भाकृअनुप
ICAR

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

वार्षिक प्रतिवेदन
Annual Report
2012 - 13

भारतीय दलहन अनुसंधान संस्थान
कानपुर 208 024

Indian Institute of Pulses Research
Kanpur 208 024

With best compliments from

Dr. N. Nadarajan
Director

Indian Institute of Pulses Research
Kanpur 208 024

वार्षिक प्रतिवेदन
Annual Report
2012 - 13

भाकृअनुप
ICAR

भारतीय दलहन अनुसंधान संस्थान
कानपुर 208 024

Indian Institute of Pulses Research
Kanpur 208 024

Published by	:	Dr. N. Nadarajan, Director Indian Institute of Pulses Research, Kanpur
Editing, layout & designing and proof reading	:	Mr. Diwakar Upadhyaya
Photography	:	Mr. Rajendra Prasad and Mr. Ved Prakash
Graphics	:	Mr. D.K. Sharma
Publication Committee	:	Dr. N. Nadarajan, Chairman Dr. P.S. Basu Dr. M.S. Venkatesh Dr. Jitendra Kumar Dr. Naimuddin Mr. Diwakar Upadhyaya, Member Secretary
Correct citation	:	Annual Report 2012-13 Indian Institute of Pulses Research, Kanpur

Printed at : Army Printing Press, 33 Nehru Road, Sadar Cantt. Lucknow-226 002, Tel : 0522-2481164

Preface

It gives me immense pleasure to present the Annual Report of IIPR for the year 2012-13 which highlights the significant achievements made by the scientists and staff of this Institute. This year again, the pulses production has crossed a benchmark of 18 million tonnes in the country, witnessing an impressive production figure for the 3rd consecutive year. In fact, in comparison to previous year's production figures among all food grains, an increase has been witnessed only in pulse crops. This has been possible due to the sincere efforts of researchers, developmental agencies, availability of quality seeds, a favourable weather and strong policy support.

The Institute made great strides in basic and applied research, and generation and transfer of improved technologies during the period. Concerted efforts of scientists have resulted in development of lentil variety IPL 316 for central zone, pigeonpea variety IPA 203 and early maturing pigeonpea hybrid IPH 09-5 for North-East plain zone and fieldpea variety IPFD 6-3 for Uttar Pradesh. Under the ambit of All India coordinated research projects, five chickpea and three pigeonpea varieties were identified for different agro-ecological zones. More than 11141 q breeder seed of 90 varieties of chickpea, 781.60 q of pigeonpea, 1381.20 q of mungbean (61 varieties), 1030.65 q of urdbean (45 varieties), 717.77 q of lentil (38 varieties) and 959.34 q of fieldpea (27 varieties) was produced, which will ensure availability of quality seed of pulses in the country. Among these, IIPR shared 560 q seed of 20 varieties.

Pulses genotypes developed by IIPR are also doing well in AICRP trials and a number of them *viz*., IPCK 2006-78 in chickpea, IPM 306-6 and IPM 2K 15-4 in mungbean, IPU 09-16 in urdbean and IPL 220, IPL 221 and IPL 325 in lentil have been promoted in advanced breeding trials. For ameliorating the efforts of breeding stable genotypes in mungbean and urdbean which can perform equally well across seasons and locations, two photo-thermo insensitive *Vigna* accessions, one each of *V. glabrescens* (IC 251372) and *V. umbellata* (IC 251442) have been identified for their use in breeding programmes.

Realizing the importance of wild accessions in broadening the genetic base of pulses, pre-breeding efforts have been initiated on a large scale. A wild garden of pulses has been established and 126 wild accessions of chickpea, 72 of lentil and 54 of *Vigna* were maintained during 2012-13. Besides this, 709 germplasm lines, 120 exotic germplasm lines and 165 exotic land races of chickpea, 746 germplasm lines of late pigeonpea, 250 of early pigeonpea, 494 of lentil, 369 of mungbean, 300 of urdbean and 450 of fieldpea were also maintained. Keeping in view the adverse effect of climate change on *rabi* and *kharif* pulses, breeding for climate resilient pulse varieties has been taken up in all major pulse crops through externally funded projects in network mode, which has started yielding dividends in the form of identification of heat and drought tolerant genotypes.

Institute scientists are giving due priority to the use of molecular marker technology and besides mapping and tagging of *Fusarium* wilt resistant genes in chickpea and pigeonpea, marker assisted breeding for this important disease has been taken up. Commendable progress has been made towards development of transgenics against *Helicoverpa armigera* in chickpea and pigeonpea. For disease diagnostics, simplex PCR-based protocols for detection of four viruses (MYMIV, MYMV, HgYMV and GBNV) have been standardized.

In long term experiments, maize-wheat-mungbean and rice-wheat-mungbean systems promised highest system productivity, thereby highlighting the importance of incorporating pulses in cereal-based cropping systems. In different soil moisture conservation practices, highest chickpea yield was recorded in zero tillage dibbling and mulching. Pre-emergence application of pendimethalin and one manual weeding gave highest yield in *kharif* mungbean, while post-emergence application of imazethapyr recorded highest yield in summer mungbean. In chickpea, pendimethalin and quizalofop ethyl combination was found best to control weeds. IIPR has also developed a manual zero till seed drill for sowing of pulses, especially in rice-fallow vertisols condition of southern India. To boost resistance breeding programme in different pulses, a number of resistant donors were also identified.

Besides development of new varieties and technologies, extensive efforts have also been put for effective dissemination of these technologies to farmers. Under TSP, more than 900 on-farm demonstrations were laid in Chhattisgarh, Uttar Pradesh and Madhya Pradesh, while two model training courses were organized at IIPR for extension workers of different states of the country. More than 1500 farmers were benefitted from farmers' trainings and exposure visits.

Institute has developed strong partnership with several national and international institutes including ICRISAT, ICARDA, DBT, DST, DAC, Indo-US AKI, Bill and Melinda Gates Foundation-Generation Challenge Programme (GCP), SAUs and other ICAR institutes and these were further strengthened in the form of successful implementation of collaborative research projects. The year also witnessed the publishing of draft genome sequence of chickpea by the collaborative efforts of 49 scientists of 10 different countries including IIPR, which has added tremendous genomic resources to pulses and will open up new avenues of genomics-based improvement of not only chickpea but also the associated food legumes.

For furthering academic pursuits, post-graduate programmes and PG attachment trainings have been expanded with MoUs signed with different universities/institutes. For human resource development a number of scientists were deputed for foreign visits as well as national and international trainings and conferences. Five new scientists joined the Institute, 4 senior scientists were promoted as principal scientists, while two Heads of Divisions were selected as Directors of ICAR institutes. The infrastructure development has also been noticeable with the coming up of training and communication centre for farmers, state-of-art laboratories, cold module for medium term storage and a modern administrative set up. The research facilities also got strengthened in the form of establishment of a new Regional Station at Bhopal in M.P., while the Regional Station *cum* Off-Season Nursery at Dharwad, Karnataka started functioning. Both these stations will prove to be a milestone in expansion of research and extension activities of IIPR, fulfill the needs of quality seed production on a large scale and will cater the research needs of pulse growing farmers of central India.

The Institute has identified major issues for R&D in the XII plan based on the recommendations of the Research Advisory Committee as well as QRT, and major thrust areas have been shortlisted including genomics, transgenics, molecular marker assisted breeding, development of hybrids in pigeonpea, climate resilient pulse varieties, resource conservation technologies, quality improvement, *etc.* I am sure that with the dedicated research efforts of the scientists and an active support from the Council, we will be able to achieve the pulse production targets as envisaged in our vision documents.

The all round growth and development of the Institute has been possible with an active involvement, able guidance and constant encouragement received from Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and Dr. Swapan Kumar Datta, Deputy Director General (Crop Science), ICAR, which I acknowledge with great respect and gratitude. I am also highly thankful to Dr. B.B. Singh, ADG (O&P), ICAR for his never ending scientific and administrative involvement, inspiration and guidance for overall growth of the Institute.

I would also like to place on records my appreciation to Drs. N.P. Singh, Sanjeev Gupta, S.K. Chaturvedi, Jagdish Singh, R.G. Chaudhary, S.K. Singh and Subhojit Datta in compiling the reports of their respective Divisions/unit. I am also highly thankful to the members of the publication committee- Drs. P.S. Basu, M.S. Venkatesh, Jitendra Kumar, Naimuddin and Editor Shri Diwakar Upadhyaya for their sincere efforts in bringing out this report in time.

(N. Nadarajan)
Director

Contents

Executive Summary

Crop Improvement

- Large seeded lentil variety IPL 316 has been released and notified for cultivation in Madhya Pradesh, Chhattisgarh, Bundelkhand region of Uttar Pradesh and parts of Rajasthan.
- Long duration pigeonpea variety IPA 203 has been identified for cultivation in eastern Uttar Pradesh, Bihar, Jharkhand, Orissa and West Bengal. Dwarf fieldpea variety IPFD 6-3 has been identified for cultivation in Uttar Pradesh.
- First early maturing pigeonpea hybrid IPH 09-5 has been identified for cultivation in eastern Uttar Pradesh, Bihar, Jharkhand, Orissa and West Bengal with distinct yield superiority over best variety UPAS 120.
- Accessions of *V. glabrescens* (IC 251372) and *V. umbellata* (IC 251442) were identified for photo-thermo-insensitivity after three years evaluation in field and controlled conditions.
- In AICRP trials, a number of genotypes have performed well and IPCK 2006-78 in chickpea, IPM 306-6 and IPM 2K 15-4 in mungbean, IPU 09-16 in urdbean and IPL 220, IPL 221 and IPL 325 in lentil have been promoted in advanced breeding trials.
- Total 709 germplasm lines of chickpea, 746 of late pigeonpea, 250 of early pigeonpea, 494 of lentil, 369 of mungbean, 300 of urdbean and 450 of fieldpea were evaluated and characterized for qualitative and quantitative traits. Besides, 120 exotic germplasm lines, 165 exotic land races and 126 wild accessions of different *Cicer* sps. in chickpea, 72 wild accessions and 118 exotic land races in lentil and 54 wild accessions of *Vigna* were also maintained.
- Mapping populations for seed size and earliness in lentil and wilt resistance and earliness in pigeonpea were maintained and advanced to next generation.
- IPC 2006-27, IPC 2006-11, IPC 2006-14, IPC 2008-02 and IPC 2006-142 were identified for mechanical harvesting. IPC 2008-57 was found cold tolerant and ICC 1164, ICC 1164, IPC 2010-81 and IPC 2008-59 were found tolerant to post-emergence herbicide, Imazethapyr.
- Screening for resistance/tolerance to biotic stresses resulted in identification of 16 *kabuli* and 19 *desi* chickpea lines resistant to wilt. Genotype IPC 2005-52 exhibited multi-race resistance against *Fusarium oxysporum* f.sp. *ciceri*. Multi-location evaluation under AICRP resulted in identification of 10 and 2 genotypes resistant against wilt and dry root rot, respectively.
- In multi-location/years testing for abiotic stresses, chickpea genotypes IPC 98-12 and IPC 97-72 showed tolerance to heat and drought, respectively.
- Total 560 q breeder seed of three varieties each of chickpea (DCP 92-3, Shubhra and Ujjawal) and pigeonpea (Bahar, NDA 1, UPAS 120), four varieties each of lentil (DPL 62, DPL 15, IPL 81 and IPL 406), fieldpea (Adarsh, Prakash, Vikas and Aman) and mungbean (Samrat, Meha, IPM 02-3 and IPM 2-14) and two varieties of urdbean (Uttara and IPU 2-43) was produced. Nucleus seed of these varieties has also been produced for production of breeder seed in 2013-14.
- Fifty nine SSR markers were screened on a set of 60 genotypes of mungbean. Seven SSR markers showed polymorphism between A and R lines of pigeonpea. Markers for testing of hybridity in IPH 09-5 have been identified.
- Interspecific crosses between cultivated and wild species involving *C. reticulatum* and *C. echinospermum* in chickpea and *Lens orientalis* and *L. odemensis* in lentil were attempted to generate variability. Variability for days to 50% flowering and pods/plant and 100 seed weight was observed in segregating population derived from interspecific crosses in lentil.
- Lentil genotype IG 4258 was validated for heat tolerance under late sown condition.
- Molecular characterization of 21 selected genotypes with 43 SSR marker and five phenotypic traits revealed diversification of Indigenous gene pool of lentil.
- Large genetic variations for yield attributes were recorded in chickpea and accession EC 600098 belonging to *Cicer cuneatum* was found possessing 5-6 seeds per pod.
- Three wild *Cicer* accessions were identified

as heat tolerant on the basis of membrane stability index and setting of seeds at higher temperature. Seven fresh crosses to incorporate heat tolerance were made and out of 115 genotypes, 23 exhibited heat tolerance in preliminary screening in chickpea.

- Chickpea accessions *viz*., ICC 7118, ICC 7102, ICC 4958, JGK 2, JG 14 (ICCV 92944), ICC 7117, JG 130, NBeG 3 and Vaibhav showed tolerance against heat under field conditions.
- Multi-year evaluation of pigeonpea genotype IPAC 79 showed tolerance to water logging. Highest plant survival rate after water logging was observed in ICP 5028 (88.10%) and LRG 30 (85%) in this year.
- Ten genotypes *viz*., BDN 2008-1, Bennur Local, ICP 1156, BDN 2008-12, TJT 501, GRG 2009, ICP 995, ICP 4575, ICP 1126, JKM 7, JKM 189 and ICP 14832 showed superiority at pod filling stage under rainfed condition.
- Urdbean genotype PGRU 95016 was identified as photo-thermo-insensitive and thermo-tolerant. Multi-location evaluation confirmed 12 genotypes of mungbean tolerant to heat and drought.
- Forty SSR markers showed polymorphism among 58 accessions of wild species in *Vigna* sps.

Crop Production

- Highest system productivity of 3411 kg/ha in terms of pigeonpea equivalent was recorded in maize-wheat-mungbean system and the trend was MWMb>PW>MWMC>MW. Under rice based system, highest system productivity of 5140 kg/ha in terms of chickpea equivalent was recorded in rice-wheat-mungbean system and the trend was RWMb>RC>RWRC>RW. Inclusion of pulses in the cereal-cereal system and integrated nutrient management system sequestered more SOC and maintained better soil health in Inceptisols.
- There was 12, 26 and 7 per cent increase in grain yield of maize due to application of 60 kg P_2O_5, 5 t FYM and 30 kg S/ha respectively, as compared to their respective control treatments.
- Better response of rajmash was observed with application of secondary (S) and micronutrient (Zn) in presence of organic manure in Inceptisols.
- Yield of summer mungbean in rice-chickpea-mungbean system was higher in residue incorporation (13%) and zero tillage (7%) in comparison to no-residue (1528 kg/ha) and conventional tillage (1481 kg/ha), respectively. Highest system productivity in terms of chickpea equivalent was obtained in rice-wheat-mungbean (6546 kg/ha), followed by rice-wheat (4424 kg/ha) and lowest in rice-chickpea (4291 kg/ha).
- Appreciable quantity of fenugreek (556 kg/ha) and spinach (1829 kg/ha) were harvested green at 38-40 days after sowing as intercrop in furrows with raised bed chickpea, which resulted in higher system productivity and return.
- In different soil moisture conservation practices, highest chickpea yield was recorded under zero tillage dibbling+mulching, followed by zero till drill+mulching and lowest under conventional sowing method.
- Highest pearlmillet equivalent yield (3612 kg/ha) was recorded with pearlmillet intercropped with greengram, followed by pearlmillet+cowpea (3227 kg/ha) and least under perlmillet sole (2635 kg/ha).
- Among moisture conservation practices, highest relative water content (62.15%) in chickpea was observed in mulch+one irrigation being at par with mulch+two irrigations, followed by mulch (56.17%).
- Highest yield of *kharif* mungbean (919 kg/ha) was recorded with pre-emergence application of pendimethalin @ 1.25 kg/ha+manual weeding, which was closely followed by pendimethalin @ 1.25 kg/ha+imazethapyr @ 100 and 80 g/ha. Lowest yield of mungbean was recorded in pendimethalin @ 1.25 kg/ha (348 kg/ha). In summer mungbean, maximum yield was recorded in post-emergence application of imazethapyr @ 80 g/ha (1017 kg/ha). Post-emergence application of imazethapyr @ 80 and 100 g/ha and weed free recorded at par grain yield and significantly higher over rest of treatments.
- In chickpea, highest yield was recorded in pendimethalin @ 1.25 kg/ha+quizalofop-ethyl

@ 125 g/ha (1360 kg/ha), which was at par with pendimethalin @ 1.25 kg/ha+ manual weeding (1331 kg/ha) and pendimethalin @ 1.25 kg/ha+quizalofop-ethyl @ 150 g/ha (1289 kg/ha). The results of 2 years study suggest that pendimethalin @ 1.25 kg/ha (PE)+quizalofop-ethyl @ 125 g/ha may be recommended for effective control of weeds in chickpea.

- Drip-fertigation at both the critical stages (branching and pod development) out-yielded the furrow irrigation due to alleviation of water stress observed during late branching (end Sept.) and pod development (end Feb.) stages. Economics of irrigation schedules favoured for higher (INR 9650) net monetary returns under drip-fertigation at both these stages.
- Lower water use, greater profile soil moisture availability and water use efficiency (65.1 kg/ha-cm) and higher plant nutrient uptake (263, 52, 114, 71.2 kg NPKS and 281 g Zn/ha) with improved soil nutrient and water availability were conspicuous with drip-fertigated plots.
- Study on efficient utilization of water and nutrients through drip-irrigation and pigeonpea based intercropping revealed that mean seed yields to the tune of 4.3 and 20.7 q/ha (50% area basis) were realized with urdbean and sorghum intercropping (50% area basis) respectively in addition to normal seed yield of pigeonpea.
- Polyethylene raised transplanted pigeonpea seedlings performed well under both ridge planting and 3 weeks after transplanting (of polythene bag raised seedling) in comparison to flat plating and other transplanting schedules. Based on biometrics and other attributes, it was revealed that partial replacement to the extent of 10 % was feasible and most economical in comparison to sole transplanting.
- In rice-pulse relay cropping system, high tillering and longer duration (160 days) variety, CR 1009 conserved more soil moisture as compared to medium tillering as well as duration (135 days) variety ADT 49. Similar results were also recorded in Inceptisols in rice-lentil relay cropping. The stubble cutting height of 30 cm across the rice habit groups conserved significantly more soil moisture than 15 cm cutting height in the surface (0-10 cm) layer.
- Soil moisture conservation practices (mulch and stubbles) and improved management practices (NPK+FYM) maintained higher soil moisture during critical crop growth stages of chickpea and lentil under rice-fallow. Initial soil moisture of surface layer at chickpea sowing was 19-22%, which receded to 14-16% in first 15 days, however, the rice straw mulch maintained 2-3% higher soil moisture over no-mulch.
- Higher SMBC (642.2 g/kg of soil), dehydrogenase activity (26.25 µg of TPF/g) and free living diazotrophs (62 x 10^4 cfu/g soil) were recorded in mulch as compared to no-mulch. Improved practice (NPK+FYM) also recorded higher values of these parameters including putative free living diazotrophs.
- IIPR has developed a manual zero-till (ZT) seed-drill for sowing of pulses especially in rice-fallow Vertisols condition of southern India. ZT seed-drill was successfully used at TRRI, Aduthurai for sowing of urdbean in rice fallow.

Crop Protection

- Total 919 chickpea accessions were screened against *Fusarium oxysporum f.* sp *ciceri* (race 2) in wilt sick plot. Disease development was very high with 100% mortality in susceptible check (cv. JG 62).
- Out of 15 wilt resistant chickpea donors, JG 315 and MPJG 89-9023 were found resistant, while JG 74, BG 212, H 82-2, GPF 2, IPC, BCP 19 and DCP 92-3 were moderately resistant.
- Among 26 chickpea accessions with stable resistance, 13 *viz*., IPC 2004-34, IPC 2005-18, -19, -24, -26, -35, -41(A), -41(B), -45, -46, -52, -64 and JG 315 showed stable resistant reaction for last 7 years. Seven lines *viz*., IPC 2004-3, -8, IPC 2005-15, -37, -44, -54 and -59 were found moderately resistant.
- Among 71 promising lines, 17 *viz*., GLK 20127, -26171, IPC 187, L 550, CSJK 46, IPC 2007-04, -36, -50, -51, IPC 2010-78, -113, -128, -215, H 06-15, BG 212, -2085, KGD 1253 and P 1-R were found resistant, besides 28 showed resistant reaction for last 2 years.

