K Sharma from ICRISAT suggested to develop consortium to generate required data to address bio-safety issues in transgenic pulses. Dr. G.P. Dixit, Project Coordinator (Chickpea) suggested sharing of segregating populations and utilization of off-season nursery for rapid generation advancement. Breeders had special interest in material generated through interspecific hybridization in chickpea and lentil that exhibited large variations for seeds/pod, pods/plant and primary/secondary branches per plant. A large number of breeding lines, germplasm accessions and donors were selected by the participants from different centres.

National Science Day Celebrated

National Science Day was celebrated on February 29, 2016 at the Institute with great enthusiasm on the theme 'Make in India: Science and Technology Driven Innovation'. Dr Renu Jain, Director, University Institute of Engineering & Technology, CSJMU, Kanpur was Chief Guest and Dr D.K. Srivastava, Joint Director, Council of Science & Technology, UP, Lucknow was Guest of Honor on the occasion. Dr. S.K. Chaturvedi, Head, Division of Crop Improvement welcomed the guests and audience. Dr. Chaturvedi highlighted the science and technology driven innovation in agriculture to make India self-sufficient in food production. Dr. Renu Jain called upon youngsters to come forward to accept the challenges and solve them scientifically. She also expressed need for popularization of scientific inventions among the common masses. Dr. Srivastava recalled the inventions by the common people of the country. Vote of thanks was given by Dr. Krishna Kumar, Head, Division of Crop Protection. The programme was jointly conducted by Dr. Mohd. Akram and Dr. R.K. Mishra.



RAC Meeting Held

The 22nd RAC meeting of the Institute was held on March, 18-19, 2016 under the chairmanship of Dr. J.H. Kulkarni, Former Vice-Chancellor, UAS, Dharwad, Karnataka. The meeting was attended by Dr. N.P. Singh, Director, IIPR, Dr. B. Venkateswarlu, Vice-Chancellor, MKV, Parbhani (M.S.), Dr. U.P. Singh, Former Head, Division of Genetics & Plant Breeding, Institute of Agricultural Sciences, BHU, Varanasi and Dr. V.V. Ramamurthy, Ex. Principal Scientist (Entomology), IARI, New Delhi. Project Coordinators of Chickpea, Pigeonpea, MULLaRP, Nodal Scientist (Arid Legumes) and all Heads of Divisions also participated in the meeting.

Dr. N.P. Singh, Director, while welcoming the Chairman and other members briefed about the progress in research and development at IIPR Kanpur during the period. He informed that eight high yielding varieties of different pulse crops were released/identified in the last one year. All India Network Programme on Arid Legume was shifted from ICAR-CAZRI to this Institute. New building and other infrastructure at IIPR Regional Station, Bhopal was inaugurated by the DG, ICAR and DG, ICARDA on February 24, 2016. Several externally funded projects such as three CRP projects, one each on Agro-biodiversity, Molecular breeding and Hybrid pigeonpea, two international projects, one on international mungbean research consortium and another on tropical legumes sponsored by Bill and Melinda Gates Foundation, two projects funded by DBT, one project on Centre for Agricultural Bio-informatics were started at the Institute. A Summer School was also organized on 'Novel genomic tools and modern breeding approaches for enhancing productivity and nutritional quality of pulse crops' where participants from across the country participated.



Chairman, RAC and other members appreciated the on-going research programmes and also congratulated the scientists for achievements made during the last year. Thereafter, Heads of Divisions and the Project Coordinators presented brief reports of the work being carried in their respective Divisions/AICRP/Units. Elaborate discussions were held on different issues related to various research programmes and recommendations were made by RAC for improving the R&D activities of the Institute.

Director's Visit at Regional Station, Fanda, Bhopal

Dr. N.P. Singh, Director visited the IIPR Regional Station, Bhopal on March 29, 2016 to review the on-going research and developmental activities of the station. He appreciated the work done in the past to create the basic facilities. He also emphasized that collective efforts should be made to develop the landscape, roads, seed stores and leveling of fields, *etc*. At this occasion, Director inaugurated the newly constructed Sehore gate (Sehore side at Bhopal-Indore Highway) of the farm for easy movement of farm workers and visitors.