- Among 213 AICRP chickpea entries, 49 *viz*., P 14, -35, -37, -38, -46, -49, -59, -61,-66, -68, -69, -71, -72, -82, -91, -109, -110, -114, -120, -123, -131,-134, -147, -148, -150, -163, -173, -185, -188, W-2, -5, -6, -7, -8, -11, -16, -18, -22, -23, -24, -25, -26, - 34, -36, -41, -42, -49, and -52 were found resistant
- Total 41 chickpea lines were screened against 6 races of *F. oxysporum* f. sp. *ciceri* under artificial inoculated sick tank condition. Eight IPC lines *viz*., 2004-34, 2005-18, -19, -30, -34, -52, -68 and 2007-4 were found resistant to race 1 and lines *viz*., IPC 2005-30, -34, -59, GNG-1861, IPC 2007-8, -68 were resistant to race 2. Only IPC 2007-4 was resistant to race 3. For race 4, only IPC 2005-52 was resistant. Three IPC lines *viz*., 2005-15, -19, and -41(A) were resistant to race 5. Against race 6, IPC lines *viz*., 2004-3, -8, -52, 2005-18, -19, -26, -30, -34, -35, -41(B), -52, -64, 2007-4 and GNG 1861 were found resistant.
- From the nine treatments used for management of viral diseases (yellow mosaic and leaf curl) of mungbean, foliar spray of 50% chlorpyrifos+5% cypermethrin @ 0.1% at 15 and 45 days after sowing was found best in significantly enhancing the yield.
- In combined seed treatment of *Trichoderma* (10 g/kg) and metalaxyl (6 g/kg) with spray of aqueous garlic bulb extract (2% w/v) at 25 DAS, Phytophthora blight incidence was least and provided significantly higher seed yield.
- Seven new generation insecticides along with NPV and *Beauveria bassiana* were evaluated against *H. armigera* in *kabuli* chickpea. Flubendiamide was found best in reducing the pod damage and recorded maximum yield (2059 kg/ha).
- The yield and thrips infestation relationship with respect to thrips incidence was calculated to be $y = 1496 - 16.8x$ *i.e.,* for unit thrips incidence, yield loss of mungbean to the tune of 16.8 kg occurred.
- Pigeonpea genotypes *viz*., ICP 7542, PDA 92-2E, PDA 93-1E, ICPL 129880(B), ICP 88022-1, PDA 92-3, KWR 92-02, DA 11, MA 2, NDA 99-7 and MA 2 were found to possess moderate resistance (PSR value 3-5) against podfly.
- Among eight insecticides/ biorational *viz.,* Neem oil, Spinosad, Indoxacarb, imidacloprid, fenvalerate, Bollcure crude, Bollcure formulated and garlic bulb extract tested in late maturing pigeonpea, Spinosad @ 75 g a.i. / ha, first spray at grain filling stage of pods and second spray at full grain stage was found best in podfly suppression as well as in enhancing the grain yield.
- Based on the equation developed to forecast the outbreak of podfly, *M.obtusa***,** the sum of Max temp, if increases more (from non-epizootic years) from 47th SMW to 4th SMW associated with corresponding period increase evening Rh, it invites outbreak situation, causing damage above ETL (4.8 maggot/100 pods from 10 randomly selected plants) in standing crop of late maturing varieties of pigeonpea.
- Three pigeonpea genotypes *viz*., IPA 1, IPA 8 and IPA 12 and three mungbean lines EC 304793, BDYR 2 and VL 112 showed resistance against *Meloidogyne javanica* in the preliminary screening.
- Four urdbean genotypes *viz*., Mash 114, DPU 88-31, Khairagarh Agra and AKU 15, three chickpea genotypes *viz*., ICC 15164, ICC 14287 and ICC 16031, six lines of lentil *viz*., PL 122, NDL 11-1, LL 1203, HUL 57, LL 1114 and VL 521 and two line of fieldpea *viz*., HUDP 963 and Pant P 161 were observed as resistant against root knot nematode, *M. javanica*.
- Distribution pattern of *F.oxysporum* f.sp. *ciceri* races indicated that Uttar Pradesh and Rajasthan have presence of 5 races. Race 3 showed highest frequency with its presence in all the states.
- Genetic diversity among 59 Indian isolates of *Fusarium oxysporum* f. sp. *cieri* from 12 chickpea growing states was studied with 80 SRAP and SRAP-RGA primer pairs. Among them only 15 (4 from SRAP-SRAP and 11 from SRAP-RGA primer combinations) showed good amplification. UPGMA cluster analysis showed all isolates aligned into two main clusters at a similarity index value of 0.22.
- In UPGMA cluster analysis, three dendrograms derived from ITS, EF-1 alpha and combined analysis revealed three identical DNA profiles present in all five groups of isolates.
- Specific primers for identification of *Fusarium oxysporum* f. sp. *ciceri* race-2 and variant 1 of

F. udum have been developed and validated.

- Twenty four donors *viz*., ICP 8858, -8859, -8862,-8863, -89048, -89049, -9174, -3012, BWR 377, AWR 74/15, BDN 1, Banda Palera, GPS 33, BSMR 736, -853, KPBR 80-2-1, PI 397430sel., PDE 92-2E, KPL 43, -44, -49, IPA 38 A, -38B and IPA 40 showed resistant reaction against wilt in sick field. Out of 200 germplasm lines, only ICP 3993, PH 1059, PH 4713 and VKG 28171 were found resistant. Another 12 pigeonpea lines *viz*. ICPL nos. 20108, 20117, 20133, 20138, 20139, 20181, 99004, 99014, 99016, 99046, 99050 and ICP 8863 among the ICRISAT wilt nursery were resistant. Similarly, out of 30 AICRP lines, KPL 43, GT 101, TS 3R, GRG 818 and GRG 822 were resistant. Genotypes AWR 74/15, Banda Palera, MA 3, KPBR 80-2-1, ICP 8858, KPL 44, PI 397430 and IPF 9 were resistant to variant 1, 2 and 3 screened in variant specific sick tanks against wilt.
- Significant reduction of wilt disease in pigeonpea was observed with *Trichoderma* strains IPT 31 and IPT 11 (9.5-10.8% against 23.7% in control). All treatments except *Trichoderma* strain from Bangalore gave 198-255 kg/ha higher yield over control.
- In a pot experiment conducted with national collection of 15 *Trichoderma strains* and 10 ppm salicylic acid, strains with code nos. 5, 9, 10, 13 and 14 were highly efficient giving < 10% chickpea wilt incidence.
- Highest population of *Trichoderma* strains IPT 31 was achieved in sorghum grain, followed by sugarcane, chickpea and pigeonpea straw. FYM and *neem* seed showed at par population among the crop residues and other organic substrates, followed by goat dung.
- Studies indicated that 5% jaggery solution and potato dextrose broth were best for liquid formulation of *Trichoderma*.
- Six urdbean lines *viz*., EL 48, 15/7, PLU 707, IPU 99-219, NP19 and IPU 98/136 showed resistant reaction against CLC. Five mungbean genotypes *viz*., HUM 16, GG 46, AKM 8803, Co 4 and BM 11 were found moderately resistant.
- The treatment involving two sprays, first of NSKE (5%) at 30 DAS and second of indoxacarb (0.86ml/l) at 45 DAS was best in obtaining the maximum grain yield (1222 kg/ha), but the reduction in CLS was non-significant. Similarly, two sprays, first of dimethoate (1 ml/l) at 30 DAS and second of emamectin benzoate (0.40g/l) also proved good in obtaining the maximum grain yield (1034 kg/ha) and also reduced CLS.
- Combination of two isolates of *Trichoderma* (consortium mode) used as seed treatment or foliar spray *viz*., IPT 10+IPT 11, IPT 10+IPT 21 and IPT 11+IPT 21 resulted in marginally significant reduction in CLS disease, but the per cent increase in grain yield was highly significant (165-245% over control).
- Eleven pairs of species specific primers have been designed and got synthesized for accurate detection of GBNV, MYMIV, MYMV, TSV, HgYMV, BCMV, PSMV, PSBMV, CCSV, CCDV and BLRV. Simplex-PCR protocols for detection of four viruses (MYMIV, MYMV, HgYMV and GBNV) have been standardized. Primer pairs (MYMIV-CPfF/ MYMIV-CPfR, MYMV-CPF/MYMV-CPR, HYMV-CPF/HYMV-CPR and GBNV-NPF/GBNV-NPR) were found suitable for accurate detection of four viruses *viz*., GBNV, MYMIV, MYMV and HgYMV.

Basic Science

- Evaluation of chickpea germplasm for combined tolerance to drought and heat led to identification of promising genotypes *viz*., Katila, Avrodhi, Vaibhav, GCP 105 and JG 11 with initial high biomass and LAI, whereas, genotypes NBEG 3, PG 12, Pusa 312, Pant G 114 and ICC 3362 with low initial biomass and LAI.
- Photo-thermo-periodic response was recorded in heat tolerant chickpea genotypes. Heat tolerant genotype ICCV 92944 flowered and set pods both under 10 h (short day) and 16 h day length (long day) at temperature beyond 35^{o}C, whereas, genotype ICC 1205 flowered only under long day length (16 h).
- The optimum temperature for photosynthesis in chickpea was worked out to be at 30^{o}C showing high quantum yield (Fv/Fm) with intense blue fluorescence images.
- Fieldpea genotypes *viz*., KPF 103, DMR 15, Pant 5, IPFD 3-6 were identified as heat tolerant. Reduction in days to first flowering *i.e.*, 42 days instead of 49 days was observed under heat stress conditions.
- Out of ten lentil genotypes tested under heat

stress conditions, maximum membrane stability index was recorded in VL 4, EC 208262, JL 1 and P 2016.

- To screen pigeonpea genotypes for heat stress tolerance by using temperature induction response technique, the challenging temperature (54°C : 3 hours) and induction temperature (30°C to 43°C in 3 hours and maintained at 43°C for 2 hours then transferred to challenging temperature (52°C 2 hours) were standardized. It will be useful for further screening for heat tolerance.
- Genetic variability for various nutritional and anti-nutritional traits in lentil germplasm was studied which showed significant variation in seed protein, total phenol content and antioxidant activity. The protein content varied from 21.5% to 36.02%, whereas the total phenol content ranged between 2.96 to 11.96 mg /100 g. The antioxidant activity ranged from 1.4 to 3.82 mmol Trolox/100g with maximum AOA in the ILWL 147.
- In lentil germplasm, the trypsin inhibitor activity (TIA) varied from 3.67 to 13.30 TIU/ mg sample, whereas the total dietary fiber tested in 17 different accessions varied from 10.26 to 21.69%.
- Wide variability was recorded for BOAA/ ODAP content in lathyrus genotypes, which varied in the range of 0.51–1.06 mg/g. The range of oxalate was 0.34-0.96 mg/g in the dehusked grains. The phytate content in lathyrus seeds was found in the range of 15.4 to 16.5 mg/g.
- Dehusking of seeds of lathyrus reduced phytates, total phenols, tannins and oxalate to the extent of 6.0, 61.3, 47.3 and 58.4% respectively. Soaking of dehusked grains in acidic (pH 4.0) or alkaline (pH 9.2) solution for 30–60 min at 80–100 °C reduced neurotoxin (BOAA) in the range of 82.43–92.62%.
- For identification and characterization of biochemical compounds imparting resistance to fungal pathogens and *H. armigera* in chickpea, the individual compounds were isolated from very active antifungal fractions by preparative TLC and crystal growth approaches and were further subjected to IR, 500 MH_z ^{1}HNMR and ^{13}CNMR analysis which revealed them to be derivatives of closely related Isoflavone and extra peaks for H and C for the extra functional substituents on the Isoflavone moiety in case of both of the wilt resistance varieties.
- Three strains of *Mesorhizobium ciceri viz*., strain no. 19, 29 and 45 improved nodulation and increased grain yield of chickpea by 30% over un-inoculated control.
- Study on growth and nutrients uptake in chickpea genotypes grown on soils with low (Oleson's P, 7 ppm, organic C 0.22%) and high P levels (Oleson's P, 23 ppm with organic C 0.43%) revealed that nodule numbers and plant weight at 30 days of growth were low at low P level. In JG 16, there was 50% reduction in plant biomass due to low P availability in soil.
- For moisture stress management in chickpea, total 127 bacteria with ACC deaminase activity were isolated from chickpea roots and rhizosphere soils. Isolate no. ACC-75a recorded highest ACC deaminase activity, while isolate no. 52c recorded lowest enzyme activity.
- Out of 26 ACC deaminase producing isolates, the best 4 isolates (No: ACC-2a, ACC-7b, ACC-7a and ACC-16b) enhanced chickpea nodulation and plant biomass at 90 DAS in the range of 40-138.6% and 30-67%, respectively under field conditions. Co-inoculation of ACC deaminase producing bacterium (isolate no. ACC-3) with *Mesorhizobium* enhanced chickpea nodulation up to 62.5% as compared to un-inoculated plants under moisture stress.
- Arbuscular mycorrhizal (AM) inoculation enhanced plant biomass and root colonization in the range of 17.3-20.3 and 25.4-31.7%, respectively, over uninoculated control at flowering phase under P sufficient and deficient conditions.

Social Science

- Gender role in different activities, decision making, drudgery perceived, source of information, adoption of modern technologies and constraints perceived in pulse production and processing was studied in seven districts of Bundelkhand region. The data were collected from 1350 men and women by interview, group discussion and observation methods.
- The majority of decisions are taken jointly, except selection of variety, crop rotation,

spray of weedicide, harvesting of crop and selling of produce, which are carried out by men belonging to medium category. The major constraints perceived by the farmers were yellow mosaic virus disease, weed infestation in k*harif* pulses, wilt in lentil and chickpea and insect problem in chickpea.

- Farmer to farmer informal diffusion of profit enhancing technologies/ practices takes place through social interactions in all the farming communities. Total 21 key farmers were identified and were motivated to diffuse the produce in the structured and unstructured manner to new farmers. The key farmers pooled 300 kg seed of improved chickpea variety for further dissemination to farmers for sowing in *rabi* 2013-14. The key farmers received yield advantage of 114 kg/ha and income advantage of Rs. 4500/ due to the demonstrated chickpea variety.
- The potential pulse based enterprises were identified and ranked first like pulses cultivation as cash crop, followed by *dal* mill, quality seed production, basket making from pigeonpea, organic farming of pulses, innovative marketing (e-marketing of processed pulses) in pulses, promotion of seed processing plants, grading and packaging of pulses, bakery/*namkeen* product, sprouted pulses and pulses soup, *dal* mill design and manufacturing.
- The analysis of training process at district levels showed that District Training Officer, Deputy Director Agriculture, District Agriculture Officer, Soil Conservation Officers are responsible for trainings on pulse crops under various central and state funded developmental schemes.
- To develop PulsExpert programme in Hindi, data were collected for major diseases and insect-pests of chickpea and pigeonpea and designed the structure of acquired knowledge/information. Knowledge has been elicited through the knowledge acquisition tool to provide user-friendly interface to domain expert(s) for entering the information.
- Collection and organization of different characteristics of germplasm data for mungbean and urdbean was completed and stored in proper computerized format for creation of genetic resource database. A home page for Germplasm Information System has been designed to facilitate the authenticate users and an interface has been developed for entry of data related to different characters of germplasm.
- In most of the pulses, prices have shown a positive trend except for urdbean. Seasonality indices were calculated based on the average prices of pulses. In case of chickpea, seasonality indices of prices were lower during January to May and lowest value of seasonal index (0.85) was in April. In pigeonpea, seasonal indices were lower during April to June and lowest being in June (0.92).
- The data of total pulses on all India basis for the last 60 years on area, production and productivity have been collected. It was observed that change in average production of total pulses between the decades 1990-2000 to 2000-10 has reduced to 0.57 as compared to 6.52 of 1950-60 to 1960-70. The change in average production has been split into different components *viz*., change in mean area and mean yield, interaction between mean area and mean yield and change in co-variance between area and yield.
- Promotion of formal and informal seed system(s) through registered farmers associations has not only helped in ensuring availability of quality seed of preferred varieties of lentil at village level, but also enhanced net income of participating farmers. Farmers obtained 30 - 50% higher profit from seed sale in comparison to grain in nearby markets of Ballia district. Similar trends were noticed in the Fatehpur district.
- Ten units (50 farmers per unit) were identified in Bahuwa block of Fatehpur for intensive application of IPM modules in chickpea. Cluster of 15 villages including 450 farmers were selected and chickpea sowing was done in 475 ha under rainfed, monocropped and partial irrigated double cropped situations. Application of Indoxacarb (15.8% EC) reduced larval population at time of pod formation in chickpea. Farmers obtained 2.5 q to 4.5 q additional yields through management of pod borer.
- It was observed that the biorationals module used with three components *i.e.*, NSKE,

HaNPV and Spinosad recorded lower per cent of pod damage (7.29%) as compared to use of NSKE and HaNPV (14.4%). The pod damage was recorded highest (16.37%) in control plots.

- Under TSP, total 201 on-farm demonstration including pigeonpea (75), urdbean (113) and mungbean (13) were laid in selected 6 districts of M.P. and 4 district of Chhattisgarh by KVKs. JU 86 and TU 94-2 varieties of urdbean along with other INM and IPM components were demonstrated. The average yield of urdbean obtained at tribal farmers' fields was 972 kg/ha with net profit Rs. 19670/ha.
- Total 740 on-farm demonstrations including chickpea (480), lentil (120), fieldpea (130) and horsegram (10) were laid in 11 tribal dominated districts of M.P., Chhattisgarh and U.P. The average yield of chickpea was obtained up to 2400 kg/ha and lentil 1800 kg/per ha, against 950 kg/ha from local seed. Fieldpea yield was obtained 1800 kg/ha against 1200 kg/ha from local seed in Lakhimpur.
- Two Model Training Course were organized in which 32 Extension Official of different states took part. Seventeen farmers' trainings and 16 exposure visits of farmers of different states were organized, wherein more than 1500 farmers took part. Collaborative programme "*Dalhan Kisano Ke liye*" with All India Radio, Kanpur was implemented and 24 episodes on different aspects of pulse improvement on weekly basis were broadcast.

Biotechnology Unit

- To map *Fusarium* wilt resistance genes, two mapping populations (JG 62 x WR 315 and K 850 x IPC 2004-52) were advanced to F_4 generation. F_2 mapping population derived from cross JG 62 x WR 315, representing 178 individuals was phenotyped for *Foc* race 1 under pot conditions and genotyped with 84 polymorphic markers.
- Genetic transformation of chickpea (cv. DCP 92-3) with AtDREB1A gene and 1167 explants were co-cultivated. Three resistant shoots identified against the selecting agent *i.e.*, kanamycin monosulphate were established and seeds were harvested from all of them. To discriminate transgenics from non-transgenics, 48 T_1 progenies (from 3 T_0) were screened with new set of oligos for the presence of gene.
- Genetic transformation (*Agrobacterium* mediated and micro-projectile) in chickpea and pigeonpea using the *Bt* gene (*cry1Ac*) was done with 73,309 and 31,187 explants, respectively. This resulted in establishment of 32 and 211 independent primary transgenics of chickpea and pigeonpea, respectively.
- Pigeonpea (Asha) and chickpea (DCP 92-3) were transformed using *Agrobacterium tumefaciens* harboring a synthetic *Bt* gene (*cry1Aabc*). Total 11 kanamycin resistant pigeonpea shoots and 33 chickpea shoots were established. Insect bioassay indicated variable mortality (20-100%).
- The F_7 RIL population (195 individuals) derived from cross of BG 256 and WR 315 was advanced and 30 polymorphic markers were identified between parents. Also, 100 cDNA clones derived from drought stress library were sequenced and nine EST-SSRs were synthesized and validated in chickpea.
- In MABC 12 F_1 plants confirm true hybrid on the basis of molecular marker were backcrossed and 57 BC_1F_1 seeds were obtained. Similarly, 7 true BC_1F_1 plants derived from KWR 108 x ICC4 958 crosses were backcrossed and 35 BC_2F_1 seeds were harvested. In pigeonpea, mapping population comprising of 191 F_5 lines (Asha x UPAS 120) for wilt resistance was advanced and 24 SSR markers were identified polymorphic between parents.

Regional Station, Dharwad

- Total 600 kg breeder seed of chickpea variety JG 11 and 200 kg breeder seed of two *kabuli* chickpea varieties *viz*., Shubhra and Ujjawal was produced. Total 265 advanced breeding lines (*desi* and *kabuli*) were evaluated and 21 high yielding elite breeding lines were selected. Ten chickpea crosses were successfully advanced during off-season.

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 1958	North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi
	Phule G 0027	Hilly areas of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region
	CSJK 6	Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region
	GLK 26155	North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi
	GNG 1969	North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi
Pigeonpea	IPH 09-5 (Hybrid)	Eastern Uttar Pradesh, Bihar, Jharkhand, Orrisa, West Bengal and Assam
	IPA 203	Eastern Uttar Pradesh, Bihar, Jharkhand, Orrisa, West Bengal and Assam
	Phule T 0012	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Maharashtra

Breeder Seed Production

Total 11141.21 q breeder seed of 90 varieties of chickpea was produced against DAC indent of 9367.94 q and 781.60 q breeder seed of pigeonpea was produced against the indent of 514.89 q. Similarly, 1381.20 q breeder seed of mungbean (61 varieties), 1030.65 q of urdbean (45 varieties), 717.77 q of lentil (38 varieties) and 959.34 q of fieldpea (27 varieties) was produced against the indent of 1243.80 q, 845.96 q, 643.60 q and 838.45 q, respectively.

About The Institute

Pulses continue to be an important ingredient of human diet specially, the huge 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 then existing varieties by improved production technologies, besides breeding for high yielding varieties of different pulse crops became the prime concern. To take up the cause, All India Coordinated Pulses Improvement Project (AICPIP) was started in 1966 at the Indian Agricultural Research Institute (IARI), New Delhi. Later in 1978, its headquarters was shifted to the then Regional Station of IARI at Kanpur under the name of Project Directorate (Pulses). It was further elevated as Directorate of Pulses Research (DPR) in 1984 and became an independent entity under the direct control of ICAR. In 1993 the DPR was upgraded and elevated to the status of Indian Institute of Pulses Research, and simultaneously, AICPIP was trifurcated into three coordinated projects on chickpea, pigeonpea and MULLaRP (mungbean, urdbean, lentil, lathyrus, rajmash and pea) to provide focused attention on each crop. Since then, the Institute is playing a key role in strengthening the nutritional security and sustenance of soil health. Besides generating basic knowledge and material, other activities of the Institute include development of appropriate crop production and protection technologies, production and supply of 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 sub-humid. The summers are very hot and winters are cool and dry. The monthly weather data for the year 2012-13 revealed that the mean monthly maximum temperature varied from 20.3^0C in January to 38.0^0C in April and the minimum temperature from 5.2^0C in January to 25.6^0C in July. Relative humidity at 17.30 h varied from 32.6% in May to 78.0% in August. During the year 2012, total 682 mm rainfall was received which was normal. The monsoonal rains withdrew by the middle of September. During winter season, 125.4 mm rainfall from November to February was received. Unusually high temperatures were recorded during the months of March (36.2^0C) and April (40.3^0C).

Multi-disciplinary research of both applied and basic nature is conducted under five divisions namely, Crop Improvement, Crop Production, Crop Protection, Basic Science, Social Science and Biotechnology Unit. To further strengthen the region specific research, the Institute has one Regional Station *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. Physical Containment Facility has been created for advancing generation of the transgenic plants and further validation of the transformants. A post-entry quarantine complex 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, 65 technical, 27 administrative and 61 supporting personnel.

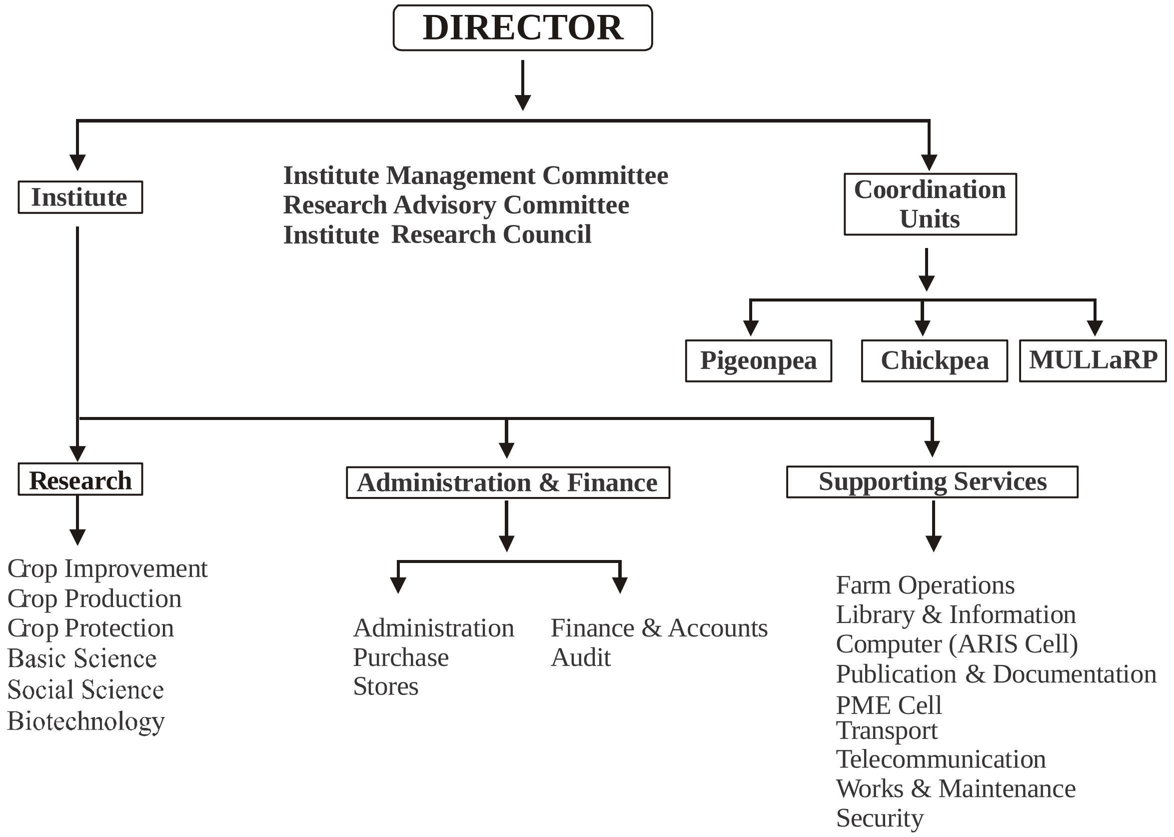
Mandate

- To act as national centre for basic and applied research on pulse crops
- To monitor, guide and coordinate research on pulses in the country
- To impart training to scientists and extension workers engaged in pulses research and development
- To foster national and international collaborations for exchange of views and material
- To disseminate information on latest pulses production technology
- To serve as an information bank on different aspects of pulses for strategic planning
- To extend consultancy services and expertise.

Major Research Programmes

- Genetic Enhancement for Yield
- 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.

Organizational Set-up

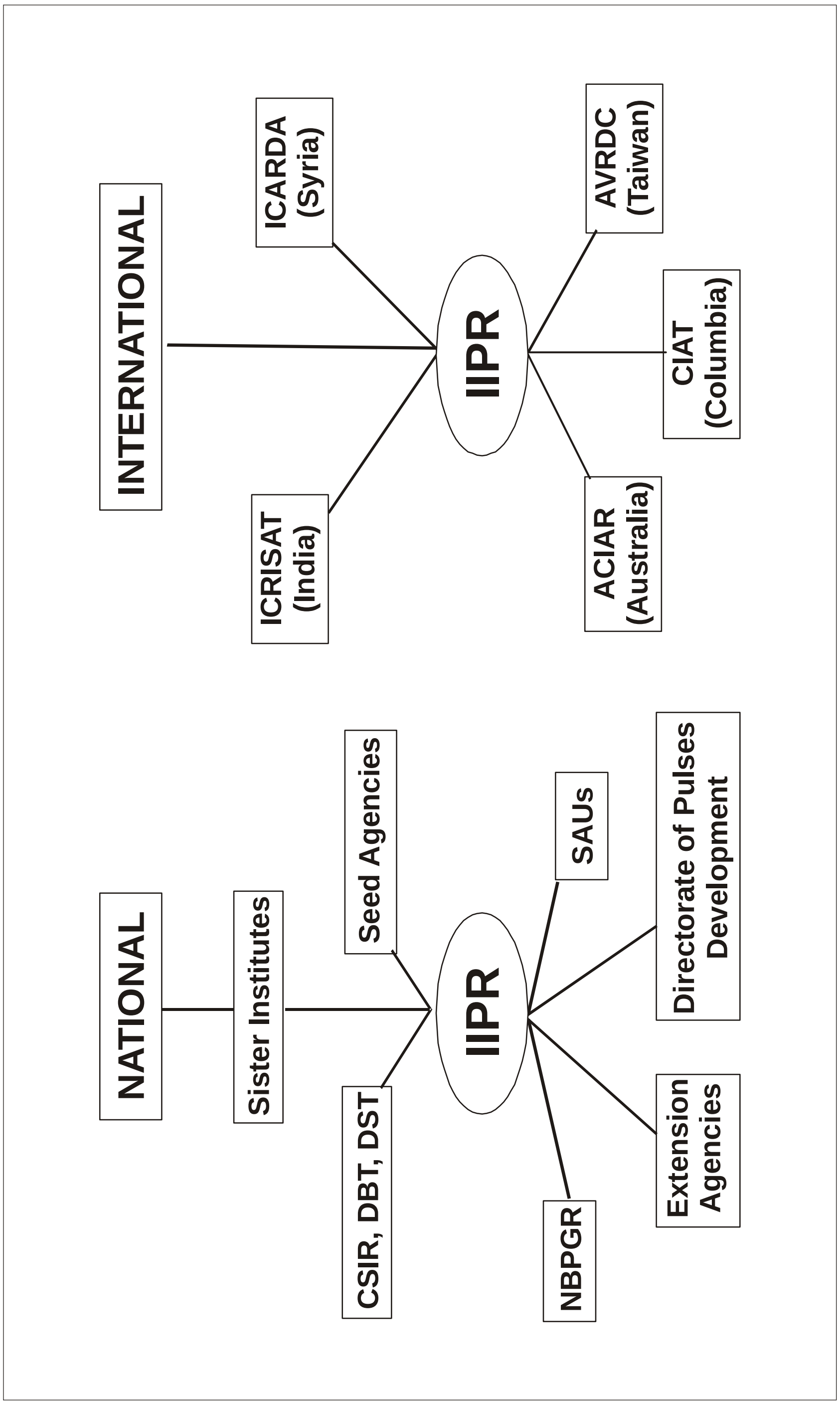


Staff Strength

As on 31.3.2013

Category	Sanctioned	In position	Vacant
RMP	1	1	-
Scientist	88	60	28
Technical	65	62	3
Administrative	27	25	2
Supporting	61	51	10

Linkage and Collaborations



Financial Statement

Statement of Receipt and Expenditure for the Financial Year 2012-13

		Rs. in lakhs
A.	**Receipt**	161.11
B.	**Expenditure**	
	Non-plan	1536.29
	Plan	349.49
C.	**Pension and other retirement benefits**	120.00
D.	**AICRPs**	
	Chickpea	
	a. Coordination Unit	12.68
	b. Grant-in-aid	1006.32
	Pigeonpea	
	a. Coordination Unit	5.45
	b Grant-in-aid	1078.50
	MULLaRP	
	a. Coordination Unit	12.06
	b. Grant-in-aid	1037.93

Status of Implementation of XII Five Year Plan (Up to 31.03.2013)

Rs. in lakhs

Head	Approved outlay	Expenditure 2012-13
A. Recurring		
Pay & Allowances/Wages	EFC not approved	---
TA		8.75
HRD		6.49
Contingency		196.52
Total		**211.76**
B. Non-recurring		
Equipment		11.65
Works		60.11
Library		34.23
Total		**105.99**
C. TSP		**31.74**
D. TOTAL (A+B+C)		**349.49**

Crop Improvement

Genetic Improvement of Pulse Crops for Plant Type and Multiple Disease Resistance

Chickpea

Performance of breeding lines in AICRP trials

Genotypes *viz*., IPCK 2006-78 is being evaluated in AVT 1 trials in different zones. Genotypes *viz*., IPC 2006-77 and IPC 2006-84 (IVT-CZ), IPCK 2006-56 (IVT-NWPZ), IPCK 2008-136 (IVT-NEPZ) along with 10 new IPC/IPCK entries are being evaluated in IVT trials.

Segregating material/generation advancement

Total 39 crosses were made to generate breeding material. F_2 seeds were harvested from 47 new crosses involving genetically diverse parents (primitive landraces and wild *Cicer* sps.). Single plant selections (3889 SPS) from segregating generations were grown for evaluation and selection of promising progenies or single plants.

Evaluation of promising breeding lines

Total 243 advanced breeding lines were evaluated under rainfed, irrigated and late sown conditions, while 81 breeding lines were screened against heat stress. Nineteen advanced breeding lines exhibited early maturity by 10-12 days in comparison to check varieties. One line, IPC 2008-57 was identified as cold tolerant on the basis of pod formation at < 8^0C temperature.

Cold tolerant line IPC 2008-57 at podding

Rainfed condition: Total 54 elite breeding lines were evaluated under rainfed condition. In one trial comprising of 27 advance breeding lines, genotypes *viz*., IPC 2008-69 (3794 kg/ha), IPC 2008-11 (3694 kg/ha), IPC 2007-28 (3578 kg/ha), IPC 2009-191 (3553 kg/ha), IPC 2010-72 (3462 kg/ha), IPC 2010-78 (3375 kg/ha) and IPC 2010-09 (3362 kg/ha) and IPC 2007-09 (3353 kg/ha) were found promising against the check varieties (JG 16: 3316 kg/ha, JG 11: 3022 kg/ha and DCP 92-3: 2928 kg/ha). The grain yield of cold tolerant line, IPC 2008-57 was 3113 kg/ha. In other trial comprising of 27 genotypes, IPC 2010-219 (3700 kg/ha), IPC 2012-08 (3261 kg/ha) and IPC 2012-174 (3238 kg/ha) out yielded check varieties (DCP 92-3, JG 16 and GNG 1581).

Irrigated condition: Advanced breeding lines were evaluated in replicated yield trials on sandy loam soil. Genotypes IPC 2012-204 (2722 kg/ha), IPC 2012-207 (2233 kg/ha), IPC 2012-226 (2172 kg/ha), IPC 2012-200 (2138 kg/ha) and IPC 2012-230 (2155 kg/ha) out yielded best check variety HC 5 in Trial I, whereas in Trial II, IPC 2010-09 (2761 kg/ha), IPC 2009-21 (2755 kg/ha), IPC 2008-76 (2688 kg/ha), IPC 2008-11 (2605 kg/ha) and IPC 2008-89 (2533 kg/ha) out yielded best check DCP 92-3 (2322 kg/ha). In preliminary yield trial, IPC 2012-04, -172, -179, -181, -194, -220, -242, IPC 2010-36, -37, IPC 2011-103, -130, -191, -200, and IPC 2008-02 performed well and surpassed the best check in grain yield. Genotype IPC 2008-11 performed well under both, rainfed and irrigated conditions.

***Kabuli* chickpea:** Three station trials were conducted to evaluate yield performance. In extra large seeded trial, IPCK 2011-161 (2166 kg/ha), IPCK 2011-37 (2144 kg/ha), IPCK 2011-160 (1980 kg/ha), IPCK 2011-124 (1975 kg/ha) and IPCK 2011-130 (1961 kg/ha) out yielded best check variety IPCK 02 (1691 kg/ha) and had good seed size. In trial on tall and erect breeding lines, IPCK 2009-145 (2580 kg/ha), IPCK 2011-182 (2547 kg/ha), IPCK 2011-302 (2369 kg/ha), IPCK 2011-183 (2363 kg/ha) and IPCK 2011-214 (1975 kg/ha) were best performers giving higher yield than the check variety IPCK 2000-29 (1838 kg/ha). In third trail with medium large seeded entries, IPCK 2011-88 (2255 kg/ha), IPCK 2011-74 (2133 kg/ha), IPCK 2011-166 (2013 kg/ha), IPCK 2011-204 (2172 kg/ha) and IPCK 2010-76 (1975 kg/ha) surpassed the best variety IPCK 2002-29 (1700 kg/ha).

Genotypes for mechanical harvesting: Five tall and erect plant type genotypes *viz*., IPC 2006-11, -14, -27, -142 and IPC 2008-02 identified for mechanical harvesting were evaluated further to assess their yield potential and stability.

Tall and erect breeding line IPC 2006-11 suitable for mechanical harvesting

Herbicide tolerance: Genotypes *viz*., ICC 1164, IPC 2010-81 and IPC 2008-59 were found most tolerant as these lines were almost not affected and only showed inhibited growth at initial stage. Among others, ICC 1161, ICC 1205, ICC 13816, IPC 2008-29, IPC 2006-134, ICC 1710, ICC 2629, IPC 2010-56 and IPC 2010-173 also exhibited tolerance to post-emergence herbicide Imazethapyr, while ICC 8522, ICC 6874 and ICC 5484 were found most sensitive.

Fusarium wilt resistance transferred in *desi* and *kabuli* background: Out of 253 advanced breeding lines (155 *desi* and 98 *kabuli*) screened in wilt sick plot, 16 *kabuli* chickpea lines (IPCK 2012-129, -141, -156, -254, -258, -269, -275, -281, -284, -289, -291, -293, -294, -296, -306 and IPCK 2012-310) exhibited wilt resistance, whereas 17 *kabuli* breeding lines showed moderate resistance. Nineteen *desi* chickpea lines (IPC 2012-1, -03, -10, -20, -28, -62, -63, -88, -92, -99, -108, -115, -182, -184, -192, -197, -198 and IPC 2012-245) exhibited resistance to wilt (predominantly race 2 of *foc)*, while 44 lines were categorized as moderately resistant. Under AICRP screening programme, genotypes *viz*., IPC 2005-58, -59, -74, -79, IPC 2007-31, -69, -96, IPC 2008-38, -103 and IPC 2009-16, exhibited fusarium wilt resistance, whereas IPC 2005-28 and IPCK 2006-78 exhibited resistance against dry root rot over locations.

BGM resistance: IPC 2004-17 and IPCK 2004-29 were found moderately resistant against botrytis grey mould and IPCK 2006-78 showed combined resistances against ascochyta blight and dry root rot.

Dry root rot resistance: IPC 2005-24, -62 and IPC 2007-68 exhibited resistance (<10% mortality) against dry root rot. IPC 2005-15, -19, -24, -52, -62 and IPC 2005-64 showed moderate resistance against DRR for two consecutive years.

Abiotic stresses tolerance: Genotypes *viz*., IPC 98-12 and IPC 97-72 were identified as heat and drought tolerant, respectively.

Nucleus seed production

Nucleus seed of chickpea variety DCP 92-3 was produced.

Pigeonpea

Long duration pigeonpea

Variety developed

A long duration pigeonpea variety IPA 203 (Bahar×Ac 314-314) has been identified for cultivation in North East Plain Zone comprising of Uttar Pradesh, Bihar, Jharkhand and West Bengal states. It has erect and compact plants, wider adaptability, resistance to *Fusarium* wilt and SMD and high protein content.

Evaluation of promising breeding lines

In two station trials, entries *viz*., IPA 330 (Type 7×Ranchi Local), IPA 331 (NA 1× KPBR 80-2-2), IPA 332 (Bahar×PI 397430), IPA 333 (Type 7×WRP 1), IPA 334 (Type 7×WRP 1), IPA 335(Type 7×WRP 1), IPA 336 (Type 7 ×WRP 1), IPA 337 (PI 397430×UPAS 120), IPA 338 (Pusa 9×Ranchi Local), IPA 339 (Kudrat selection 1), IPA 340 (Kudrat selection 2), IPA 341 (HJP 13 selection), ICPL 99098, IPA 342 (NA1×KPBR 80-2-2), IPA 343 (Pusa 9×Ranchi Local) along with two checks are being evaluated for agronomic traits.

Generation of breeding material

Nine fresh crosses *viz*. Bahar×KPL 43, Bahar×KPL 44, Bahar×KPBR 80-2-1, NA 1× KPL 43, NA 1×KPL 44, NA 1×KPBR 80-2-1, IPA 203×KPL 43, IPA 203×KPL 44 and IPA 203×KPBR 80-2-1 were attempted to combine resistance against major biotic and abiotic stresses with high yield potential. Six backcross and F_3 progenies were advanced through selfing. Single plant selection were made in 6 F_4 (62 SPS), 27 F_5 (105 SPS), 10 F_6 (101 SPS) and 2 BCF_5 (12 SPS).

Mapping population

Two F_5 mapping populations (Bahar×66 B) for earliness and (UPAS 120×Asha) for *Fusarium* wilt tolerance are maintained and advanced through SSD.

Material generated for basic genetic studies

An early cleistogamous line (ICPL 87154) was crossed and backcrossed with Bahar and IPA 203 for incorporation of high cleistogamous trait into improved cultivars. The 6 F_2 and backcross generations derived from crossing between above were studied for genetics of floral characteristics. A F_2 population derived from cross between MA 3 and its leaf mutant was analyzed for studying genetics of leaf and floral characteristics. The segregating populations derived from open pollinated out-crossed plants were studied with the aid of morphological markers for estimating out-crossing rate in Bahar, IPA 7-5, MAL 13, IPA 20 and other long duration pigeonpea.

Nucleus seed production

Nucleus seed of IPA 203, NA 1, Asha and Bahar was produced through artificial selfing and progeny testing.

Seed multiplication

Genetically pure seeds of 15 promising genotypes including early, medium and long duration pigeonpea were produced through selfing. Seeds of eight promising entries *viz*., IPA 206, IPA 7-4, IPA 7-5, IPA 7-10, IPA 11-1, IPA 11-9, IPA 11-10 and IPA 344 (MAL 13 x Kudrat) were multiplied through selfing for constitution of trials.

Short duration pigeonpea

Evaluation of advanced breeding lines

Total 8 entries were evaluated in station trial along with two checks Pusa 992 and UPAS 120. Entry IPA 13-37 exhibited 7.4% yield superiority over the best check Pusa 992.

Generation of breeding material

Fourteen fresh crosses were made for earliness, growth habit, selfing nature and higher yield using ICPL 20335/ICPL 87119, 67 B, ICPL 87154, UPAS 120/ Pusa 992 as trait-specific donors, respectively. F_2 seeds were harvested from 5 F_1s (UPAS 120×ICPL 87154, ICPL 87154×CoRG 9701, CoRG 9701×UPAS 120, CoRG 9701×ICPL 87154 and UPAS 120×CoRG 9701). Single plant selections were made in 2 F_2s (11 SPS), 2 F_3s (15 SPS), 14 F_4s (50 SPS) and 5 F_6s (30 SPS).

Germplasm maintenance

Genetic purity of 27 accessions including lines of early maturity group (Manak, Paras, ICPL 88039, AL 15, AL 201, UPAS 120, Pusa 992 and ICPL 87154) was maintained through selfing of single plants.