IIPR Participated in Special Session on Promotion of Pulse in Bundelkhand

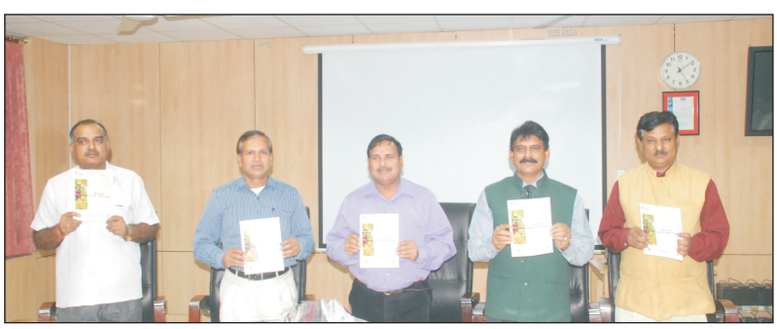
Scientists from ICAR-Indian Institute of Pulses Research, participated in *Bundelkhand Krishi Pradarshini and Kisan Mela* organized by ATARI, Zone IV, Kanpur on March 29-30, 2016 at Lalitpur, Uttar Pradesh. Hon'ble Union Minister for Water Resources, River Development and Ganga Rejuvenation, Govt. of India, Ms. Uma Bharti was Chief Guest of the function. She unveiled 'Prime Minister's Crop Insurance' scheme. A special session on 'Strategies for Promotion of Pulses in Bundelkhand' was also organized wherein Dr. S.K. Chaturvedi of IIPR eleborated technologies and strategies for enhancing pulses production in the region. Dr. Purushottam highlighted income generation through pulse enterprising activities to check migration of rural youth to urban areas. Dr. U.C. Jha shared information on suitable heat and drought tolerant chickpea cultivars for the region. A farmers' friendly extension bulletin *Bundelkhand Main Chana Utpadan Ki Unnat Taknike* was also released by the Hon'ble Minister.



Non-availability of quality seed of recommended varieties and timely arrangements of pesticides emerged as main constraints faced by pulse growers of the region. Later, Dr. A.K. Singh, DDG (Agril. Extn.), ICAR, visited the ICAR-IIPR stall and took keen interest in latest varieties of pulses. Hundreds of farmers including farm women and youth visited IIPR stall and enquired about pulses. Literature on package of practices for various pulse crops was distributed among farmers and mobile numbers of visiting farmers were also collected for follow up.

Organization of Sensitization Workshop/Training of KVKs

To facilitate the transfer of new technologies/ varieties in cluster Front Line Demonstrations on Pulses under NFSM during current season (2015-16), sensitization Workshop/Training was jointly organized by Agriculture Technology Application Research Institute (ATARI) Zone IV and Indian Institute of Pulses Research, Kanpur on November 18-19, 2015. Total 81 participants (Senior Scientists-cum-heads and Subject matter specialists) from Uttar Pradesh and Uttarakhand actively participated. Director, ATARI (Zone IV), Kanpur and his team reviewed KVK wise progress of conductance of FLDs on pulses. Dr. N.P. Singh Director of Institute highlighted present scenario and prospects of pulses in Uttar Pradesh and Uttarakhand. His major concern was to organize effective and quality demonstrations of pulses to provide technological back stopping to main Department of Agriculture of State. Varietal, agronomical management, insect-pest, diseases and post-harvest management aspects were covered in this training programme. Major emphasis was given on creation of Seed-hubs by potential KVKs to meet the seed demand of preferred varieties in particular district. Dr. Udham Singh Gautam, Director ATARI, Zone IV coordinated this training programme.



Brainstorming Meeting on Promotion of Pulses in Non-traditional Niches: Summer Cultivation

Brainstorming meeting on 'Promotion of pulses in non-traditional niches: Summer cultivation' was organized on February 9-10, 2016 at ICAR-IIPR. The meeting was attended by 119 participants from all stakeholders including scientists, farmers, extension personnel, policy makers from U.P., M.P., Rajasthan, Karnataka, West Bengal, Punjab, Delhi, J&K, Telangana and Directorates of different crops under DAC, Ministry of Agriculture and Farmers Welfare, GoI.

While inaugurating the meeting Dr. B.B. Singh, ADG (O&P), ICAR, applauded mungbean varietal development programme which led to bring additional area under non-traditional niches. The success of new cultivars like IPM 02-3 and IPM 02-14 of mungbean in non-traditional niches clearly demonstrates the greater scope of pulses in summer cultivation. Dr. A.K. Tiwari, Director, Directorate of Pulses Development, Bhopal opined that new innovations are further needed to promote summer pulses.

Dr. D.P. Malik, Additional Commissioner (NFSM), DAC, GoI informed that summer pulses could be promoted in the states where assured irrigation facilities exist. Dr. N.P. Singh, Director, IIPR, pointed out the difficulty in conducting cluster demonstrations of summer pulses as production areas are very scattered. The demonstrations need to be planned in accordance to cropping pattern of the region. Dr. Masood Ali, Former Director, IIPR while highlighting the further scope of pulses in non-traditional niches suggested for more funding support to improve research infrastructure and



capacity building. Dr. Sanjeev Gupta, PC, MULLaRP and Nodal Officer of the Brainstorming Session stressed on micro-irrigation, mechanization, creation of village level seed hubs and effective IPM strategy for promotion of summer pulses cultivation. Besides inaugural session, there were four technical sessions in which deliberations were held by subject matter specialists on topical themes.

Visit of Team of CACP, New Delhi

Chairman along with Member Secretary and Member of Commission for Agriculture Cost and Prices (CACP) visited this Institute on October 31, 2015. An interactive meeting-cum-discussion was also organized. Dr. N. P. Singh, Director highlighted major technological breakthrough and future strategy of pulse crops. Arrivals and prices of pulses in different seasons were discussed. Minimum support price and procurement process of pulses were main issues during interaction. All Project Coordinators and Heads of Divisions took part in the meeting. Team also participated in the state training programme at Institute. Extension officials and farmers of Bundelkhand region expressed their



views on production and marketing trends of pulses to the team of CACP.