Mungbean

Photo-thermo-insensitive accessions of *Vigna* identified

One accession each of *V. glabrescens* (IC 251372) and *V. umbellata* (IC 251442) were identified for photo-thermo-insensitivity after three years evaluation in field and controlled conditions. These accessions showed normal flower and pod setting as well as pollen viability. Both accessions have semi-erect growth habit, indeterminate growth pattern and dark green leaves. *V. glabrescens* has yellow flowers, long and constricted pods and dark green, mottled seeds, while *V. umbellata* has light yellow flowers, smooth and curved pods, and shining, oval and large seeds. Both genotypes exhibited resistance against major diseases including MYMIV and powdery mildew, thus can be utilized in developing photo-thermo-insensitive genotypes in mungbean and urdbean.

V. glabrescens (IC 251372)

V. umbellata (IC251442)

Performance of breeding lines in AICRP trials

Two entries *viz.*, IPM 306-6 and IPM 2K 15-4 were promoted to AVT 1. Former entry was for NEPZ (*Kharif*) and later was for CZ (Spring) and NWPZ, NHZ, NEPZ (Summer). Five entries *viz.*, IPM 312-9, IPM 410-3 and IPM 205-7 (Spring/summer), IPM 2K 15-4 (*Kharif*) and IPM 312-394 (*Rabi*) are being evaluated in IVT for all zones. Five entries *viz.*, IPM 9901-6, IPM 2K 14-9, IPM 2K 14-5, IPM 5-3-22 and IPM 6-5 are under evaluation in state adaptive trials in Uttar Pradesh.

Evaluation of promising breeding lines

Three station trials in spring/summer and two station trials and one PYT in *kharif* were conducted. In spring/summer, three entries *viz.*, IPM 544-6 (1384 kg/ha), IPM 99-125 (1334 kg/ha) and IPM 2K 14-7 (1196 kg/ha) in ST 1, three entries *viz.*, IPM 312-17 (1200 kg/ha), IPM 312-321 (1136 kg/ha) and IPM 9901-11 (1120 kg/ha) in ST 2 and two entries *viz.*, IPM 544-7 (mungbean x *V. trilobata* derivative) and IPM 512-1 (1416 kg/ha) in ST 3 were found promising. During *kharif*, three entries IPM 104-3 (1905 kg/ha), IPM 544-6 (1880 kg/ha) and IPM 312-244 (1822 kg/ha) were high yielders in ST 1 and two entries *viz.*, IPM 545-1 (1916 kg/ha) and IPM 406-1 (1845 kg/ha) out yielded the best checks in ST 2. In PYT, entry IPM 07-146K (2092 kg/ha) recorded highest yield, followed by IPM 312-134-135K (1861 kg/ha) and IPM 2K 14-5-2 (1853 kg/ha) against checks IPM 2-3 (1842 kg/ha) and IPM 2-14 (1786 kg/ha).

Generation of breeding material

Fresh F_1 from 6 cross combinations (PDM 139×SML 668, PDM 139×TMB 37, PDM 139×NM 1, PDM 139×Sona Yellow, IPM 2-14×TMB 37 and IPM 2-14×SML 668) were generated using the selected germplasm and cultivated donors. In mungbean× mungbean crosses, single plant selections were made in F_3 (188 SPS), F_4 (58 SPS), F_5 (66 SPS) and F_6 (265 SPS) generations. Progeny bulks were made in F_7 (17 lines), F_8 (19 lines) and F_9 (5 lines) generations. In mungbean×urdbean/distant crosses, single plant selections were made in F_2 (700 SPS), F_5 (18 SPS), F_6(220 SPS) and F_7 (47 SPS) generations. Progeny bulks were made in F_7 (2 lines), F_6 (2 lines) and F_9 (11 lines). Active germplasm of 160 accessions were also grown.

Transferability of SSR markers

Total 384 SSRs of *Phaseolus*, adzuki bean, blackgram and greengram were screened on 20 diverse genotypes of greengram. Fifty nine markers which showed amplification are being screened on a set of another 60 genotypes.

Quality seed production

Total 340 kg nucleus seed of four mungbean varieties *viz.*, IPM 99-125 (60 kg), Samrat (140 kg), IPM 2-3 (72 kg) and IPM 2-14 (68 kg) was produced.

Urdbean

Performance of promising lines in AICRP trials

A high yielding, and MYMV and CLS resistant line IPU 09-16 has been promoted to AVT 1 in NWPZ. Genotype IPU 10-17 (915 kg/ha) performed well in southern zone in IVT *kharif* trials. Two entries *viz*., IPU 10-23 (*Kharif*) and IPU 10-4 (*Rabi*) are being evaluated in IVT.

Evaluation of promising breeding lines

Out of 19 entries evaluated in station trial, three entries *viz*., IPU 11-08 (1020 kg/ha), IPU 11-02 (1010 kg/ha) and IPU 11-06 (998 kg/ha) out yielded the best check IPU 94-1 (775 kg/ha).

Generation of breeding material

Fresh 17 crosses (Uttara×IPU 2000-01, Uttara×IPU 02-43, PU 31×Mash 114, PU 40×PU 31, PU 31×PU 94-2, PU 40×VBG 04-008, Shekhar 2×VBG 04-008, PU 40× TU 17-4, PU 40×KUG 216, *V. sylvestris*×Uttara, Jalpaiguri local×Uttara, VBG 04-008×Shekhar 2, Uttara×*V. sylvestris*, DPU 88-31×Jalpaiguri local, IPU 33×Jalpaiguri local, SPS 5×IPU 02-43 and PU 94-2×Shekhar 2) were attempted to incorporate resistance to MYMV/MYMIV, powdery mildew and Cercospora leaf spot into the background of high yielding varieties. Single plant selections were made in 9 F_3 (140 SPS), 17 F_4 (225 SPS), 10 F_5 (250 SPS) populations on the basis of plant type, reaction to MYMV and powdery mildew and 12 progeny bulks were also identified as promising.

Genetic diversity analysis

Sixty six germplasm accessions including breeding lines, local germplasm and released varieties were evaluated for various agro-morphological traits. These accessions showed high variation for grain yield/plant (40.5%), grain yield/plot (37%), biological yield/plant (38.9%), number of pods/plant (30.4%) and number of clusters/plant (29.2%). Based on clustering analysis, accessions from distant clusters were selected for hybridization to generate diversity in breeding programme.

Lentil

Variety developed

A high yielding variety IPL 316 (Sehore 74-3×DPL 58) with average grain yield of 1324 kg/ha and large seeds (3.1 g/100 seeds) has been released and notified for cultivation in Madhya Pradesh, Chhattisgarh, Bundelkhand region of U.P. and parts of Rajasthan. It showed 30.7% yield superiority over the best check DPL 62. It has orange cotyledons and is resistant to rust and moderately tolerant to wilt.

Field view of IPL 316

Performance of breeding lines in AICRP trials

Two small seeded entries *viz*., IPL 220 [(DPL 44×DPL 62)×DPL 58] and IPL 221 [(DPL 44×DPL 62)×DPL 58] were promoted to AVT 1 for North-eastern and North-western plain zones and one large seeded entry *viz*., IPL 325 [(ILL 101×E 362)×DPL 62] has been promoted to AVT 1 for North hill zone. Large seeded extra early entry IPL 532 (EC 208355×DPL 62) was retained for further evaluation in AVT 1. Seven new entries including three bold seeded (IPL 326, IPL 327, IPL 328), three small seeded (IPL 222, IPL 223, IPL 224) and one extra early (IPL 534) are being evaluated in IVT.

Evaluation of promising breeding lines

Two station trials with 15 entries each and one preliminary yield trial with 60 entries were conducted. At main farm, three entries *viz*., IPL 6892 (2622 kg/ha), IPL 91155 (2629 kg/ha) and IPL 91267 (2781 kg/ha) were high yielders compared to best check DPL 62 (2470 kg/ha) in ST-1. These entries also showed highest harvest index (55-57%). However, highest biomass recorded in IPL 6196 (6025 kg/ha) compared to best check DPL 62 (5270 kg/ha) was observed poor in yield. In ST-2, four entries *viz*., IPL 11735 (2419 kg/ha), IPL 10778 (2470 kg/ha), IPL 1066 (2441 kg/ha) and IPL 10800 (2641 kg/ha) were high yielders compared to best check DPL 15 (2387 kg/ha). These entries also showed highest harvest index (53-62%). Similar to ST-1, highest biomass (5384 kg/ha) recorded in IPL 11700 (5384 kg/ha) compared to best check DPL 15 (4597 kg/ha) was observed poor in yield. In PYT, out of 60 entries, three entries *viz*., IPL 10780 (2889 kg/ha, IPL 91213 (2933 kg/ha) and IPL 10820 (3067 kg/ha) performed well.

Generation of breeding material

Eight fresh cross combinations including (ILL 7663×IPL 534, IPL 221×IPL 321, IPL 534×IPL 321, JL 1×VKS 16/11, IPL 98/193×VKS 16/11, IPL 533×IPL 121929, IG 560150 ×IPL 534 and DPL 15×LL 864) were attampted for genetic improvement for biomass, resistance to disease, root traits, seed size and earliness. The F_2 seeds were harvested from 82 F_1 plants involving 22 crosses. Single plant selection was done in 29 F_2 (686 SPS), 28 F_3 (583 SPS), 22 F_4 (176 SPS), 17 F_5 (100 SPS) and 70 progeny bulks were identified as promising in 22 F_5/F_6.

Development and maintenance of mapping populations

Mapping populations of 145 F_6 RILs for wilt resistance derived from a cross Precoz (S)×PL 02 (R) and 184 F_6 RILs for earliness and seed size derived from cross L 4603 (Early)×Precoz (Late) were advanced. Trait specific mapping populations for early seedling vigor (ILL 6002×ILL 9997/DPL 15 and ILL 7663×DPL 15) and root traits (IPL 98/193×EC 208362) were advance to F_3 and F_4 generation using single pod descent method.

Nucleus seed production

Total 430 kg nucleus seed of five released varieties (IPL 81, IPL 406, DPL 15, DPL 62 and IPL 316) was produced.

Fieldpea

Variety developed

A high yielding dwarf field pea variety IPFD 6-3 (average yield 2662 kg/ha) developed from the cross KPMRD 389×HUDP 7 has been identified for cultivation in UP state. It is resistant to powdery mildew and moderately resistant to rust disease. Its seeds are medium large, round, smooth and white.

Performance of breeding lines in AICRP trials

Two tall entries *viz.*, IPF 10-21 and IPF 11-15 for Central Zone have been promoted to AVT 2 and AVT 1, respectively. Two dwarf entries *viz.*, IPFD 11-10 and IPFD 11-5 have been promoted in AVT 1 for NHZ. Two dwarf entries *viz.*, IPFD 10-12 and IPFD11-5 have been promoted in AVT 2 and AVT 1 for central zone (CZ), respectively. Four new entries *viz.*, IPF 12-17 and IPF 12-20 (Tall), IPFD 12-8 and IPFD 12-2(Dwarf) are being evaluated in IVT.

Evaluation of breeding material

Nine tall and 24 dwarf entries were evaluated in PYT, while 11 dwarf and 11 tall entries were evaluated in station trials.

Generation of breeding material

Total 39 crosses involving Pant P 14, EC 1, FC 1, HUDP 15, Rachna, MDP 2, HFP 4, HFP 8909, IPF 99-25, S 143, EC 8495, EC 564815, IPF 5-19, IPFD 1-10, SGS 10, G-10, Satha Matar, P 1795, IPFD 99-13, IPFD 2012-11, VL 42, EC 499762, IPFD 6-3, Mslognittee and P 1459 as parents were made for large seed size, seeds/pods, pod length, pods/plant, earliness, powdery mildew resistance and rust tolerance. Two crosses (IPF 99-25×Pant P 14) and (IPF 99-25×EC 1) were evaluated for inheritance study. F_2 seeds was harvested from 48 F_1s. Single plant selections were performed in 37 F_2 (370 SPS) , 49 F_3 (530 SPS) and the 31 F_4 (340 SPS) populations for earliness, seed size, pod length, resistance to powdery mildew, rust and yield/plant. Progeny bulks were made in F_5 (295 lines) and F_6 (225 lines) generations.

Nucleus seed production

Nucleus seed of four released varieties *viz.*, Adarsh, Aman,Vikas and Prakash was produced.

Germplasm maintenance

Total 450 accessions of fieldpea were maintained.

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

Screening of land races and DNA extraction

Total 186 and 30 land races of chickpea were screened against *Fusarium* wilt in wilt sick plots and dry root rot in laboratory, respectively. Only one landrace (ILC 4455) was found resistant against dry root rot. DNA was extracted from 8 parental lines for marker assisted breeding.

Generation of breeding material and phenotyping of mapping population

F_1 seeds were harvested from 5 cross combinations (WR 315×JG 03-14-16, BG 212× JG 03-14-16, IPC 2008-57× JG 03-14-16 , JG 16×JG 03-14-16 and JG 16× IPC 2008-57) for transferring resistance to dry root rot and *Fusarium* wilt. F_3 mapping population comprising of 198 plants (JG 62xWR 315) was phenotyped for *Fusarium* wilt race 2.

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

Evaluation for drought and terminal heat tolerance

For drought tolerance, 35 accessions were evaluated in both irrigated and rainfed conditions including JGK 1, ICCV 4958, ICCV 92944 and RSG 888 as checks. Five accessions *viz.*, FLIP 06-59C, FLIP 06-12C, IPC 2009-186, ICCV 07110 and IPC 2009-102 were identified for early vigor and early flowering and accessions IPC 2009-161 (3.7), ICCV 07110 (2.9), IPC 2009-102 (2.8), GG 2 (2.1) were selected on the basis of leaf area index. For heat tolerance, 33 accessions were evaluated in late shown conditions. Four accessions *viz.*, PG 96006, K 850, ICC 5912 and Phule G 5 were selected for earliness.

Generation of breeding material

Total 10 sets of crosses were attempted (DCP 92-3×ICC 92944, DCP 92-3×ICC 4958, DCP 92-3×ICCV 96030, DCP 92-3×ICC 1205, KWR 108×ICCV 96030, JG 16×ICC 4958, JG 315×KWR 108, KWR 108×ICC 4958, ICC 1205×KWR 108 and PG 96006×ICC 92944).

Germplasm maintenance

Total 16 accessions *viz*., ICC 17160, ICC 5680, ICC 10448, ICC 8261, ICC 13124, ICC 5912, ICC 10685, ICC 4418, ICC 5383, ICC 3761, ICC 4991, ICC 13124, ICC 15618, ICC 14831, ICC 1422 and ICC 2969 were multiplied and maintained.

Pre-breeding in Pigeonpea for Widening Genetic Base

Generation of breeding material

Eight crosses *viz*., MN 5×*C. scarabaeoides*, ICPL 88039×*C. scarabaeoides*, IPA 33-13 ×*C. scarabaeoides*, IPA 35-13×*C. scarabaeoides*, IPAC 3×IPAC 4, IPAC 3×IPAC 8, IPAC 3×ICP 88039 and IPAC 3×Prabhat were attempted to incorporate resistance against major biotic and abiotic stress into high yielding lines. F_2 seeds were harvested from 25 F_1 plants derived from cross between trait specific lines and improved breeding lines or varieties. F_2 population comprising of 653 individuals of a cross Early 3×*C. scarabeoides* (ICP 15685) were recorded for various agro-morphologically traits for studying their genetics. F_2 derivatives of this cross were also crossed with IPAC 4, IPAC 8, Prabhat, NA 1, Bahar, IPAC 79, IPAC 42, IPAC 70-1 and ICPL 85010 for transferring trait specific genes. BC_1F_2/F_3 populations were generated from the crosses *C. cajan*×*C. cajan*, *C. cajan*×*C. scarabeoides* and *C. cajan*×*C. cajanifolius* for studying the genetics of various traits.

A F_2 plant of UPAS 120 x ICP 15761

A F_2 recombinant morphologically similar to cultivated pigeonpea was obtained from a F_2 population derived from cross UPAS 120×*C. scarabeoides* (ICP 15761).

Evaluation and characterization of germplasm

Total 248 germplasm lines were evaluated for yield attributing traits and *Fusarium* wilt resistance. Four germplasm lines including IPAC 4, IPAC 67, IPAC 66 and IPAC 68 were identified for resistance against *Fusarium* wilt. Out of 36 lines screened for *Phytopthora* blight tolerance in sick plot nursery, IPAC 3 showed tolerance over two years.

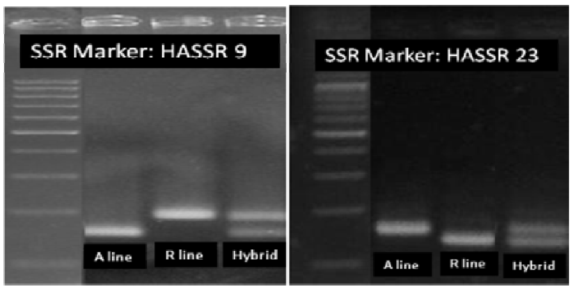
Identification trait specific accession of wild species

Accessions ICP 15685 and ICP 15761 of *C. scarabaeoides* showed flowering and pod setting at high temperature (40^0C). These accessions were also early in flowering, resistant to *Fusarium* wilt and tolerant to *Phytopthora* stem blight. The F_1 of *C. cajan*×*C. scarabaeoides* also showed pod setting and seed formation at above 35^0C.

A chimeric twig having two distinct colour flowers (red and yellow) was observed in a plant of true breeding line IPAC 80 of pigeonpea.

Evaluation and Production of Cytoplasmic Genetic Male Sterility Based Hybrids for Enhancement of Productivity and Stability of Yield in Pigeonpea

Total 66 SSR markers were assessed for polymorphism on parental lines *viz*., PA 163A (A-line) and AK 261322 (R-line). Seven SSRs *viz*., CCB-9, HASSR-3, HASSR-9, HASSR-23, HASSR-35, HASSR-37 and HASSR-43 showed polymorphism between parents (Fig. 1). These polymorphic SSRs were confirmed by true heterozygous nature of the hybrid IPH 09-5 used in the present study.



The name of the each SSR marker has been indicated on the top of each gel image. 100 bp DNA ladder (on extreme left) has been used as standard

Fig. 1: SSR based molecular profiles of the hybrid and its parents

Identification and Evaluation of Herbicide Tolerant/Resistant Genotypes of Pigeonpea

Total 1561 lines of pigeonpea comprising of germplasm (1119), released varieties (69), minicore (129), wild relatives (92) and derivatives of Indo-African derivatives (152) were screened against post-emergence herbicides. Foliar application of herbicides (Imazethapyr @ 4 ml/liter, followed by Glyphosate @ 5 ml/liter of water) was sprayed with a gap of 45 days. Only 20 genotypes exhibited some degree of tolerance.

Plant Genetic Resources – Collection, Evaluation and Maintenance

Chickpea

Total 709 germplasm accessions were rejuvenated and characterized for 21 qualitative and quantitative traits and other 3128 accessions were maintained in medium term cold module. Variability for days to 50% flowering ranged between 43 days (EC 571932) to 121 days (ICC 1943) and days to maturity ranged between 141 days (ICC 4559) to 153 days (FLIP 03-23c).

Pigeonpea

Thirty two cultivated genotypes of *Cajanas cajan* and one *C. scarabeoides* accession collected from different parts of Tripura valley and six accessions of perennial vegetable type pigeonpea *viz*., IPAC 63, IPAC 64, IPAC 65, IPAC66, IPAC 67 and IPAC 68 were maintained. Seed size of these accessions ranged from 14 to 17.5 g per 100 seed. Among these, IPAC 66 and IPAC 68 showed high degree of resistance against *Fusarium* wilt in the wilt sick plot over two years. In addition to this, 54 accessions of wild relatives of pigeonpea (*Cajanus scarabeoides* : 37, *C. albicans* and *C. cajanifolius* : 2 each, *C. platycarpus* : 3, *Rhyncosia cana, R. minima* and *R. rothii* : 1 each, *R. aurea* : 2, *C. sericious* and *C. acutifolius* : 1 each) were maintained under net house for seed multiplication.



Cajnus cajanifolius *Rhyncosia rothii* *Cajnus scarabaeoides*

Total 746 accessions belonging to early medium and long duration groups and 250 early maturing genotypes were rejuvenated and multiplied for seeds.

Mungbean and Urdbean

Collection

Thirty five wild and cultivated species accessions of *Vigna* including *V. aconitifolia* (10), *V. trilobata* (6), *V. stipulacea* (5), *V. radiata* (8), *V. mungo* (3) and *Macrotyloma uniflorum* (3) were collected from different parts of Tamil Nadu.

Evaluation and maintenance

Total 369 accessions of mungbean were rejuvenated and evaluated for various morphological and quantitative traits. Following genotypes were identified promising for various traits:

Character	Promising accessions
Early flowering (< 38 days)	JBT 37/100, E 3-8, BM 11, EC 30400
No. of primary branches (>3)	LM 11-68, DMG 10742, EC 30401, IC 470
No. of pods/plant (> 45)	INM 646, IC 2056, IC 39500, KMS 112
Pod length (>7.5cm)	LM 97, EC 319035, DMG 1030, IC 15205
No. of seeds per pod (> 12)	EC 369225, GG 46, DMG 1058, LM 109
100 Seed weight (> 3.25g)	DMG 1081, JBT 37/35, EC 319049
Days to maturity (< 70 days)	BM 11, LM 12, EC 304993, JBT 37/35

Total 300 accessions of urdbean were rejuvenated and evaluated for various morphological and quantitative traits. Following genotypes were identified promising for various traits:

Character	Promising accessions
Early flowering (< 40 days)	PGRU 95016, IPU 99-221, PLU 277
No. of primary branches (>3)	HPU 302, PLU 28, UH 8038, UPU 83-3
No. of pods/plant (> 35)	UH 8026, U 135, PLU 446, IPU 99-218
Pod length (>4.5cm)	PU 19, UH 8515, PLU 448, GP 215
No. of seeds per pod (> 5)	TU 91-2, IC 106066, IPU 2K-21, UH 817
100 Seed weight (> 4 g)	UPU 9710, TU 99-2, NHKG 31, IPU 96-12
Days to maturity (< 72 days)	PLU 28, UH 99-144, IPU 99-24, PLU 277

Lentil

Total 257 accessions of active germplasm and 237 accessions of core collection were maintained and evaluated for different traits. Total 450 accessions received from NBPGR were evaluated for agronomic traits in Kanpur conditions. Genotype IG 560150 was identified for earliness (<60 days flowering) and used in breeding programme. Accession EC 78933 was identified for short internode length. IPL 98/193 identified earlier as donor for root traits showed tolerance to drought among 58 entries of active germplasm evaluated under drought conditions in rain-out shelter. One thousand accessions of base collection were also rejuvenated.

Genetic Enhancement of Pulses through Distant Hybridization

Wild accessions of different crops including 29 accessions of lentil *(L. culinaris, L. odemensis, L. orientalius* and *L. ervoides*), 17 of chickpea (*C. pinnatifidum, C. judaicum, echinospermum, C. reticulatum* and *C. cuneatum*) and 54 of *Vigna* (*V. trilobata*, *V. umbellata*, *V. radiata* var. *radiata*, *V. delzelliana*, *V. mungo* var. *mungo*, *V. hainiana*, *V. radiata*, *V. pilosa*, *V. vexillata* , *V. mungo* var. *sylvestris*, *V. radiata* var. *sublobata*, *V. radiata* var. *setulosa*, *V. mungo*, *V. unguiculata*, *V. trinervia* var. *bournei*, *V. triervia*, *V. glabrescens* and *V. mungo* var. *sylvestris*) were maintained. These were raised in pots as well as field after scarification. Distant crosses were also attempted between wild accessions (*L. orientalis* and *L. odemensis*) and cultivated lentil. Similarly, in chickpea, successful crosses were attempted between *C. reticulatum* and *C. arietinum* (cv. Pusa 256 and Vijay).

Efforts toward standardization of double haploidy protocol were also continued in Narayen, Xena and Bumper genotypes of chickpea. Green proliferating calli were obtained and 100% callus regeneration was recorded on modified B5 medium supplemented with 5 ppmTDZ/0.50 mg/L kinetin and 2mg/L 2,4-D and 30 g sucrose.

Quality Breeding in Lentil

Twenty genotypes were grown in pots. In control, one set was grown in pot having soils with no use of addition Zn and Fe, while another set of same genotypes was grown in pots having soils treated with standard dose of Fe and Zn. The plants were harvested at the time of flowering and at the time of maturity. Analysis of seed sample showed highest Zn (28.75 ppm) in genotype FLIP 95-34L and highest Fe (63.25 ppm) in FLIP 2003-25L.

Breeder Seed Production

Total 560 q breeder seed of three varieties each of chickpea (DCP 92-3, Shubhra and Ujjawal) and pigeonpea (Bahar, NDA 1, UPAS 120), four varieties each of lentil (DPL 62, DPL 15, IPL 81 and IPL 406), fieldpea (Adarsh, Prakash, Vikas and Aman) and mungbean (Samrat, Meha, IPM 02-3 and IPM 2-14) and two varieties of urdbean (Uttara and IPU 2-43) was produced. Nucleus seed of these varieties has also been produced for production of breeder seed in 2013-14.

Externally Funded Projects

Breaking Yield Barriers in Lentil through Introgression of Useful Genes from Unadapted Landraces and Wild Gene Pool

Maintenance of wild species and landraces

Seventy two accessions of five wild species (*Lens orientalis, L. odemensis, L. nigricans, L. erevoides* and *L. tomentosus*) and 118 accessions of Mediterranean land races were maintained.

Generation of F_1 and F_2 seeds

F_1 seeds were harvested from 5 fresh crosses between wild accessions (*L. orientalis* and *L. erevoides*) and land races (3 crosses), and cultivated species (2 crosses). F_2 seeds were harvested from 32 F_1 plants derived from 21 crosses involving wild species (*L. orientalis* and *L. odemensis*) as one of the parents. F_2 populations derived from cross made between cultivated and *L. orientalis* showed segregation for earliness, leaf size, seed size and biomass. These F_2 populations were advanced through SSD and single plant was harvested for advancing in F_3. The F_2 population derived from cross made between cultivated and land race of Ethiopia (IG 69513I×DPL 15) showed segregation and recombinants were identified and selected for strong stem and 3-4 pods/peduncle. Donor ILWLS 118 identified earlier for earliness (<90 days maturity) was validated under different sowing dates.

Evaluation for heat tolerance

Three accessions *viz*., FLIP 2009-55L, IG 2507 and IG 4258 along with 118 land races were grown under late condition for validation and identification of heat tolerant genotypes.

Genotyping of selected genotypes using SSR markers

DNA was isolated from wild species and land races for molecular characterization with SSR markers. Impact of gene introgression from Mediterranean germplasm was studied among 21 genotypes including exotic lines on the basis of SSR markers and five phenotypic traits. Among 65 SSR markers, 43 showed polymorphism.

Pre-breeding and Genetic Enhancement in Breaking Yield Barriers in *Kabuli* Chickpea

Maintenance of wild species and land races

Total 120 exotic germplasm lines, 165 exotic land races and 82 accessions of 7 wild *Cicer* species *viz*., *Cicer reticulatum, C. echinospermum, C. pinnatifidum, C. bijugum, C. judaicum, C. cuneatum* and *C. chorassanicum* from ICARDA accessions are being maintained. To assess the variability for different traits, 71 accessions belonging to 7 wild *Cicer* species were evaluated. All accessions of 6 wild *Cicer* species had 1-2 seeds/pod where as acc. EC 600098, belonging to *C. cuneatum* had 5-6 seeds/pod though seeds size was very small.

Hybridization

Six interspecific crosses and 3 crosses using land races and desirable agronomic base were made to broaden the genetic base and develop suitable tall and erect plant types.

Improving Heat Tolerance in Chickpea for Enhancing its Productivity in Warm Growing Conditions and Mitigating Impacts of Climate Change

Performance of genotypes under heat stress conditions

Genotypes *viz.*, ICC 7118, ICC 7102, ICC 4958, JGK 2, JG 14 (ICCV 92944), ICC 7117, JG 130, NBeG 3 and Vaibhav were observed as promising. Similarly, out of 81 advance breeding lines, IPC 2008-57, IPC 2008-11, IPC 2006-77, IPC 2006-126, IPC 2006-127, IPC 2007-09, IPC 2007-28, IPC 2007-29, IPC 2010-219, IPC 2011-30, IPC 2009-50, IPC 2005-59, IPC 2010-37, IPC 2010-62, IPC 2011-86 and IPC 2011-123 performed well. ICC 10685 and ICC 4567 were identified as most sensitive to heat stress.

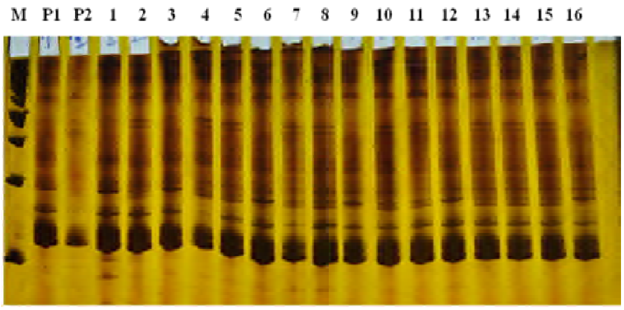
Screening against heat stress

Breeding material generated

Eight crosses were advanced to elucidate mechanism of heat tolerance and transfer heat tolerance in desirable agronomic background. Four crosses were advanced to collect F_3 seeds. Besides these, 5 F_2, 2 F_3 and 7 F_4 were also advanced and SPS are being evaluated under heat stress conditions.

Deployment of Molecular Markers in Chickpea Breeding for Developing Superior Cultivars with Enhanced Disease Resistance

Fifty one BC_2F_1 plants (Pusa 256×Vijay) were subjected to foreground selection using the markers TA 110, TA 96 and TA 37 and 16 plants were heterozygotes at marker loci. Background selection of these 16 plants with 36 markers resulted in 71-91% recovery of Pusa 256 genome (Fig. 2). Eight plants showing highest genome recovery (80-91%) were further backcrossed with Pusa 256 and 122 BC_3F_1 seeds were obtained. Total 22 BC_2F_1 plants were identified as heterozygotes at TA 96 and TR 19 marker loci in another cross (Pusa 256×WR 315). These plants were backcrossed with Pusa 256 and 86 BC_3F_2 seeds were obtained.



Lane M: 100 bp ladder: P1 (Pusa 256), Lane: P2 (Vijay), Lane 1-16: BC_2F_1

Fig. 2: Foreground selection for resistance to FW (*foc* 2) in cross Pusa 256×Vijay with marker TA 37

Selection and Utilization of Water-logging Tolerant Cultivars in Pigeonpea

Five pigeonpea lines, *viz.*, NA 1, IPAC 79, IPAC 42, IPAC 76 and LRG 30 showed relative tolerance against water-logging last year. These five putative water-logging tolerant lines along with highly sensitive line ICPL 7035 were tested under water-logged and normal conditions. Highest mortality was observed in ICPL 7035, while genotype IPAC 79 showed tolerance to water-logging.

Genotype IPAC 79 under water logging

Forty nine other entries were also evaluated for water-logging tolerance. Highest plant survival rate after water logging was observed in ICP 5028 (88.10%), followed by LRG 30 (85%). However four entries *viz.*, ICPB 2043, ICPL 87091, ICPL 87051 and ICPL 7035 showed sensitivity to water logging. Highest chlorophyll difference before and after water-logging (> 10 units) was observed in ICPL 88034, ICPL 20117 and ICPL 20125. The root capacitance before and after water-logging was shown in ICP 8857 (0.09) and Asha (0.14). Though water-logging significantly delayed the initiation of flowering (7-15 days) in most of the entries, it was observed up to 30-46 days in ICPB 2039 (30 days), ICPL 20238 (33 days), ICPH 2431 (45 days) and ICPL 2376 (46 days).

Evaluation and Production of Cytoplasmic Genetic male sterility (CGMS) based Hybrids for Enhancement of Productivity and Stability of Yield in Pigeonpea

Hybrid variety developed

An early maturing high yielding pigeonpea hybrid IPH 09-5 (average yield 1864 kg/ha) developed from a cross between PA 163A (CGMS line or 'A' line or female parent) and 261322 R (restorer line or 'R' line or male parent) has been identified for NEPZ. This hybrid possesses >33% superiority in grain yield over the best existing variety UPAS 120. It is resistant to *Fusarium* wilt and sterility mosaic diseases and has brownish red colour and round shape seeds and 9.3 g/100 seed weight. It matures 8-10 days earlier as compared to UPAS 120.

Development of F_1 hybrids

Fifteen crosses were attempted involving eight early maturing CMS lines *viz.*, AL 101 A, UPAS 120 A, PA 163 A, CoRG 990047 A, CoRG 990052 A, ICP 2039A, ICP 2089 A and GT 30 A and 4 restorers *viz.*, 261354 R, 261322 R, 250157R and 250173R.

Evaluation of early hybrids in coordinated trials

IHT (Early): In IHT (Early) trial of NZ, two hybrids *viz.*, IPH 12-3 (3185 kg/ha) and IPH 12-4 (2955 kg/ha) were superior to best check UPAS 120 (2147 kg/ha) by 48.34% and 37.63%, respectively. Similarly, three hybrids *viz.*, IPH 12-3 (2168 kg/ha), IPH 12-4 (2098 kg/ha) and IPH 12-1 (2016 kg/ha) were superior to best check UPAS 120 (1579 kg/ha) by 37.30, 32.86 and 27.67%, respectively.

AHT 1+AHT 2 (Early): Two hybrids, *viz.*, IPH 11-1 (2740 kg/ha) and IPH 10-2 (2588 kg/ha) out yielded the best check UPAS 120 (2268 kg/ha) by 20.81% and 14.11%, respectively at main farm of the Institute. However, at new research farm, both these hybrids yielded 2298 kg/ha (IPH 11-1) and 2375 kg/ha (IPH 10-2) with yield superiority of 42.55% and 47.33%, respectively over the best check UPAS 120 (1612 kg/ha).

Station trial: Three hybrids *viz.*, UPAS 120×AK 261322 (2654 kg/ha), ICP 2039×AK 250173 (2456 kg/ha) and ICP 2039×Co 1 (2413 kg/ha) showed 32.76%, 22.86% and 20.71% yield superiority, respectively over UPAS 120 (1999 kg/ha). Overall, hybrid UPAS 120×AK 261322 was found to be best performer.

Transfer of male sterility into genetically diverse backgrounds

CMS line ICP 2089A was used as female parent for transferring its male sterility to Pusa 992, which was used as male (recurrent) parent. Sufficient BC_5F_1 seeds have been harvested. Also, BC_5F_1 seeds were harvested from BC_4F_1 plant of GT 288A×ICP 88039 by using ICP 88039 as male recurrent parent for transfering the male sterility of GT 288 A in ICP 88039.

Maintenance of parental lines

Twenty one crosses were carried out between 21 A lines and their respective B lines for maintaining these A lines of early, mid-late and long duration group for development of hybrids. Twenty one maintainer lines and sixty one (36 early, 14 medium and 11 long duration) restorer lines were maintained by strict selfing by covering the single plants with nylon net.

National Initiative on Climate Resilient Agriculture

Evaluation of pigeonpea, greengram and blackgram germplasm for drought and temperature extremities

Sources of resistance

Sources of drought resistance in pigeonpea were explored in wild species *C. sericious*, *C. scarabaeoides* and *C. aquitifolius* based on osmotic adjustment. Some of these wild sps showed very high osmotic adjustment (OA) up to 2.5 MPa under drought. Out of fifty pigeonpea genotypes from ICRISAT evaluated, BDN 2008-1, Bennur Local, ICP1156, BDN 2008-12, TJT 501, GRG 2009, ICP 995, ICP 4575, ICP 1126, JKM 7, JKM 189 and ICP 14832 appeared to be superior at pod filling stage under rainfed condition.

Blackgram genotype PGRU 95016 identified as photo-thermo-insensitive and thermo-tolerant is able to flower at both 10 and 16 h photo-period at 25/15 and 36/20^{0}C max/min temperature regimes and pollen germination at 43^{0}C. Two wild accessions of *Vigna viz.*, *V. glabrescens* (IC 251372) and *V. umbellata* (IC 251442) were identified as photo-thermo insensitive.

Based on multilocation evaluation, 12 promising genotypes identified in greengram *viz.*, IPM 02-16, IPM 9901-10, IPM 409-4, IPM 02-3, PDM 139, IPM 02-1, IPM 2-14, IPM 9-43-K, PDM 288, EC 470096, IPM 2K14-9 and IPM 2K14-5 have been confirmed to be tolerant to heat and drought.

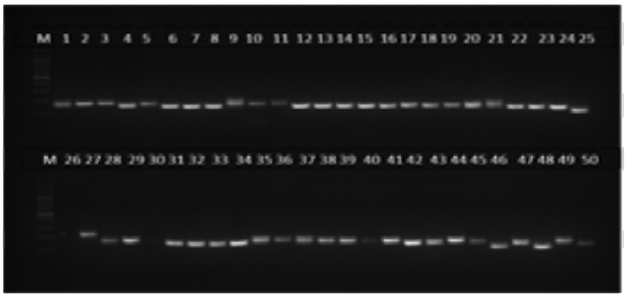
Based upon sucrose synthase activity and protein profiling as biochemical markers, promising greengram (mungbean) genotypes *viz*., PDM 139 (Samrat), IPM 02-1, PDM 288, IPM 05-3-21and ML-1257 are presently under field trial across diverse agroclimatic zones prone to be affected by recurrent high temperature stress.

Effect of high temperature and CO_2

High CO_2 induces closure of stomata and inhibits photosynthesis in blackgram. High temperature x CO_2 interaction studies revealed negative impact on greengram and blackgram both. Results indicated formation of leaf starch at high CO_2 leading to poor assimilate export from source to sink and grain filling is adversely affected. The high carbon dioxide is however beneficial after setting of strong sinks *i.e.*, developing grains with high sucrose synthase activity.

Molecular marker analysis

Molecular marker analysis was done in 58 genotypes of *Vigna* including 50 wild accessions and 4 standard check cultivars each of mungbean and urdbean. These genotypes were subjected to SSR screening using already reported 87 primer pairs from *Phaseolus*, adzuki bean, mungbean and urdbean background. Till now, 52 SSRs have been screened for diversity analysis in all 58 accessions, among which 40 were found polymorphic, while 12 were found monomorphic (Fig. 3).



Lane M: 100bp ladder, 1-50: Vigna accessions

Fig. 3: Screening of wild accessions of *Vigna* with 'X65' marker from adzuki bean background,

Screening for frost tolerance

Pigeonpea genotypes *viz*., IPAC 76, IPAC 77, IPAC 78, IPAC 80, IPAC 85, IPAC 114, IPAC 127, IPAC 245 CP 246, Amar and IPA 16F showed less flower and pod drop in peak winter as compared to other long duration lines. Five germplasm lines exhibited less damage to frost in low lying areas. Visual observations on flowering and pod development indicated that IPAC 234 and IPAC 114 have better recovery (Fig. 4).

Fig. 4 : Frost damage (left) and recovery (right)

Crop Production

Long Term Fertility and Cropping Systems Studies

Permanent trials were initiated in 2003 on maize and rice based cropping systems involving pulses to study their long term impact on crop productivity and soil quality under intensive cropping systems.

Maize based cropping system

Four cropping sequences *viz.*, maize-wheat (MW), maize-wheat-mungbean (MWMb), pigeonpea-wheat (PW) and maize-wheat-maize-chickpea (MWMC) were evaluated at three nutrient management practices *viz.*, control, integrated (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 NPKSZnB). Inclusion of pulses in the cereal based system increased the system productivity as well as yield of component crops. Highest pigeonpea equivalent yield (PEY) of 3411 kg/ha was recorded in maize-wheat-mungbean system and the trend was MWMb>PW>MWMC>MW (Fig. 5). Among different nutrient management practices, inorganic recommended fertilization (NPKSZnB) had highest system productivity, followed by integrated (crop residue+biofertlizer +FYM @ 5t/ha + 50 % NPKS) and control (Fig. 6).

Rice based cropping system

Four rice based cropping systems *viz.*, rice-wheat (RW), rice-chickpea (RC), rice-wheat-mungbean (RWMb) and rice-chickpea-rice-wheat (RCRW) were evaluated at three fertilizer management systems *viz.*, control, integrated (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 NPKSZnB). Inclusion of pulses in the cereal based system increased the system productivity as well as yield of component crops. Highest system productivity of 5140 kg/ha in terms of chickpea equivalent yield (CEY) was recorded in rice-wheat-mungbean system and the trend was RWMb>RC>RWRC>RW (Fig. 7). Among different nutrient management practices inorganic (NPKSZnB) recommended fertilization had higher system productivity over integrated (crop residue +biofertlizer+FYM @ 5t/ha + 50 % NPKS) and control (Fig. 8).