State Level Training Courses Organized

State level training course on 'Hi-tech production technology of pulse crops' was organized in two batches during 12-16 October and 27-31 October 2015 at this Institute. Both training courses were sponsored and financed by Directorate of Agriculture, State Agriculture Management Centre, Rahmankheda, Lucknow under ATMA scheme. In Ist batch, total 35 participants including Deputy Director, Consultants, Block Team Managers, Subject Matter Specialists and achiever farmers of Kanpur division took part. Total 33 participants form different districts of Chitrakoot Dham division, Banda took part in second batch training course which was organized during 27-31 October 2015. In both training courses, Dr. N.P. Singh, Director of Institute briefed about technological breakthrough and urged to the participants for inclusion of pulses under prevailing farming system(s) for maintaining sustainable agriculture and nutritional security. Interactive lectures were delivered by Subject Matter Specialists on varietal, agronomical, pests and diseases and post-harvest management. In each lecture practical session was given top priority. Exposure visits were arranged in both training programmes. IIPR developed farmers' friendly literature were given to each participant. Both training courses were coordinated by Dr. Sushil Kumar Singh, Principal Scientist and Head (Social Science).



Participation of IIPR in ICAR Zonal Sports Tournament-2015

The Institute participated in ICAR Zonal Sports Tournament-2015 (North Zone) organised at Indian Institute of Soil and Water Conservation, Dehradun, during 18-21 April, 2015. The contingent of 43 players participated in Table Tennis, Carom, Chess, Volley Ball Shooting, Volley Ball Smashing, Football, Badminton, Kabaddi, Javlin throw, Shotput and Race during sport tournament. Players won five medals in individual events *i.e.*, Gold medal in long jump, Silver medal in 100 metre race and Badminton singles, Bronze medal in 400 and 1500 meter race. Volleyball smashing team got the runner-up medal. Dr. Rajesh Kumar accompanied the contingent as CDM and Sri K.N. Gupta as team manager.



मेरा गाँव मेरा गौरव कार्यक्रम

'मेरा गाँव मेरा गौरव' कार्यक्रम के सफल क्रियान्वयन हेतु संस्थान में 16 बहुविषयक दल बनाए गए हैं। विभिन्न जनपदों (फतेहपुर, कानपुर देहात, कानपुर नगर और



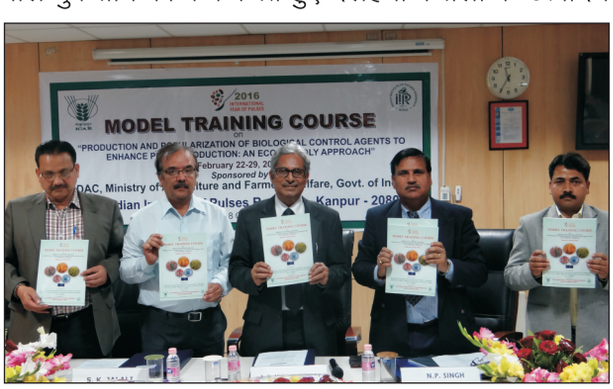
जालौन) के 36 गाँवों का सर्वेक्षण किया गया। किसानों से मूलभूत जानकारी प्राप्त की गई एवं सुधार हेतु कारगर प्रौद्योगिकी की योजना को अंतिम रूप दिया गया है।

इस कार्यक्रम के अंतर्गत दिनाँक 2 जनवरी, 2016 को कानपुर देहात (उ.प्र.) के अंगदपुर में एक वैज्ञानिक–कृषक परिचर्चा का आयोजन किया गया। परिचर्चा के दौरान डा. एस.के. चतुर्वेदी ने बताया कि परस्पर सहयोग से किस प्रकार बीजों का उत्पादन किया जाए। साथ ही उन्होंने उच्च उपज वाली प्रजातियों, रोग एवं कीट प्रबन्धन एवं किसानों की तरक्की में संस्थान के सहयोग/भूमिका पर महत्वपूर्ण जानकारी दी। डा. उम्मेद सिंह ने दलहनी एवं अन्य फसलों की खेती के सम्बन्ध में नवीनतम जानकारी उपलब्ध कराते हुए बीजोपचार, खरपतवार नियन्त्रण, जल प्रबन्धन तकनीक, उर्वरक प्रयोग आदि जैसे महत्वपूर्ण विषयों पर किसानों को महत्वपूर्ण जानकारी दी। श्री एस.के. मीणा ने किसानों को दलहनी खेती की वर्तमान समस्याओं से निपटने के कारगर उपाय बताते हुए सरकार की कृषक कल्याणकारी योजनाओं से परिचित कराया।

उक्त कार्यक्रम में 200 से अधिक किसानों ने भाग लिया। कृषकों ने वैज्ञानिकों को रोगग्रस्त पौधे, खरपतवार एवं मृदा के नमूने दिखाये और अपनी खेती सम्बन्धी समस्याओं को विस्तार से बताया। वैज्ञानिकों ने सभी समस्याओं का समाधान और निराकरण बताया। संस्थान के वैज्ञानिकों ने किसानों के खेतों का भ्रमण किया। इस अवसर पर 18 किसानों को मृदा स्वास्थ्य कार्ड का भी वितरण किया गया।