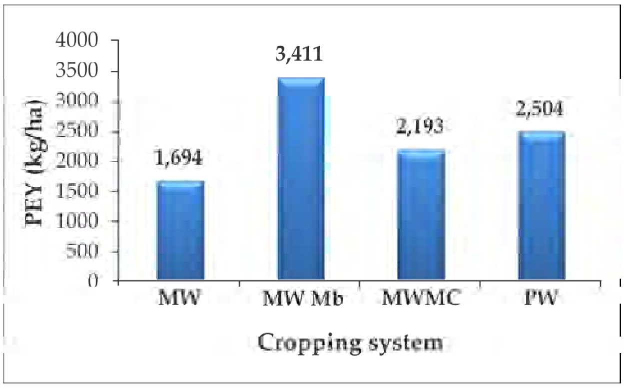


Fig. 5 : Pigeonpea equivalent yield as influenced by different cropping systems in maize based system

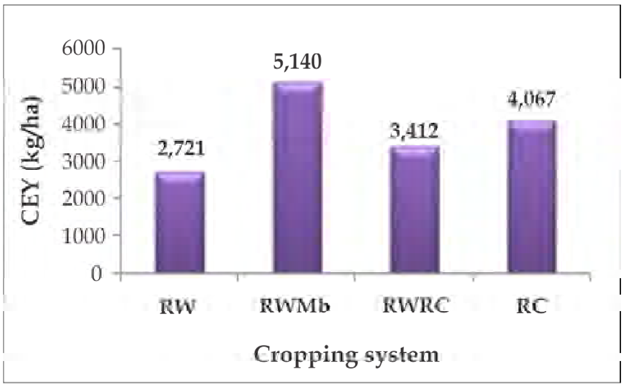


Fig. 7 : Chickpea equivalent yield as influenced by different cropping systems under rice based system

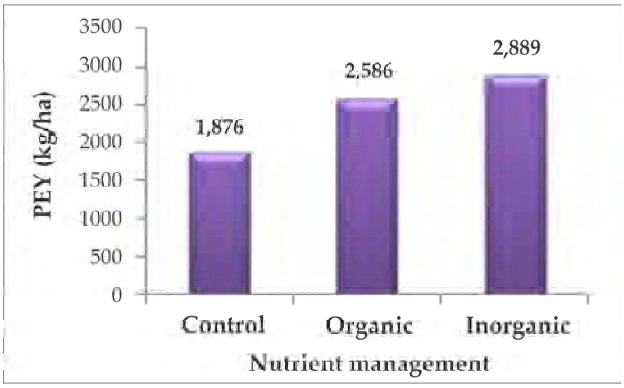


Fig. 6 : Effect of nutrient management on pigeonpea equivalent yield in maize based system

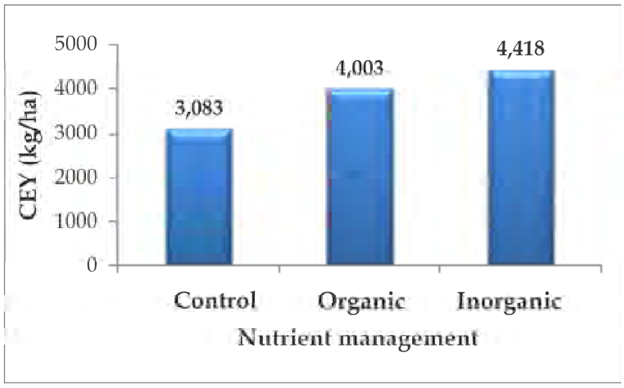


Fig. 8 : Effect of nutrient management on system productivity in lowland rice based system

Nutrient Management

Phosphorus and sulphur management in maize-chickpea cropping sequence

A field experiment on the effect of phosphorus and sulphur on maize–chickpea cropping sequence was initiated comprising of 3 levels of P (0, 30 and 60 kg P_2O_5/ha) and 2 levels of FYM (0 and 5 t/ha) applied to maize, 4 treatments of sulphur *viz.*, (1) No sulphur to maize and chickpea (M0C0); (2) 30 kg S/ha to maize and no sulphur to chickpea (M30C0); (3) No sulphur to maize and 30 kg S/ha to chickpea (M0C30) and (4) 15 kg S/ha each to maize and chickpea (M15C15). There was 12, 26 and 7 per cent increase in grain yield of maize due to application of 60 kg P_2O_5, 5t FYM and 30 kg S/ha, respectively, as compared to their respective control treatments. Similary, an increase at 16, 15 and 11.7% in chickpea grain yield was recorded with application of FYM, phosphorus and sulphur, respectively, as compared to control. Nodulation and growth attributes of chickpea were also significantly increased due to application of P, S and FYM.

Effect of S, Zn and FYM levels on rajmash

A pot experiment was conducted in rajmash (Cv. PDR 14) to evaluate the effect of S (0, 15 and 30 kg/ha), Zn (0 and 10 kg $ZnSO_4$/ha) and FYM (0 and 10 t/ha) in 2 soil types *viz.*, virgin and cultivated soil. Biomass and pod number/plant were significantly improved with application of S, Zn and FYM (Fig. 9). 30 kg S/ha+10 kg Zn/ha+10 t FYM/ha recorded highest biomass/plant (30.9 and 42.7 in virgin and cultivated soil, respectively). The pod number/plant was also maximum in this treatment (12.6 and 26.0 in virgin and cultivated soil, respectively) indicating good response of rajmash to application of secondary (S) and micronutrient (Zn) in presence of organic manure in Inceptisols.

Fig. 9. Effect of S, Zn and FYM levels on rajmash

Carbon dynamics and carbon sequestration potential in pulses

Long term effect of cropping system and applications of organic and inorganic amendments on total soil organic carbon and different soil C fractions was evaluated. Soil organic carbon (SOC) fractions *viz.*, C*frac* 1 to 4 were analysed based on their oxidizability under 12 N and 18 NH_2SO_4. Inclusion of pulses in riec-wheat (RW) and maize-wheat (MW) cropping systems increased soil organic carbon and its different fractions. Inclusion of summer mungbean in RW and MW systems improved the total organic carbon content, being greater in surface soil (0-0.2 m depth). In both the production systems, crop rotation had significant effect on labile fraction of the TOC. Application of crop residues along with FYM @ 5 t/ha and biofertilizers resulted in greater amounts of carbon fractions and highest lability and carbon management index (CMI) over control and the recommended inorganic (NPKSZnB) treatment, particularly in the system where mungbean was included. Inclusion of pulses in the cereal-cereal system and the organic nutrient management system sequestered more soil organic carbon and maintained better soil health (Fig. 10 & 11).

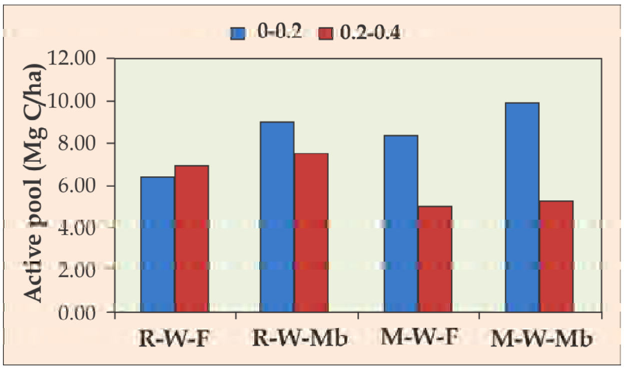


Fig. 10 : Effect of cropping system on active carbon pool under maize and rice based system

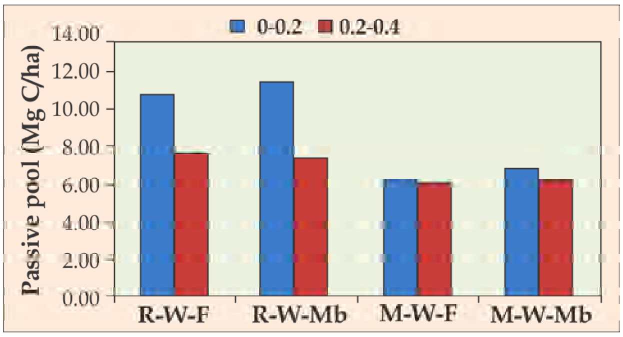


Fig. 11 : Effect of cropping system on passive carbon pool under maize and rice based system

Resource Conservation Technology

Conservation tillage and residue management in pulse based system

A field experiment on effect of resource conservation technology in pulse based cropping system was evaluated which included 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). Yield of summer mungbean was higher in case of residue incorporation (13%) and zero tillage (7%) in comparison to no-residue (1528 kg/ha) and conventional tillage (1481 kg/ha), respectively. Highest system productivity in terms of chickpea equivalent yield was obtained in rice-chickpea-mungbean (6546 kg/ha), followed by rice-wheat (4424 kg/ha) (Fig. 12).The improvement in soil fertility status was recorded after three years of crop cycle in case of residue incorporation as well as in pulse based cropping systems (Fig. 13).

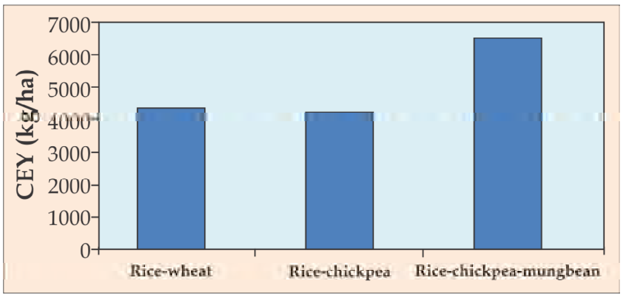


Fig. 12 : Chickpea equivalent yield under different cropping systems

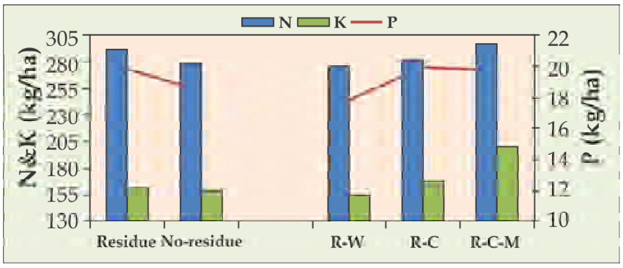


Fig. 13 : Soil fertility status under residue management and pulse based cropping systems

Performance of maize-chickpea cropping system under permanent raised bed

A study was initiated during *kharif* 2011 to maximize the system productivity of maize-chickpea cropping system under permanent raised bed. A raised bed of 75 cm width was prepared during *kharif* season with tractor drawn raised bed maker on which maize was grown. Maize grain yields ranged between 4029-4515 kg/ha. During *rabi* season, 2 and 3 rows of chickpea was grown on raised bed after reshaping the bed with raised bed maker. Intercropping of leafy vegetables like fenugreek and spinach were taken in furrows to utilize the available space during early post-rainy season. Three weed management practices *viz*., control, mulching and chemical methods were also used. During second year, appreciable quantity of fenugreek (556 kg/ha) and spinach (1829 kg/ha) was harvested green at 38-40 days after sowing (Fig. 14). Chickpea yield was also not influenced by any of the above factor. However, highest chickpea equivalent yield (3712 kg/ha) was obtained in maize-chickpea+spinach system, followed by maize-chickpea+fenugreek (3500 kg/ha) and lowest in maize-chickpea system.

Fig. 14. Intercropping of spinach in furrows

Conservation of soil moisture through tillage and mulch in chickpea under rice-chickpea system

A study was initiated during *kharif* 2010 to see the effect of soil moisture conservation practices on chickpea productivity under rice fallows. Transplanted rice was grown during rainy season and chickpea was grown under residual soil moisture condition. Five moisture conservation treatments comprised of zero tillage+dibbling sowing+mulching, zero tillage+no till drill sowing+mulching, deep tillage (disc plough+harrow), deep tillage+mulching and conventional method (harrow+ cultivator). Highest chickpea grain yield (2140 kg/ha) was recorded in zero till+seed drill, followed by zero till+dibbling (2060 kg/ha) and were significantly higher than conventional tillage (1858 kg/ha).

Moisture and nutrient conservation in pearlmillet-chickpea sequence

The effect of pulse intercrop, soil moisture conservation practices and nutrient management options on chickpea productivity was assessed in pearlmillet (Cv. Proagro 9444) intercropped with greengram and cowpea - chickpea (Cv. JG 16) system. The treatments comprised of pearlmillet sole, pearlmillet+cowpea, pearlmillet+greengram in main plot, mulch, mulch+one irrigation, mulch+two irrigation in sub-plot and 75% RDF, 100% RDF in sub-sub plot. Highest pearlmillet equivalent yield (3612 kg/ha) was recorded when pearlmillet was intercropped with greengram, followed by pearlmillet+cowpea (3227 kg/ha) and lowest under pearlmillet sole (2635 kg/ha). Among moisture conservation practices, highest relative water content (62.15%) in chickpea was observed in mulch + one irrigation being at par with mulch+two irrigations, followed by mulch (56.17%). Significant improvement in relative water content at 90 DAS was recorded (Fig. 15) when chickpea was grown with 100% RDF (61.18%) over 75% RDF (59.13).

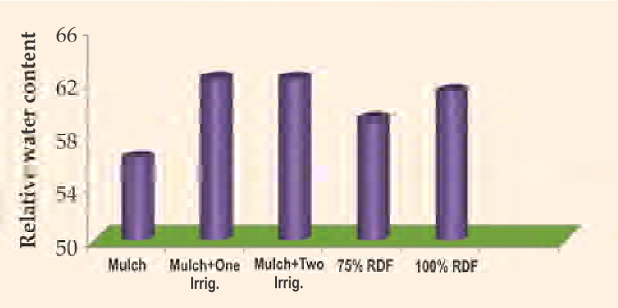


Fig. 15: Relative water content (%) of chickpea leaves at 90 DAS

Evaluation of transplanted pigeonpea

Three to five weeks old seedlings raised in polythene bags packed with soil and FYM mixture (1:2) were transplanted in ridges/flat in the moist field by mid-August. This trial was carried out in case of transplanted pigeonpea as a potential measure for compensating the yield loss due to low plant population. Adequate number of healthy plant stand could be maintained through transplanting of polyethylene raised seedlings as a measure of crop contingency. The plants grew vigorously under simulated upland condition (ridges) thereby escaping from both water stagnation and seedling blight. The plants performed well under both ridge planting and 3 weeks after transplanting (of polythene bag raised seedling) in comparison to flat planting and other transplanting schedules. Ridge transplanted seedlings performed 27.4% better over flat planted. Three weeks old seedlings raised in polythene bags significantly out-performed the older seedlings (4 and 5 weeks). Thus, polyethylene raised transplanted pigeonpea has potential to produce 30% higher yield over direct seeded one grown *in situ* (Table 1).

A field trial on further refinement of transplanting method as a measure towards possibility of replacing a certain number of seedling (per cent basis) on the gaps due to seedling mortality under normal seeding (through transplanting as a contingency measure) was taken up. The treatments included 0 (*in situ*), 10, 20% replacement of gaps (dying or dead seedling on number basis) through transplanting and sole transplanting at 3 and 4 weeks. Based on biometrics and other attributes, it revealed that partial replacement to the extent of 10% was feasible and most economical. Transplanting at 3 weeks was superior over 4 weeks (Fig. 16).

Table 1. Effect of transplanting methods and age of polythene raised seedlings of pigeonpea

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Net return (x000' Rs/ha)	BCR
Planting method				
Flat	3088	6262	46.7	2.03
Ridge	3933	7473	73.1	2.49
C.D. (0.05)	471	NS	15.6	0.28
Age of transplanted seedling				
3 weeks	4851	9326	107.2	3.03
4 weeks	3668	7898	67.0	2.23
5 weeks	3064	5075	44.0	1.78
In situ seeding	3699	6850	92.3	4.12
C.D. (0.05)	881	2589	29.1	0.52

Water Management

Efficient management of water for higher productivity in pulses

To study the efficient utilization of water and nutrients through drip-irrigation and its economic viability in pulses, a field experiment was carried out with three irrigation schedules (0.4, 0.6 and 0.8 IW/CPE ratio) and five pigeonpea based intercropping in combination with irrigation *viz*., pigeonpea (NA 1) sole as rainfed in raised bed (control) with RD-NPK at planting (S1), pigeonpea+urdbean (IPU 2-43) on raised bed+drip-fertigation of ½ NK during branching and pod development of pigeonpea (S2), pigeonpea+urdbean on raised bed+furrow irrigation during critical stages with RD-NPK at planting (S3), pigeonpea+sorghum (MSH 51) on raised bed+drip-fertigation with ½ NK during branching and pod development of pigeonpea (S4) and pigeonpea+sorghum on raised bed+furrow irrigation during both the critical stages with RD-NPK at planting (S5). The intercrops of urdbean and sorghum were adjusted in the inter-row space of pigeonpea (Fig. 17). The crop was given the recommended dose of fertilizers except the intercrops (with 50% NPK as per area occupied). It was observed that mean seed yields to the tune of 4.3 and 20.7 q/ha (50% area basis) were realized with urdbean and sorghum intercropping, respectively (Table 2) in addition to normal seed yield

Fig. 16. Performance of transplanted pigeonpea at 3 *versus* 4 weeks

Fig. 17 : Intercropping of pigeonpea+sorghum/urdbean (2:2) in raised bed of 60-120x20 cm (paired row)

Table 2. Effect of irrigation treatments on intercrop yield (kg/ha)

Treatment	Urdbean		Sorghum	
	Seed	Stalk	Grain	Straw
Pigeonpea	-	-	-	-
Pigeonpea +urdbean (drip)	433	820	-	-
Pigeonpea +urdbean (furrow)	434	1019	-	-
Pigeonpea +sorghum (drip)	-	-	2029	3997
Pigeonpea +sorghum (furrow)	-	-	2126	3849
CD(P=0.05)	NS	103	NS	NS

of main crop of pigeonpea. Since both the intercrops were grown during rainy months (up to 90 days), water was not limiting during its growth period.

Influence of precision tillage on crop water use and productivity in summer pulses

A study was undertaken on the role of precision tillage through application of laser principle for land levelling in combination with normal preparatory (sowing) tillage on crop water use and productivity especially in summer pulses. Possibility of saving of water through precision irrigation (through micro-sprinkler) as a water saving measure under dry and hot summer was explored taking summer mungbean and urdbean grown as catch crops during spring/ summer.

Evaluation of laser leveller and precision irrigation (micro-sprinkler) in urdbean

Weed Management

Post-emergence herbicide for *kharif* mungbean

A field study was continued for second year to optimize the dose of imazethapyr - a post-emergence herbicide in mungbean, applied @ 40, 60, 80, and 100 g/ha alone and in combination with pre-emergence (PE) pendimethalin @ 1.25 kg/ha. Major weeds at the experimental site were *Digera arvensis, Commelina benghalensis, Digitaria sanguinalis, Panicum sp.* and *Cyperus rotundus*. Highest weed number (403/m^2) at 35 DAS was recorded in application of imazethapyr @ 40 g/ha, followed by imazethapyr @ 60 g/ha and lowest in pendimethalin @ 1.25 kg/ha+manual weeding (131/m2). However, highest weed biomass (147.7 g/m^2) was recorded in pendimethalin @ 1.25 kg/ha, followed by imazethapyr @ 40 g/ha (92.3 g/m^2) and lowest in pendimethalin @ 1.25 kg/ha+manual weeding (15.4 g/m^2). Significantly higher nodules dry weight (3.75 mg/plant) was recorded in pendimethalin @ 1.25 kg/ha+imazethapyr @ 100 g/ha and lowest in pendimethalin @ 1.25 kg/ha (1.8 mg/plant) (Fig. 18). Highest yield of mungbean (919 kg/ha) was recorded in pre-emergence application of pendimethalin @ 1.25 kg/ha+manual weeding, which was closely followed by pendimethalin @ 1.25 kg/ha+imazethapyr @ 100 and 80 g/ha. Lowest yield of mungbean was recorded in pendimethalin @ 1.25 kg/ha (348 kg/ha).

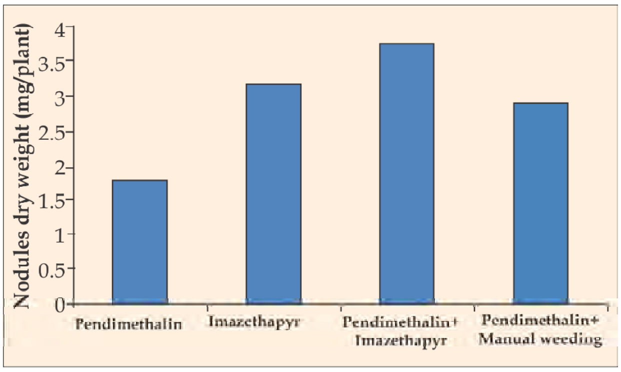


Fig. 18 : Effect of herbicides on nodule dry weight in mungbean

Post-emergence herbicides for chickpea

A field experiment was continued for second year to find out the optimum dose of quizalofop-ethyl in combination with pendimethalin. Different doses of quizalofop-ethyl as 50, 75, 100, 125 and 150 g/ha were applied as post-emergence in combination with pendimethalin @ 1.25 kg/ha as pre-emergence. Major weeds at the experimental site were *Chenopodium album, Anagalis arvensis, Fumaria parviflora, Melilotus indica, Phalaris miner* and *Cyperus rotundus*. Highest yield of chickpea was recorded in pendimethalin @ 1.25 kg/ha+quizalofop-ethyl @ 125 g/ha (1360 kg/ha), which was at par with pendimethalin @ 1.25 kg/ha+manual weeding (1331 kg/ha) and pendimethalin @ 1.25 kg/ha+quizalofop-ethyl @ 150 g/ha (1289 kg/ha). The results of 2 years study suggest that pendimethalin @ 1.25 kg/ha (PE)+quizalofop-ethyl @ 125 g/ha may be recommended for effective control of weeds in chickpea.

Efficacy of imazethapyr in summer mungbean

A field study was conducted during 2011 and 2012 to see the efficiency of imazethapyr in summer mungbean applied @ 40, 60, 80 and 100 g/ha along with pendimethalin. Major weeds present in the summer mungbean were *Trianthema monogyna*, *Portulaca quadrifolia* (Broad leave), *Digitaria sanguinalis*, *Setaria glaua, Panicum maximum* (grassy) and *Cyperus rotundus* (sedges). Sedges (*Cyperus rotundus*) were the dominant weed in the field, followed by grassy and broad leave weeds. Lowest number of sedges was recorded in imazethapyr @ 100 g/ha, followed by imazethapyr @ 80 g/ha and highest in pendimethalin. However, lowest number of grassy weeds were recorded in weed free, followed by imazethapyr @ 80 g/ha, which was at par with imazethapyr @ 100 g/ha and pendimethalin @ 1.25 kg/ha (PE). Similarly, lowest number of broad leave weeds in herbicide treatments was recorded in imazethapyr @ 80 g/ha. Effective control of all types of weeds was recorded in post-emergence application of imazethapyr @ 80 and 100 g/ha. Highest value of weed control index was obtained in imazethapyr @ 100 g/ha (60%) and imazethapyr @ 80 g/ha (55.1%), while it was lowest in imazethapyr @ 40 g/ha (Fig. 19). Maximum yield of mungbean was recorded in post-emergence application of imazethapyr @ 80 g/ha (1017 kg/ha), which was at par with imazethapyr 100 g/ha and weed free and significantly higher over rest of the treatments.

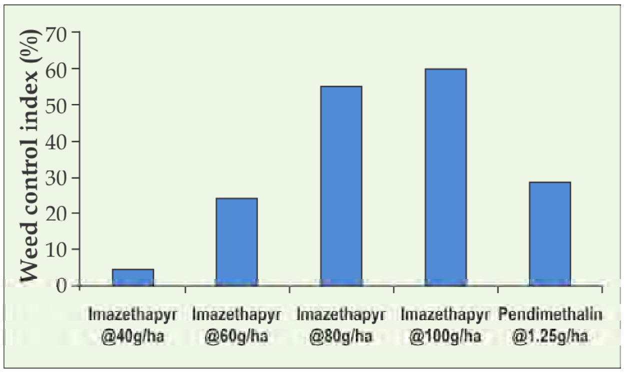


Fig.19: Weed control index of herbicide treatments in summer mungbean

Mechanization for Pulses

Low-cost manually operated no-till drill suitable for rice-fallow condition

In eastern and southern India, pulse seeds are usually broadcast in standing rice fields 10-15 days before rice harvest. No-till drill developed for rice-fallow for Inceptisols was not working properly in Vertisols. Thus, design of manually operated no-till drill was refined for Vertisols (Fig. 20). The modified no-till drill machine can be used for timely sowing of pulses in line at a reduced cost and at proper depth without any residue clogging. It requires low pulling force due to double disc opener fitted with rolling coulter and hence, less drudgery involved in comparison to existing inverted 'T' type no-till drill. It has field capacity of 0.05 ha/h with the help of two manpower and is expected to be used for working on 20 ha per year. The cost of operation of manual zero-till drill is Rs.925/ha (Table 3). This manually operated IIPR No-Till Drill was successfully demonstrated at Aduthurai (Tamil Nadu) under rice fallow condition.

Table 3. Details of refined design of No-Till Drill

Particular	Specification	Field performance
Overall dimensions (LxBxH)	970x520x1380 mm	Operating speed =2.0-3.0 km/h
Source of power	Manual	Field capacity = 0.05 ha/h
Type/no. of furrow openers	Double disc type/01	Labour requirement=40 Man h/ha
Seed and fertilizer metering mechanism	Fluted roller	Cost of operation = 925 Rs/ha (Labor charge @ Rs.185/man-day)
Drive wheel	Circular ring - front mounted	Energy consumption =78.4 MJ/ ha
Seed placement depth	30-50mm, adjustable	

Fig. 20 : Refined No-Till Drill

IIPR Mini *Dal* Mill and development of allied milling machineries

In Satake type grain testing mill, different emery grades (16, 20, 24, 30 and 36 No. mesh grit sizes) were evaluated for water treated pigeonpea, untreated lentil and fieldpea. For water treated pigeonpea 24 grade (Fig. 21), for lentil 16 grade (Fig. 22) and for fieldpea 20 grade (Fig. 23) emery disk were found to yield maximum *dal* recovery.

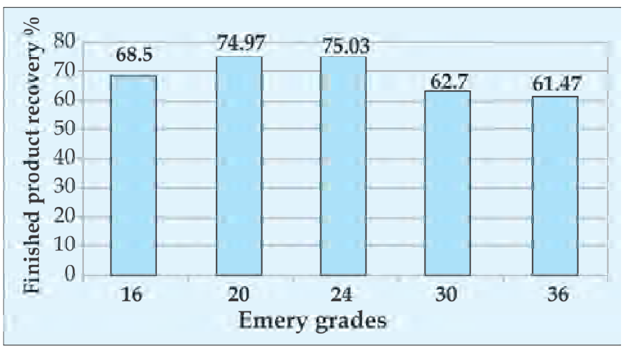


Fig. 21: Evaluation of emery grades for water treated pigeonpea

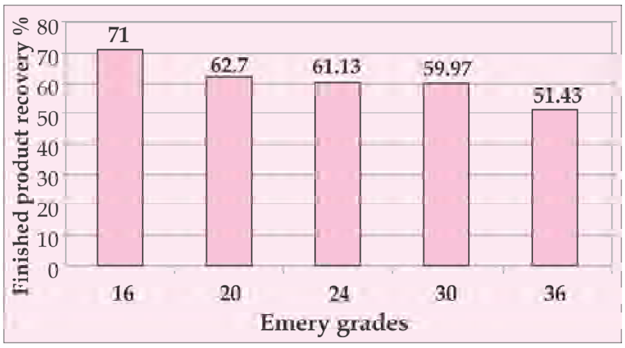


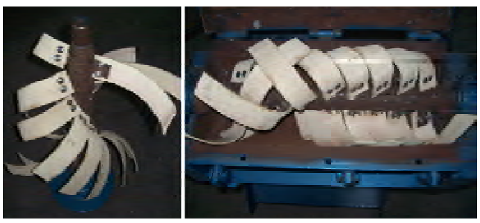
Fig. 22: Evaluation of emery grades for untreated lentil

Fig. 23: Evaluation of emery grades for fieldpea

Experimental *dal* mill was redesigned to accommodate emery disks of different grades and their combination to form a roller:

Nylon belt polisher was designed and developed to accommodate on shaft of experimental *dal* mill:

Nylon rope polisher was designed and fabricated:



Externally Funded Projects

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

In rice-pulse relay cropping system, higher soil moisture (about 40%) was recorded at the time of pulses sowing. After harvest of rice, soil moisture depleted very fast which resulted in formation of cracks in Vertisols within a month (Fig.24). Soil moisture in the experimental black soil ranged from 33% to 35.5% at the time of sowing of urdbean under rice-fallow relay cropping. After the harvest of paddy, the moisture reached to 29.4% in 0-10 cm soil depth. The high tillering and long duration (160 days) variety CR 1009 conserved more soil moisture as compared to medium tillering as well as short duration (135 days) variety ADT 49. Similar results were also recorded in Inceptisols in rice-lentil relay cropping. The stubble cutting height of 30 cm across the rice habit groups conserved significantly more soil moisture than 15 cm cutting height in the surface (0-10 cm) layer. Comparing two urdbean cultivars, ADT 3 was more efficient in conserving soil moisture in comparison to VBN 4. Highest relative water content (89.7%) and specific leaf weight (71.1 g/cm^2) in urdbean (ADT 3) were recorded at 45 DAS under CR 1009 rice with 30 cm stubble height. The same trend was also noticed in case of nodulation, root length as well as root biomass. The tall habit group of rice also maintained higher rhizobium and PSB population in the soil. These resulted in higher numbers of pods/plant and grain yield of urdbean in ADT 3 variety under CR 1009 rice habit group and 30 cm stubble height.

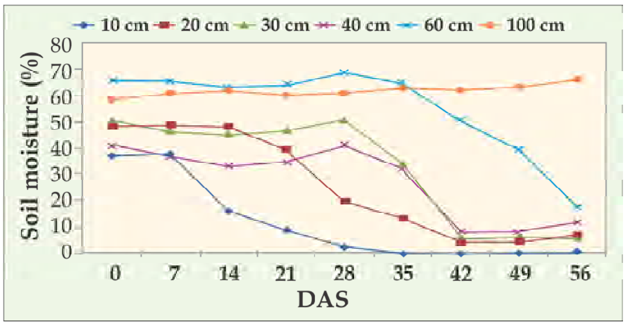


Fig.24: Soil moisture dynamics in urdbean under rice-fallow in Vertisol

The basic infiltration rate of soil after rice harvest was higher in stubbles (9.75 mm/h), followed by mulching (6.75 mm/h) and no-mulch (5.75 mm/h) in Inceptisols in rice-fallow pulse system. Higher basic infiltration rate was also recorded in NPK+FYM applied to rice crop in comparison to NPK and farmers' practice. Soil moisture conservation practices (mulch and stubbles) and improved management practices (NPK+FYM) maintained higher soil moisture during critical crop growth stages of chickpea and lentil under rice-fallow (Fig. 25). Initial soil moisture of surface layer at chickpea sowing was 19-22% which receded to 14-16% in first 15 days, however, the rice straw mulch maintained 2-3% higher soil moisture over no-mulch.

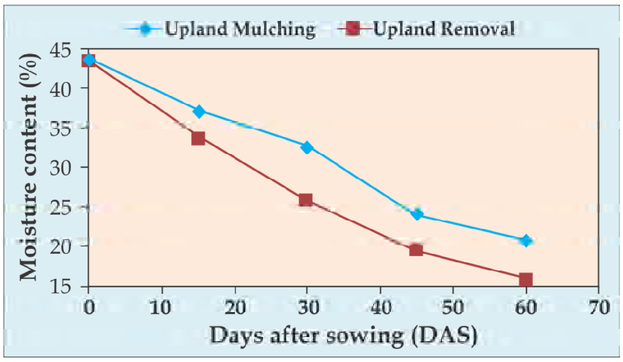


Fig. 25: Soil moisture dynamics in lentil under rice (upland)-fallow condition in NEH region

With the consequence of maintaining higher soil moisture in mulch, stubbles and NPK+FYM, higher relative water content in chickpea leaves was observed under these treatments. Higher SMBC (642.2 mg/kg of soil), dehydrogenase activity (26.25 µg of TPF/g) and free living diazotrophs (62×10^4 cfu/g soil) were recorded in mulch as compared to no-mulch (Fig 26). Improved practice (NPK+FYM) also recorded higher values of these parameters including putative free living diazotrophs.

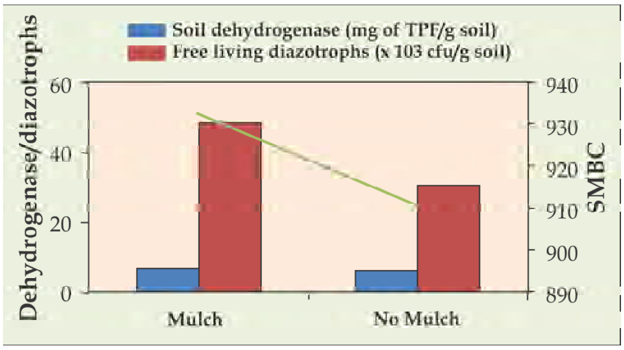


Fig. 26: Effect of mulch on soil biological properties

Major weed flora prevailing in rice fallow-pulse was *Chenopodium album, Convolvulus arvensis, Anagallis arvensis, Cynodon dactylon* and *Cyperus rotundus*. Higher weed number (28/m^2) and biomass (52.9 g/m^2) at 60 DAS was recorded in local rice varieties, than HYV's (Pant Dhan 12). Low weed biomass was recorded in mulching and standing stubble as compared to removal. Weed infestation was less in case of Jaki 92-18, a early high biomass varieties than DCP 92-3 (medium high biomass).

Efficient Management of Water and Nutrients for Enhancing Productivity of Pigeonpea through Drip-fertigation

A field experiment was carried out to assess the critical stage based supplemental drip-fertigation in long duration pigeonpea in comparison to the standard practice. Three planting patterns and five drip-fertigation schedules (rainfed as control, drip-fertigation at branching, pod development and at both branching and pod development, and furrow irrigation at both stages) were evaluated. Seed yield of 3710 kg/ha was realized with drip-fertigation. Planting patterns (paired row, normal/wide row with average crop geometry of 90 x 20 cm) did not influence crop performance, yet split irrigation (2 cm) through drip and fertigation (half of N+K) either at branching or at both branching and pod development produced significantly (19.6 and 21.3%) higher seed yield over rainfed pigeonpea. Drip-fertigation at both the critical stages also out yielded (9.4%) furrow irrigation during second year because of respite from water stress observed following withdrawal of rainfall during late branching and pod development stages (Fig. 27). Other yield traits especially pods/plant, 100 seed weight and harvest index (increase of 6.4%) showed similar trend with that of seed yield (Table 4). Economics of irrigation schedules favoured for higher net monetary returns (Rs. 9650) in terms of both per day profit and productivity under drip-fertigation at branching and branching+pod development.

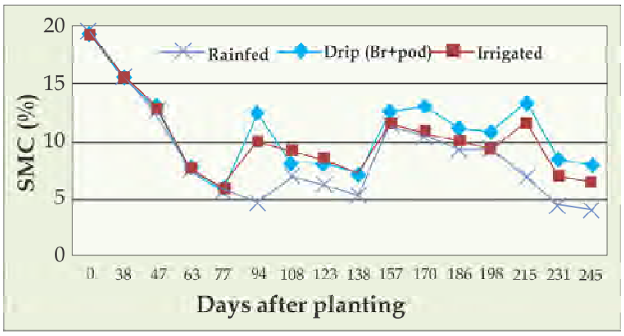


Fig. 27: Periodic soil moisture (SMC %) in soil profile

Table 4. Effect of drip-fertigation on seed yield, yield attributes, harvest index and net returns

Treatment	Seed yield (kg/ha)	Pods/ plant	100 seed wt. (g)	HI (%)	Net return (₹ '000/ ha)	Productivity/ day (kg)
Rainfed	2858	256.0	9.9	29.6	66.4	11.2
Drip^{Br}	3419	305.9	10.5	31.9	74.9	13.5
Drip^{pod}	3092	283.6	9.9	31.3	64.4	12.2
Drip^{Br+pod}	3468	298.4	10.3	32.0	76.1	13.7
Irrign^{Br+pod}	3262	257.0	10.2	31.5	74.5	12.8
CD(P=0.05)	225	40.2	0.3	1.30	7.0	0.9

Crop Protection

DISEASES

Wilt

Chickpea

Total 919 accessions were screened against *Fusarium oxysporum f.* sp *ciceri* (race 2) in wilt sick plot. Disease development was very high with 100% mortality in susceptible check (cv. JG 62).

Stability of donors

Out of 15 wilt resistant donors, two (JG 315 and MPJG 89-9023) were found resistant and seven *viz*., JG 74, BG 212, H 82-2, GPF 2, IPC, BCP 19 and DCP 92-3 were moderately resistant.

Accessions with stable resistance

Among 26 accessions with stable resistance, 13 *viz*., IPC 2004-34, IPC 2005-18, -19, -24, -26, -35, -41(A), -41(B), -45, -46, -52, -64 and JG 315 showed stable resistant reaction for last 7 years. Seven lines *viz*., IPC 2004-3, -8, IPC 2005-15, -37, -44, -54 and -59 were found moderately resistant.

Promising lines

Among 71 promising lines, 17 *viz*., GLK 20127, -26171, IPC 187, L 550, CSJK 46, IPC 2007-04, -36, -50, -51, IPC 2010-78, -113, -128, -215, H 06-15, BG 212, -2085, KGD 1253 and P 1-R were found resistant and thirty two lines *viz*., CSJK 54, JG 92-3774, CSJ 515, IPCK 491, IPC 2006-56, IPC 2007-28, -39, -45, -48, -96, IPC 2008-2, -10, IPC 2009-43, -66, IPC 2010-05, -38, -41, -61, -71, -120, -121, -123, -146, -173, -185, GL 27103, H 04-06, H 06-53, W-50(NRL), JG 315, P2 and P3 were found moderately resistant for last 4-5 years.

Among 98 new promising entries, 28 *viz*., IPCK 2011-65, -70, -92, -94, ICCV 004514(101), -008305(127), ICCV O-8116 (129), CSJ 515, P 8, -82, -109, -143, -161, -171, GMG 150, IPC 08-60, GHG 1969, CSJK 54, GLK 28127, NNW 23, -25, -29, -54, -56, -59, -85, -94, -107, -108, -117, -134, -155 and IL 251754 have shown resistant reaction for last 2 years. Entries *viz*., IPCK 2011-28, -31, -59, -72, -78, Phule G 071-02, PS-PBG 5, P 7GL 27104, P 3,-35, -64, -70, -84, -101, -114, GNG 1996, -2005, -2064, IPC 07-56, IPC 2006-77, P 99CSJ513, H 08-93, HK 06-152, NNW 02, -12, -19, -24, -27, -48, -57, -60, -64, -69, -78, -81, -82, -83, -90, -99, -113, -114, -122, -138, -144, -146, -149, -150, W-9 and W-7 were found moderately resistant.

Among 213 AICRP entries, 49 *viz*., P 14, -35, -37, -38, -46, -49, -59, -61,-66, -68, -69, -71, -72, -82, -91, -109, -110, -114, -120, -123, -131,-134, -147, -148, -150, -163, -173, -185, -188, W-2, -5, -6, -7, -8, -11, -16, -18, -22, -23, -24, -25, -26, - 34, -36, -41, -42, -49, and -52, were found resistant, while 57 *viz*., P 17, -22, -23, -24, -25, -29, -32, -36, -40, -45, -54, -55, -56, -64, -65, -67, -74, -79, -80, -81, -83, -86, -96, -97, -100, -107, -111, -113, -116, -117, -124, -127, -138, -141, -151, -154, -162, -164, -170, -191, -194, -196, W 1, -3, -4, -10, -17, -20 -31, -32, -33,-38, -39, -40, -43, -47 and -48 were moderately resistant.

Among ICRISAT wilt nursery, 7 *viz*., ICCV 03706, -04514, -07306, -08113, -08123, -08125, -08305 were resistant, while 12 *viz*., ICCV 07107, ICCV 07111, ICCV 07118, ICCV 07304, ICCV 08116, ICCV 08117, ICCV 08120, ICCV 08124, ICCV 08505, ICCV 08523, ICCV 11322 and ICCV 08310 were moderately resistant.

Among 452 breeding lines, 45 such as IPCK-12-129, -132, -141, -156,-258, -267, -269, -275, -278, -281, -282, -284, -289, -291, -293, -294, -296, -306, -310, IPC-12-03, -10, -18, -20, -28, -48, -59, -62, -63, -88, -92, -99, -108, -115, -117, -182, -184, -186, -192, -197, -198, -245, -246, ILC 10729, ILC 8666 and 8632 were found resistant, while 72 *viz*., IPCK12-136, -137,-138, -140, -143, -144, -157, -159, -160, -161, -254, -255, -256, -260, -261, -262, -270, -280, -285, -290, -297, -307, IPC12-04, -02, -05, -07, -09, -11, -13, -19, -21, -24, -25, -26, -29, -36, -37,-38, -39, -41, -46, -49, -50, -51, -52, -82, -83, -86, -89, -91, -94, -96, -97, -100, -103, -106, -114, -118, -121, -187, -184, -199, -201, -203, -211, -216, -217, -222, -239, -244, ILC0 (Replic), -68 and -20 were moderately resistant.

Screening for wilt resistance

Race specific resistance

Total 41 chickpea lines were screened against 6 races of *F. oxysporum* f. sp. *ciceri* under artificial inoculated sick tank condition. Eight IPC lines *viz*., 2004-34, 2005-18, 2005-19, 2005-30, 2005-34, 2005-52, 2005-68 and 2007-4 were found resistant, while 12 lines *viz*., IPC 2004-3, -8, -52, IPC 2005-26, -27, -35, -41(A), -41(B), -44, -45, -59 and -64 were moderately resistant to race 1 and lines *viz*., IPC 2005-30, -34, -59, GNG-1861, IPC2007-8, -68 were resistant and IPC 2004-52, IPC 2005-19, -24, -41(B), -43, -44, -52 and IPC2007-56 were moderately resistant to race 2. Only IPC 2007-

4 was resistant to race 3, however 4 IPC lines *viz*., 2004-52, 2005-18, -52 and -59 were found moderately resistant. For race 4 only IPC 2005-52 was resistant and 3 IPC line *viz*., 2005-26, -59 and 2007-4 were moderately resistant. Three IPC lines *viz*., 2005-15, -19, and -41(A) were resistant to race 5, while IPC 2004-8, IPC 2005-34, -35 and -59 were moderately resistant. Against race 6, IPC lines *viz*., 2004-3, -8, -52, 2005-18, -19, -26, -30, -34, -35, -41(B), -52, -64, 2007-4 and GNG 1861 were found resistant, while GPF 2, KWR 108, IPC 2004-34, IPC 2005-15, -24, -41(A), -43, -59 -62, and IPC2007-56 were moderately resistant.

Development of race-specific sick plots

Inoculum of *Fusarium oxysporum* f. sp. *ciceri* (*Foc*) race 1, 2, 3, 4 was added to micro-plots of 50 sqm each and chickpea crop of JG 62 as a check variety was grown. At the end of crop season wilt was >95 % in JG 62 in all the 4 races.

Lentil

Morphological characters of 33 isolates of *Fusarium oxysporum f.* sp. *lentis* were studied. Data on colony growth recorded after one week of incubation revealed that 4 of them were slow growing (colony diameter d" 5 cm) and 12 had moderate growth (colony diameter >5-7 cm). Rest 17 isolates were fast growing (colony diameter >7cm). Isolates varied in mycelial colour. Thirteen isolates had white colour mycelium and 14 had white mycelium with violet or pinkish shade. Five isolates had pale white mycelium and one had dark purple colour mycelium.