मॉडल प्रशिक्षण कार्यक्रम का आयोजन

कृषि एवं सहकारिता विभाग, कृषि एवं किसान कल्याण मंत्रालय, भारत सरकार द्वारा प्रायोजित 'दलहन उत्पादन को बढ़ाने के लिए जैविक नियन्त्रण कारकों का उत्पादन एवं प्रचालनः पर्यावरण अनुकूल दृष्टिकोण' विषय पर संस्थान में 22–29 फरवरी, 2016 को आठ दिवसीय माडल प्रशिक्षण कार्यक्रम का आयोजन किया गया। इस अवसर पर प्रो. ए.एन. मुखोपाध्याय, पूर्व कुलपति, असम कृषि विश्वविद्यालय, जोरहट ने अपने उद्घाटन भाषण में रोग एवं कीटों से होने वाले नुकसान को कम करते हुए दलहनी फसलों के उत्पादन



को बढ़ाने में जैविक नियत्रंकों की भूमिका पर महत्वपूर्ण जानकारी दी। उन्होंने बताया कि जैविक नियन्त्रण कारक, रासायनिक कीटनाशकों का सर्वोत्तम विकल्प हैं और यह पर्यावरण एवं जैव मण्डल के लिए सुरक्षित भी हैं। संस्थान के निदेशक डा. नरेन्द्र प्रताप सिंह ने बताया कि दलहन उत्पादन में आत्मनिर्भरता प्राप्त करने के लिए बायोइन्टेसिव एकीकृत कीट प्रबन्धन अति आवश्यक है। डा. एस.के. जलाली, विभागाध्यक्ष, आणविक कीट विज्ञान, एन.बी.ए.आई.आर. बंगलूरू, ने बताया कि यह आवश्यक है कि किसानों को जैव नियंत्रण कारकों की पर्याप्त जानकारी हो और उनका इस प्रौद्योगिकी में पूर्ण विश्वास हो। इस कार्यक्रम में देश के विभिन्न 10 राज्यों के राज्य कृषि एवं उद्यान विभागों के प्रतिनिधियों ने भाग लिया। प्रशिक्षण के दौरान भिन्न–भिन्न विषयों पर अतिथि विशेषज्ञों ने 10 व्याखान प्रस्तुत किए एवं संस्थान के वैज्ञानिकों द्वारा 25 व्याख्यान दिए गए। डा. डी.के. श्रीवास्तव, संयुक्त निदेशक, विज्ञान एवं प्रौद्योगिकी परिषद, लखनऊ एवं डा. रेनू जैन, निदेशक, यूनिवर्सिटी इन्स्टीट्यूट ऑफ इंजीनियरिंग एण्ड टैक्नोलाजी, सी.एस.जे.एम. विश्वविद्यालय, कानपुर इस प्रशिक्षण के समापन समारोह के मुख्य अतिथि थे।

जय किसान जय विज्ञान कार्यक्रम मनाया गया

संस्थान में दिनाँक 29 दिसम्बर, 2015 को जय किसान जय विज्ञान कार्यक्रम मनाया गया। इस अवसर पर च.शे.आ.



कृषि एवं प्रौद्योगिकी विश्वविद्यालय, कानपुर और बाँदा कृषि एवं प्रौद्योगिकी विश्वविद्यालय, बाँदा के कुलपति डा. सुरेन्द्र लाल गोस्वामी मुख्य अतिथि थे। दीप प्रज्ज्वलन के पश्चात संस्थान के निदेशक डा. नरेन्द्र प्रताप सिंह ने अतिथियों एवं सभागार में उपस्थित सभी का स्वागत किया। अपने उद्‌बोधन में डा. गोस्वामी ने वैज्ञानिक शोधों का भरपूर लाभ किसानों तक पहुँचाने का आह्‌वाहन किया। उन्होंने सलाह दी कि किसानों की सहभागिता के साथ ऐसे कार्यक्रम चलाये जाये जिनके शोध परिणाम किसानों के खेत में भी दिखाई दें। उन्होनें वैज्ञानिको का आह्‌वाहन किया कि इसके लिए मिशन बना कर किसानों के हित में कार्य किया जाये।

संस्थान के निदेशक डा. सिंह ने बदलते जलवायु परिदृश्य, पर्यावरण प्रदूषण तथा खेती पर इसके दुष्प्रभाव पर चिन्ता व्यक्त करते हुए स्वस्थ पर्यावरण पर जोर दिया और उर्वरको के सन्तुलित उपयोग की सलाह दी। डा. सिंह ने संस्थान की विभिन्न गतिविधियों और उपलब्धियों पर प्रकाश डाला। उन्होंने कहा कि विभिन्न अन्तर्राष्ट्रीय एवं राष्ट्रीय परियोजनायें अत्यन्त लाभप्रद रही हैं और उनसे उन्नत प्रजातियों, तकनीकी तथा मानव संसाधन विकास में सफलता मिली है। उन्होनें कहा कि इन सभी उपलब्धियों का लाभ किसानों को मिल रहा है, जिससे उनकी आय में वृद्धि हो रही है और जय किसान जय विज्ञान का मिशन पूरा हो रहा है।

कार्यक्रम में किसान–वैज्ञानिक संवाद का भी आयोजिन किया गया। इसमें किसानों ने अपनी खेती संबंधी कठिनाइयों के बारे में प्रश्न पूछे और वैज्ञानिकों ने उनके समाधान बताये।



धन्यवाद् प्रस्ताव डा. संजीव गुप्ता ने प्रस्तुत किया तथा कार्यक्रम का संचालन डा. आदित्य प्रताप ने किया।

रबी दलहनी फसलों की उत्पादन तकनीकी पर कृषक प्रशिक्षण

दिनाँक 4–5 दिसम्बर, 2015 को संस्थान में जैव प्रौद्योगिकी विभाग, भारत सरकार द्वारा वित्तपोषित दलहन कृषकों का सामाजिक, आर्थिक व सशक्तिकरण परियोजना



के अन्तर्गत रबी दलहनी फसलों की उत्पादन तकनीकी पर दो दिवसीय कृषक प्रशिक्षण कार्यक्रम का आयोजन किया गया। इस प्रशिक्षण में कानपुर देहात जनपद के सिलहरा व सलेमपुर ग्रामों के 49 किसानों ने भाग लिया। कार्यक्रम का उदघाटन करते हुए संस्थान के निदेशक डा. नरेन्द्र प्रताप सिंह ने अपने उदबोधन में कृषकों को प्रशिक्षण से अधिकाधिक लाभान्वित होने की सलाह दी और उन्नत उत्पादन तकनीक के प्रयोग पर बल दिया। कार्यक्रम में रबी दलहनी फसलों जैसे चना, मटर व मसूर फसलों की संस्तुत प्रजातियाँ, सस्य प्रबंधन, रोग व कीट प्रबंधन तकनीकी पर किसानों को प्रशिक्षित किया गया। प्रतिभागी किसानों को दलहन प्रसंस्करण तकनीक व मृदा परीक्षण के महत्व पर भी प्रशिक्षित किया गया। कार्यक्रम का समन्वयन डा. उमा साह व डा. पी. आर. साबले ने किया।

हिन्दी दिवस का आयोजन

भारतीय दलहन अनुसंधान संस्थान में दिनाँक 23 सितम्बर, 2015 को हिन्दी दिवस समारोह पूर्वक मनाया गया। प्रतिष्ठित कवि एवं वरिष्ठ पत्रकार डा. सुरेश अवस्थी इस



समारोह के मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक डा. नरेन्द्र प्रताप सिंह ने की। समारोह में संस्थान के सभी वैज्ञानिक, तकनीकी, प्रशासनिक एवं सहायक वर्ग के कर्मचारियों ने भाग लिया। अतिथियों का स्वागत करते हुए डा. सिंह ने कहा कि हिन्दी अपनी सरलता और सहज बोधगम्यता के कारण पूरे देश में समझी और बोली जाती है और राष्ट्रीय सम्पर्क सूत्र की महती भूमिका निभा रही है। उन्होंने कहा कि हिन्दी जीवन के हर क्षेत्र में व्यापक स्तर पर उपयोग की जा रही है। सरकारी कामकाज में भी हिन्दी का प्रयोग निरंतर बढ रहा है। सभी क्षेत्रों में हिन्दी की सफलता का परचम लहरा रहा है। उन्होंने वैज्ञानिकों का आवाहन किया कि नई तकनीकी जानकारी किसानों तक उन्ही की भाषा में पहुँचाने के लिए सतत प्रयास करें और हिन्दी के नये प्रकाशनों पर बल दिया।

अपने उद्‌बोधन में डा. अवस्थी ने कहा कि प्रतिभाओं के मुखर होने में भाषा का प्रबल योगदान होता है। हम अपनी भाषा में अधिक स्पष्ट एवं प्रभावी ढंग से अपने विचार एवं विषय को प्रकट कर सकते हैं। यही हमारी उन्नति का संवाहक होता है। अतः हमें अपनी राजभाषा हिन्दी का अधिक से अधिक प्रयोग करना होगा निजी कार्यों में और सरकारी कामकाज में भी। निदेशक डा. सिंह ने मुख्य अतिथि को शाल पहनाकर एवं स्मृतिचिन्ह भेंट कर सम्मानित किया। इस अवसर पर डा. अवस्थी ने स्वरचित कविता पाठ से संस्थान को भाव–विभोर कर दिया।

श्री दिवाकर उपाध्याय, सचिव, राजभाषा ने संस्थान में राजभाषा की प्रगति आख्या प्रस्तुत की। इस अवसर पर मुख्य अतिथि ने संस्थान की राजभाषा पत्रिका दलहन आलोक 2015 तथा हिन्दी के अन्य नये प्रकाशनों यथा संस्थान का वार्षिक प्रतिवेदन का विमोचन किया।

हिन्दी पखवाड़े में आयोजित विभिन्न प्रतियोगिताओं के विजयी प्रतिभागियों कु. कीर्ति त्रिपाठी, श्रीमती मीनाक्षी वार्ष्णेय, श्री कन्हैया लाल, सुश्री पूर्णिमा के.एन., डा. गोविन्द कान्त श्रीवास्तव, श्रीमती रश्मि यादव, श्रीमती रीता मिश्रा, सर्वश्री राधा कृष्ण, अजीत प्रताप सिंह, गुलाब चन्द्र शर्मा, कैलाश चन्द्र सक्सेना, हृदय नारायण मौर्या, राम बाबू, एवं सुश्री सुषमा सक्सेना तथा कार्यालयीन कामकाज में हिन्दी का उत्कृष्ट प्रयोग करने के लिए कु. कीर्ति त्रिपाठी, श्रीमती रीता मिश्रा, श्रीमती मीनाक्षी वार्ष्णेय, सर्वश्री आलोक कुमार सक्सेना, राजेन्द्र निगम, राजेन्द्र कुमार, गुलाब चन्द्र शर्मा, मो. शब्बीर एवं श्री हरगोविन्द राठौर को मुख्य अतिथि ने पुरस्कार और प्रमाण पत्र प्रदान किए। कार्यक्रम के अन्त में डा. सुशील



कुमार चतुर्वेदी, विभागाध्यक्ष, फसल सुधार ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन श्री दिवाकर उपाध्याय, मुख्य संपादक ने किया।

Personnel

As on 31.3.2016

A. Research Management

1.	Dr. N.P. Singh	Director

B. AICRP on MULLaRP

2.	Dr. Sanjeev Gupta	Project Coordinator

C. AICRP on Pigeonpea

3.	Dr. I.P. Singh	Project Coordinator

D. AICRP on Chickpea

4.	Dr. G.P. Dixit	Project Coordinator

E. AINP-Arid Legumes

5.	Dr. Shiv Sewak	Principal Scientist & Nodal Officer

F. Scientific

Crop Improvement

6.	Dr. S.K. Chaturvedi	Plant Breeding	Head of the Division
7.	Dr. P.K. Katiyar	Plant Breeding	Principal Scientist
8.	Dr. Farindra Singh	Plant Breeding	Principal Scientist
9.	Dr. Aditya Pratap	Plant Breeding	Senior Scientist
10.	Dr. Jitendra Kumar	Plant Breeding	Senior Scientist
11.	Dr. A.K. Srivastav	Plant Breeding	Scientist (Senior Scale)
12.	Mr. Udai Chand Jha	Plant Breeding	Scientist
13.	Mr. Debjyoti Sen Gupta	Plant Breeding	Scientist
14.	Mr. Abhishek Bohra	Plant Breeding	Scientist
15.	Dr. Ashok Kumar Parihar	Plant Breeding	Scientist
16.	Mr. Biswajit Mondal	Plant Breeding	Scientist
17.	Mr. Amrit Lamichaney	Seed Science & Technology	Scientist
18.	Dr. Satish Niak S.J.	Genetics & Plant Breeding	Scientist
19.	Dr. Basavaraja T.	Genetics & Plant Breeding	Scientist

Plant Biotechnology

20.	Dr. N.P. Singh	Biotechnology	Head of the Division (Acting)
21.	Mr. Prakash G. Patil	Biotechnology	Scientist
22.	Dr. Khela Ram Soren	Biotechnology	Scientist (Senior Scale)
23.	Dr. Alok Das	Biotechnology	Scientist (Senior Scale)
24.	Ms. K.N. Purnima	Biotechnology	Scientist
25.	Mr. P.S. Shanmugavadivel	Biotechnology	Scientist
26.	Mr. Arvind Kumar Konda	Biochemistry	Scientist
27.	Dr. Neetu Singh Kushwah	Biotechnology	Scientist

Crop Production

28.	Dr. S.S. Singh	Agronomy	Head of the Division
29.	Dr. C.S. Praharaj	Agronomy	Principal Scientist
30.	Dr. Narendra Kumar	Agronomy	Senior Scientist
31.	Dr. Ummed Singh	Agronomy	Senior Scientist
32.	Mr. Kali Krishna Hajara	Agronomy	Scientist
33.	Mr. Chaitanya Prasad Nath	Agronomy	Scientist

Crop Protection

34.	Dr. Krishna Kumar	Plant Pathology	Head of the Division
35.	Dr. (Mrs.) Hem Saxena	Entomology	Principal Scientist (Upto 31.8.2015)
36.	Dr. Bansa Singh	Nematology	Principal Scientist
37.	Dr. Shiva Kant Singh	Entomology	Principal Scientist
38.	Dr. Mohd. Akram	Plant Pathology	Senior Scientist
39.	Dr. Naimuddin	Plant Pathology	Senior Scientist
40.	Dr. R.K. Mishra	Plant Pathology	Senior Scientist
41.	Dr. R. Jagdeeswaran	Nematology	Scientist
42.	Mr. P.R. Saabale	Plant Pathology	Scientist
43.	Dr. G.K. Sujayanand	Entomology	Scientist
44.	Mr. Bandi Sanjay Maruti	Entomology	Scientist
45.	Mr. Devindrappa	Nematology	Scientist
46.	Dr. Manjunatha L.	Plant Pathology	Scientist
47.	Mr. Kiran Gandhi Bopatla	Entomology	Scientist

Basic Science

48.	Dr. Jagdish Singh	Plant Physiology	Head of the Division
49.	Dr. Mohan Singh	Microbiology	Principal Scientist
50.	Dr. R.P. Srivastava	Biochemistry	Principal Scientist (Upto 31.8.2015)
51.	Dr. P.S. Basu	Plant Physiology	Principal Scientist
52.	Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
53.	Dr. Lalit Kumar	Agril. Chemistry	Senior Scientist
54.	Dr. M. Senthilkumar	Microbiology	Senior Scientist
55.	Dr. S. Paul Raj	Microbiology	Scientist (Senior Scale) (Upto 21.12.2015)
56.	Mr. Alagupalamuthir Solai	Plant Physiology	Scientist (Upto 12.6.2015)
57.	Mr. Nand Lal Meena	Biochemistry	Scientist
58.	Mr. S. Gurumurthi	Plant Physiology	Scientist
59.	Mr. Surendra Kumar Meena	Biochemistry	Scientist
60.	Mr. Dhyaneshwar Namdeo Borase	Microbiology	Scientist

Social Science

61.	Dr. S.K. Singh	Agril. Extension	Principal Scientist & Acting Head (Upto 2.2.2016)
62.	Dr. Rajesh Kumar	Agril. Extension	Principal Scientist & Acting Head
63.	Dr. (Mrs.) Uma Sah	Agril. Extension	Senior Scientist
64.	Dr. Purushottam	Agril. Extension	Senior Scientist
65.	Mr. Devraj	Computer Application	Senior Scientist
66.	Mr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)
67.	Mr. Deepak Singh	Agril. Statistics	Scientist (Upto 2.1.2016)
68.	Mr. Shripad Bhat	Agril. Economics	Scientist (On study leave)
69.	Mr. K. Ravi Kumar	Agril. Extension	Scientist

G. Regional Centre-cum Off-Season Nursery, Dharwad (Karnataka)

70.	Dr. M.S. Venkatesh	Soil Science	Principal Scientist & Station In-charge
71.	Dr. Revanappa	Plant Breeding	Scientist

H. Regional Station, Bhopal (Madhya Pradesh)

72.	Dr. Dibendu Datta	Plant Breeding	Principal Scientist
73.	Dr. K.K. Singh	Agronomy	Principal Scientist (Upto 5.5.2015)
74.	Dr. (Mrs.) Archana Singh	Eco. Botany & PGR	Senior Scientist
75.	Dr. D.N. Gawande	Plant Breeding	Scientist
76.	Dr. Ram Lal Jat	Agronomy	Scientist

I. Technical

77.	Mr. Diwakar Upadhyaya	Chief Editor (T-9)
78.	Mr. D.N. Awasthi	Chief Architect (T-9)
79.	Dr. T.N. Tiwari	Chief Technical Officer (T-9)
80.	Mr. D.K. Sharma	Chief Technical Officer (T-9)
81.	Mr. Desh Raj	Chief Technical Officer (T-9)
82.	Dr. M.P. Singh	Chief Technical Officer (T-9)
83.	Dr. Ved Ram	Chief Technical Officer (T-9) (Upto 30.6.2015)
84.	Mr. S.P.S. Chauhan	Chief Technical Officer (T-9)
85.	Mr. R.S. Mathur	Assistant Chief Technical Officer (T-7/8)
86.	Dr. G.K. Srivastava	Assistant Chief Technical Officer (T-7/8)
87.	Dr. Omkar Nath	Assistant Chief Technical Officer (T-7/8)
88.	Mr. Radha Krishan	Assistant Chief Technical Officer (T-7/8)
89.	Mr. Vijendra Singh	Asstt. Chief Technical Officer (T-7/8) (Upto 29.2.2016)
90.	Mr. A.B. Singh	Assistant Chief Technical Officer (T-7/8)
91.	Dr. Aditya Prakash	Assistant Chief Technical Officer (T-7/8)
92.	Mr. S.K. Garg	Assistant Chief Technical Officer (T-7/8)
93.	Mr. Ramesh Chandra	Assistant Chief Technical Officer (T-7/8)
94.	Mr. Ved Prakash	Asstt. Chief Technical Officer (T-7/8)

95.	Mr. A.P. Singh	Senior Technical Officer (T-6)
96.	Mrs. Rashmi Yadav	Senior Technical Officer (T-6)
97.	Mr. G. S. Pandey	Senior Technical Officer (T-6) (Upto 22.4.2015)
98.	Dr. Ranjan Kumar Srivastav	Senior Technical Officer (Upto 7.11.2015)
99.	Mr. Rajendra Prasad	Senior Technical Officer (T-6)
100.	Dr. R.K. Srivastava	Senior Technical Officer (T-6)
101.	Mr. R.K.S. Yadav	Technical Officer (T-5)
102.	Mr. Krishna Autar	Technical Officer (T-5)
103.	Mr. Kailash Chandra	Technical Officer (T-5)
104.	Mr. S.K. Dwivedi	Technical Officer (T-5) (Upto 30.9.2015)
105.	Mr. Lakhan	Technical Officer (T-5)
106.	Mr. R.K. Singh	Technical Officer (T-5)
107.	Mr. Rakesh	Technical Officer (T-5)
108.	Mr. Malkhan Singh	Technical Officer (T-5)
109.	Mr. Ashraf Khan	Technical Officer (T-5)
110.	Mr. Arvind Singh Yadav	Technical Officer (T-5)
111.	Mr. R.M. Pal	Technical Officer (T-5)

J. Administrative

112.	Mr. K.N. Gupta	Finance & Accounts Officer (Upto 31.10.2015)
113.	Mr. Panchoo Lal	Administrative Officer
114.	Mrs. A. Abraham	Assistant Administrative Officer (Upto 30.11.2015)
115.	Mr. Shukdeo Mehto	Assistant Administrative Officer
116.	Mr. Rajeev Nigam	Asstt. Administrative Officer
117.	Mr. B.K.Verma	P.S. to Director

Appointment, Transfer, Promotion, etc.

Appointments

Name	Post	Discipline	Date of joining
Mr. Bandi Sanjay Maruti	Scientist	Entomology	10.4.2015
Dr. Satish Niak S.J.	Scientist	Genetics & Plant Breeding	10.4.2015
Mr. Devindrappa	Scientist	Nematology	10.4.2015
Dr. Manjunatha L.	Scientist	Plant Pathology	10.4.2015
Mr. Ram Lal Jat	Scientist	Agronomy	10.4.2015
Dr. Basavaraja T.	Scientist	Genetics & Plant Breeding	10.4.2015
Mr. Chaitanya Prasad Nath	Agronomy	Scientist	9.10.2015
Mr. Kiran Gandhi Bopatla	Scientist	Entomology	9.10.2015
Mr. K. Ravi Kumar	Scientist	Agril. Extension	9.10.2015
Dr. Krishna Kumar	Head, Division of Crop Protection	Plant Pathology	1.1.2016

Transfers

Name	Designation	From	To	W.e.f.
Dr. K.K. Singh	Principal Scientist	ICAR-IIPR, Kanpur	ICAR-IISR, Lucknow	5.5.2015
Mr. Alagupalamuthir Solai	Scientist	ICAR-IIPR, Kanpur	ICAR-IISR, Calicut	12.6.2015
Dr. Ranjan Kumar Srivastav	Sr. Technical Officer	ICAR-IIVR, Varanasi	ICAR-IIPR, Kanpur	14.7.2015
Dr. S. Paulraj	Scientist	ICAR—IIPR, Kanpur	ICAR-CPCRI, Kasaragod	21.12.2015
Dr. Neetu Singh Kushwah	Scientist	ICAR—NRC on Litchi, Muzaffarpur	ICAR—IIPR, Kanpur	26.12.2015
Mr. Deepak Singh	Scientist	ICAR-IIPR, Kanpur	IASRI, New Delhi	2.1.2016

Dr. S.K. Singh, Principal Scientist and Acting Head, Division of Social Science was relieved on February 2, 2016 to join as Director, Agriculture Technology Application Research Institute (ATARI), Jodhpur (Rajasthan).

Promotions

Name	Promoted to	W.e.f.
Dr. M. Senthil Kumar	Sr. Scientist	3.1.2014
Dr. Rajesh Kumar Srivastava	Sr. Technical Officer (T-6)	23.6.2015
Mr. Rajendra Prasad	Sr. Technical Officer (T-6)	1.1.2015
Mr. Rajeev Nigam	Asstt. Administrativ Officer	3.3.2016
Dr. M.P. Singh	Chief Technical Officer	1.7.2015
Dr. Ved Ram	Chief Technical Officer	1.7.2015
Mr. S.P.S. Chauhan	Chief Technical Officer	15.4.2014
Mr. Ved Prakash	Asstt. Chief Technical Officer	27.8.2015

Retirement

Name	Post held	Date of retirement
Mr. Raghubansi Singh	Technical Assistant (T-2)	30.5.2015
Mr. Prahalad	Technical Assistant (T-2)	30.6.2015
Mr. Ved Ram	Asstt. Chief Technical Officer	30.6.2015
Dr. (Smt.) Hem Saxena	Principal Scientist	31.8.2015
Dr. R.P. Srivastav	Principal Scientist	31.8.2015
Mr. Deo Mani Pandey	Technical Assistant	30.9.2015
Mr. K.N. Gupta	Sr. Finance & Accounts Officer	31.10.2015
Mr. S.K. Dwivedi	Technical Officer	31.10.2015
Mrs. A. Abraham	Asstt. Administrative Officer	30.11.2015
Mr. Vijendra Singh	Asstt. Chief Technical Officer	29.2.2016

Obituary

Mr. Ganesh Shankar Pandey, Sr. Technical Officer, left for his heavenly abode on 22.4.2015. May his soul Rest in Peace.

Mr. Ranjan Kumar Srivastav, Sr. Technical Officer, left for his heavenly abode on 7.11.2015. May his soul Rest in Peace.



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