Dry root rot

Chickpea

Total 36 chickpea lines were screened against *Rhizoctonia bataticola,* the causal fungus of dry root rot disease under artificially inoculated condition in sick tanks using isolate Rb 9. Genotype R 7, R 9, R 10, R 11, R 14, R 15, R 16, R 17, R 18, R 19, R 20, R 21, R 22, R 23, R 24, L 550, IPC 2005-24, IPC 2005-62 and IPC 2007-68 showed resistant reaction (>10%), while R 13, R 5 and R 6 were moderately resistant (>10-20%).

Mungbean

Pathogenicity of 65 *R. bataticola* isolates on mungbean *cv.* Samrat was carried out. All the isolates irrespective of their original host crop from which they were isolated, showed 21 to 96% plant mortality. Based on their pathogenic ability, four isolates *viz*., Rb 4, Rb 5, Rb 23 and Rb 30 were grouped as weak pathogenic (<25%) and 12 *viz*., Rb 2, Rb 7, Rb 10, Rb 12, Rb 13, Rb 16, Rb 22, Rb 28, Rb 29,Rb 37, Rb 44 and Rb 48 as moderately pathogenic (>25 to 50%), while rest were highly pathogenic (>50%).

Host resistance

Genotypes RNG 268, Dholi, HUM 16, ML 212, LGG 407, ML 267, TG 4, PS 10, MH 2-15 and PKVAM-44 were found resistant (<10% plant mortality) and genotypes AKM 8803, GM 3, Pratap, Pant M 1, TARM 18, OBBG 52, HUM 2, ML 131 and ML 613 were moderately resistant (>10-20% plant mortality). Genotypes *viz*., Co 6, RMG 344, HUM 2, ML134, ML613, Co GG 912, Sujata, Sona yellow, GM 4, K 851, RNG 62, LGG 410, Pusa 105, Pusa 95-31, Salimar 1, Vamban 1 Pusa 9072, Ganga 1, HUM 6, LGG 450 and SML 32 were found susceptible (>20%-50% plant mortality).

Management of viral diseases

Among the nine treatments including control used for management of viral diseases (yellow mosaic and leaf curl) of mungbean, the foliar spray of 50% chlorpyriphos+5% cypermethrin @0.1% at 15 and 45 days after sowing was found best, followed by seed treatment with imidacloprid 17.8 SL @5ml/kg seeds and seed treatment with Trichoderma @ 6g/kg in significantly enhancing the yield., All the treatments reduced the disease incidence, though it was not statistically significant.

Phytophthora blight

Pigeonpea

Host resistance: Forty six accessions were screened for resistance to Phytophthora blight (*Phytophthora drechsleri* f. sp. *cajani*) under natural infestation, along with artificial inoculation on standing crop at 25 days after sowing. UPAS 120 was sown as check after every two rows of test entry. UPAS 120 recorded 52.1% incidence of the disease. Two accessions *viz*., IPAPB 7-2-1 and ICP 15685-1 had <10% disease incidence, while 13 entries had 10-20% incidence. IPAPB 7-2-1 confirmed its resistance to the disease for the second year in succession.

Management: An experiment was laid out with spray of garlic bulb aqueous extract (2% w/v) at 25 days after sowing, compared to check (no spray) and garlic bulb extract, *Trichoderma* and fungicides as seed treatments individually and in combinations. The trial was laid out with spacing of 60 cm x 30 cm using cv. UPAS 120. Effect of spray of garlic bulb aqueous extract at 25 DAS was significant ($P < 0.05$). Phytophthora blight incidence was least in combined seed treatment of *Trichoderma* (10 g/kg) and metalaxyl (6 g/kg) combined further with spray of aqueous garlic bulb extract (2% w/v) at 25 DAS. The combined seed treatment did well for the second year in succession, which confirmed its ability to provide protection against the initial disease incidence. Combined seed treatments (*Trichoderma* + metalaxyl) supplemented with the spray (garlic bulb extract) provided significantly higher seed yield over control.

INSECT PESTS

Helicoverpa armigera

Chickpea

Seven new generation insecticides along with NPV, *Beauveria bassiana* and control were evaluated against *H. armigera* in two varieties of *kabuli* chickpea *i.e.*, Subhra and Pusa 1053. In case of Subhra, minimum pod damage (2.8%) was recorded with Flubendiamide, followed by Rynaxypyr (3.1%), Emamectin (3.7%), Chlorfenapyr (4.1%), Metaflumizone (4.5%), Novaluron (5.1%), Diafethiuran (5.4%), HaNPV(5.8%) and *B. bassiana*(6.5%) against 8.8% in control. Yield was also recorded highest (2010 kg/ha) in case of Flubendiamide, followed by Rynaxypyr (1997 kg/ha), Diafethiuran (1818 kg/ha), Novaluron (1818 kg/ha), HaNPV(1815 kg/ha), *B. bassiana* (1804 kg/ha), Chlorfenapyr (1760 kg/ha), Emamectin (1720 kg/ha) and Metaflumizone (1706 kg/ha) against 1526 kg/ha in control. Same trend was observed with Pusa 1053. Minimum pod damage (5.2%) and maximum yield (2059 kg/ha) was recorded with Flubendiamide against maximum pod damage (9.8%) and minimum yield (1592 kg/ha) in control. Other insecticides followed the same order as in Shubhra.

Thrips

Monitoring of thrips, natural enemies and leaf curl disease in mungbean and urdbean

The population of thrips in summer mungbean (cv. Meha) ranged from 6.8 to 32.5/5 plants, where as in urdbean (cv. Uttara) thrips incidence was low and ranged from 4.8 to 11.8/5 plants. Highest incidence of thrips was observed in 16th SMW in mungbean, where as in urdbean it was in 18th SMW (Fig. 28). The correlation studies on the thrips population and weather parameters showed negative correlation (-0.748 in mungbean and – 0.586 in urdbean) with rainfall, whereas all other factors showed positive effect. Among the predators of thrips, *Brumoides suturalis, Coccinella transversalis, Cheilomenes sexmaculata, Micraspis discolour, Coccinella septempunctata, Phrynocaria perrotteti* were predominant in summer mungbean ecosystems. Incidence of leaf curl disease was very low in both mungbean and urdbean.

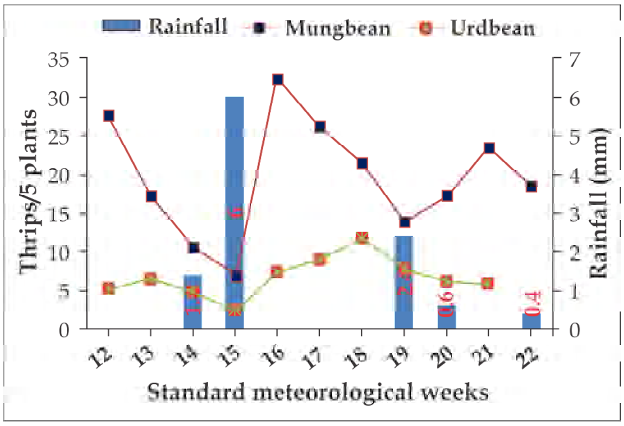


Fig. 28: Population dynamics of thrips in mungbean and urdbean vis-a-vis rainfall

Identification of thrips

Among various species of thrips infesting *Vigna* sp., two species of thrips *i.e., Megalurothrips distalis* (Karny) and *Caliothrips indicus* Bagnall are specific to summer mungbean and urdbean and cause severe damage.

Estimation of yield loss due to thrips

The yield and thrips infestation relationship with respect to thrips incidence was calculated to be y = 1496 - 16.8x *i.e.*, for unit thrips incidence, yield loss of mungbean to the tune of 16.8 kg occurred (Fig. 29).

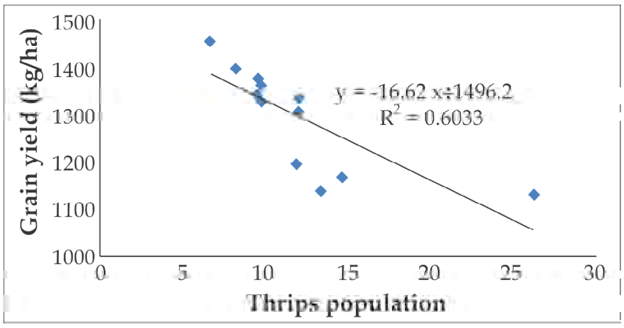


Fig. 29: Yield infestation relationship in summer mungbean

Thrips management in mungbean

Sowing dates and spacing: Sowing times had significant effect on incidence of thrips and grain yield of summer mungbean. More thrips population was recorded in crop sown in first week of March (13.2/5 plants) than third week of March (10.7/5 plants). Narrow row-to-row spacing of 20 cm attracted more thrips as compared with wider spacing of 30 cm.

Insecticides/biopesticides: Spraying of thiomethoxam 25WG had lowest number of thrips (6.6/5 plants), whereas the highest number of thrips (26.2/5 plants) were recorded from untreated control, which was statistically different from other treatments. Grain yield of mungbean also differ significantly by the different treatments (Fig. 30). Highest grain yield (1455.4 kg/ha) was recorded in thiomethoxam 25WG treatment, followed by imidacloprid 17.8 SL (1398.5 kg/ha) which

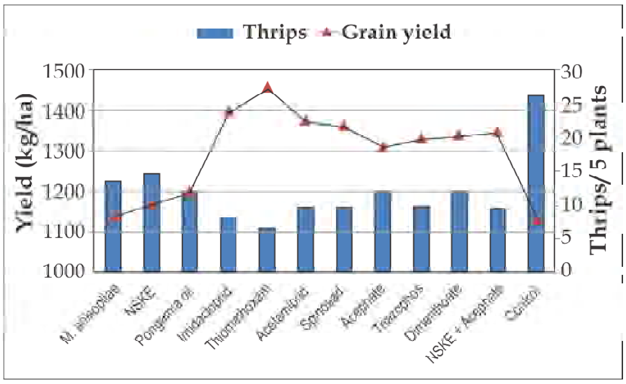


Fig. 30: Bio-efficacy of insecticides/biopesticides on thrips incidence and yield in mungbean

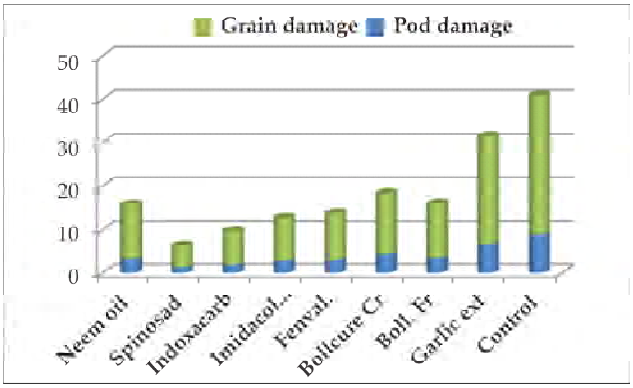


Fig. 31: Efficacy of newer insecticides against podfly

were significantly superior over control (1132.6 kg/ha). The interaction effect between sowing dates and insecticides as well as spacing and insecticides showed significant effect on the grain yield.

Podfly, *Melanagromyza obtusa* Malloch

Screening of promising pigeonpea genotypes against podfly

Pigeonpea genotypes *viz*., ICP 7542, PDA 92-2E, PDA 93-1E, ICPL 129880(B), ICP 88022-1, PDA 92-3, KWR 92-02, DA 11, MA 2, NDA 99-7 and MA 2 were found to possess moderate resistance (PSR value 3-5).

Economic threshold and economic injury level of podfly in pigeonpea

Economic injury level (EIL) of podfly was worked out to be 4.8 maggots/100 pods, where as the economic threshold level (ETL) was found to be 4.5 maggots/100 pods for 1st standard meteorological week (SMW) which was computed based on economic injury level and daily reproduction rate of podfly.

Management

Eight insecticides *viz*., Neem oil, Spinosad, Indoxacarb, imidacloprid, fenvalerate, Bollcure crude, Bollcure formulated and garlic bulb extract were tested against podfly in late maturing variety NDA 1. Two sprays of Spinosad @ 75 g a.i. /ha, first at grain filling stage of pods and second at full grain stage were found best in podfly suppression, followed by Indoxacarb @ 60 g a.i. /ha. (Fig. 31). The least grain and pod damage (%) was registered in case of two sprays of Spinosad 162 ml/ha application, followed by indoxacarb 0.007% (500ml/ha). As regards their effect on crop yield, the former registered 1183 kg/ha grain yield, followed by Indoxacarb (1044 kg/ha) against the later. All the insecticides were significantly superior over control (717 kg/ha).

Forecasting module for podfly

Podfly dynamics in pigeonpea and growing degree day

Max temp, if increases more (from non-epizootic years) from 47th SMW to 4th SMW, associated with corresponding period increase evening Rh, it invites outbreak situation, causing damage above ETL (4.5 maggot/100 pods from 10 randomly selected plants). The podfly spatio-temporal dynamics of its various life stages was recorded during 2011-12 at different locations (Kanpur, Varanasi and Faizabad on two varieties (Bahar and NDA 1). The pest dynamics data were computed with prevailing weather components of all that locations. The correlations of number of eggs/pod, number of larvae/pod, %pod damage inflicted by *M.obtusa* were correlated and the significance of key abiotic factors was tested for their significance/insignificance role vital for the pest dynamics.

At all the locations temperature (Max) exhibited a significant positive role in population fluctuation of podfly. The podfly initiated at 5th SMW in Varanasi followed by Kanpur in 7th SW, and in Faizabad in 9th SW. The podfly declined and terminated in 11thSW in Varanasi in 14th SW in Kanpur and Faizabad.

Growing degree-days (GDD) requirement of podfly was computed to simulate its spatio-temporal build up under field condition. GDD requirement at varying constant temperatures revealed that at 6°C and 9°C there was no egg hatch. At 12°C eggs and larval stages could survive but subsequent there was diapauses in pupal stage. The podfly stages survived from 12 to 32°C. There was no egg hatch beyond 36°C.The degree day requirement of podfly revealed 48.42, 196.27 and 143.82 for egg, larva and pupa, respectively.

Forecast model of podfly, *M.obtusa*

Equation developed

P(y=0, 1) = 1/1+cxb (-z)

Z=3.128-0.00728+Z141

(i) Group 0 = -4.428+0.01712 Z 141

(ii)Group 1 = 0.01712+0.02246 Z 141

Max temp in combination with evening Rh played significant role during epizootic years (14years)

Where, in Z141 : First 1 denotes Max. Temp; Second 1 denotes weighted interaction with middle value 4 indicates Rh (Relative humidity).

The sum of Max temp, if increases more (from non-epizootic years) from 47th SMW to 4th SMW associated with corresponding period increase evening Rh, it invites outbreak situation, causing damage above ETL (4.8 maggot/100 pods from 10 randomly selected plants).

It can be concluded that if sum of Max temp increases more from 47th SMW to 4th SMW coupled with corresponding period increased evening Rh, that is also exceedingly more in comparisons to non-epizootic years, it certainly invites outbreak situation of podfly and might cause economic injury when going beyond ETL (4.5 maggot/100 pods) in standing crop of late maturing varieties of pigeonpea.

Bruchids

Screening of mungbean and urdbean accessions for resistance to bruchids

Out of seven entries of mungbean *viz*., ML 1268, ML 1453, ML 1165, LGG 460, MH 907, CoGG 912, and PKV AKM 4 screened against bruchid (*C. chinensis*), none exhibited resistance under free-and no-choice test. Out of 4 entries of urdbean, 2 entries *viz*., TU 40 and TU 80 were found resistant based on both choices test.

NEMATODES

Root-knot nematode

Genotypes of different pulses were screened against root knot nematode *Meloidogyne javanica* under pot conditions and based on gall index were categorized as resistant, moderately resistant or susceptible.

Pigeonpea

Out of 18 genotypes, 3 *viz*., IPA 1, IPA 8 and IPA 12 were observed as resistant. Four genotypes *viz*., IPA 3, IPA 13, IPA 17 and IPA 18 were moderately resistant.

Mungbean

None of the 14 entries screened was found resistant, however three entries *viz*., MH 729, MH 709 and IPM 20-9-3 gave moderately resistant reaction. Of the other 14 genotypes screened, three *viz*., EC 304793, BDYR 2 and VL 112 were found resistant and four *viz*., DMG 1121-1, DPC 1056, AKP/NP/8/63 and VC 206-68 were moderately resistant.

Urdbean

Out of 11 entries screened, AKU 7-1 was observed resistant, while SU 11-136 was observed moderately resistant. Of the other 19 genotypes screened, four *viz*., Mash 114, DPU 88-31, Khairagarh Agra and AKU 15 were observed as resistant and SPS 41and IPU 99-233 were moderately resistant.

Chickpea

Out of 20 genotypes, three *viz*., ICC 15164, ICC 14287 and ICC 16031 were observed as resistant and ICC 14980 as moderately resistant. Forty two genotypes found promising under field conditions were again evaluated under micro plot and pot conditions. Only genotype ICC 15646 gave moderately resistant reaction. This indicated that under field or micro plot conditions, there are chances of plants escapeing nematode infection. It is therefore very important to re-evaluate the genotype under artificial inoculation conditions.

Lentil

Out of 53 entries screened, six *viz.,* PL 122, NDL 11-1, LL 1203, HUL 57, LL 1114 and VL 521 were found resistant, where as eight *viz.,* PL 101, LL 1231, RLB 314, IPL 324, LH 07-27, LH 84-8, L 4706 and IPL 531 were moderately resistant.

Fieldpea

Among 36 entries screened, two *viz*., HUDP 963 and Pant P 161 were found resistant and five *viz*., HUDP 15, RFP 63, Pant P 184, IPFD 1-10 and KPMR 902 were found moderately resistant.

Bio-control

Efficacy of four strains of *Paecilomyces lilacinus viz*., NBAII 56, 57, 58 and 72 procured from NBAII, Bangalore was tested by egg mass assay, cyst assay, adult female assay and egg hatching assay. All the four strains were found effective in suppressing the nematode population in *Vigna* and chickpea in green house conditions.

Lesion nematode

Chickpea

Different inoculum levels *viz*., 10, 100, 500, 1000, 5000 and 10000 nematodes per pot (eight inch diameter) were used to understand the pathogenicity of lesion nematode using chickpea variety DCP 92-3 along with un-inoculated check. Observations on plant growth parameters and nematode multiplication were recorded at three months after sowing. Plant height reduced significantly in treatments where inoculum was 5000 nematodes and above. Similarly, fresh and dry shoot weights were reduced significantly in pots with 1000 nematodes and above per pot. The reduction in branches was observed at nematode inoculum level of 100 nematodes and above as compared to check. At the end of experiment, nematode population in root and soil was increased with increase in initial inoculum. However, the multiplication rate of nematode decreased with increase in inoculum level, highest being 9.0 with minimum inoculum level (10 nematodes/pot) and lowest 1.9 in maximum inoculum level of 10000 nematodes/pot (Table 5).

Table 5: Plant growth characters and root lesion nematode multiplication in different treatments (Average of five replications)

Treat-ment (No. of lesion nema-tode/pot)	Plant height (cm)	Fresh shoot wt. (g)	Dry shoot wt. (g)	Av. Bran-ches	Nematode population			Multi-plicat-ion rate
					Root	Soil	Total	
Check*	29.4	9.11	3.429	10.6	-	-	-	-
10	29.2	8.32	3.299	8.4	58	32	90	9.0
100	28.8	7.37	2.725	7.3	307	370	677	6.8
500	28.8	7.16	2.670	7.2	1105	1035	2140	4.3
1000	27.5	6.76	2.460	5.4	1494	1666	3160	3.2
5000	24.6	5.34	2.203	4.6	7956	6536	14492	2.9
10000	23.8	5.16	2.192	4.2	10731	8480	19211	1.9
CD at 5%	3.7	1.95	0.7 57	2.4	987	712	1165	

*Nematode free pot

Externally Funded Projects

Outreach Project on *Phytophthora, Fusarium* and *Ralstonia* Diseases of Horticultural and Field Crops - *Fusarium* Wilt of Pigeonpea and Chickpea

Pigeonpea wilt (*F. udum*)

Biodiversity

A distribution map of *F. udum* variants identified in different states of India has been prepared. Uttar Pradesh has all the 7 variants, followed by Maharashtra and Karnataka (6 each); M.P. and Bihar (5 each); A.P. and Rajasthan (4 each), Haryana (3); T.N. and Jharkhand (2 each) and W.B. (one).

Molecular diversity

Genetic relationships of 45 isolates of *Fusarium udum* collected from 11 different geographical location of pigeonpea growing area in India were analyzed using two different markers systems *viz.*, the internal transcribe spacer (ITS) region of nuclear ribosomal DNA and alpha transcription elongation factor (EF-1 alpha). In UPGMA cluster analysis, isolates were grouped into two major clusters (I & II) at a similarity index value 0.12 (Fig. 32). Cluster I comprised of 32 isolates that were further delineated into four sub-clusters at a similarity index value 0.14. Cluster II consisted of 13 isolates that were further delineated into two sub-clusters at a similarity index value of 0.19. In UPGMA cluster analysis, three dendograms derived from ITS, EF-1 alpha and combined analysis revealed genetic variation in the isolates. The comparative statistical analysis results showed EF-1 alpha marker to be more effective than ITS.

Diagnostics

In order to develop appropriate molecular markers (diagnostic marker) to identify *Fusarium udum* and *Fusarium oxysporum* f. sp. *ciceri*, a reference set of five variants of *Fusarium udum* and six races *Fusarium oxysporum* f. sp. *ciceri* maintained at IIPR, Kanpur was

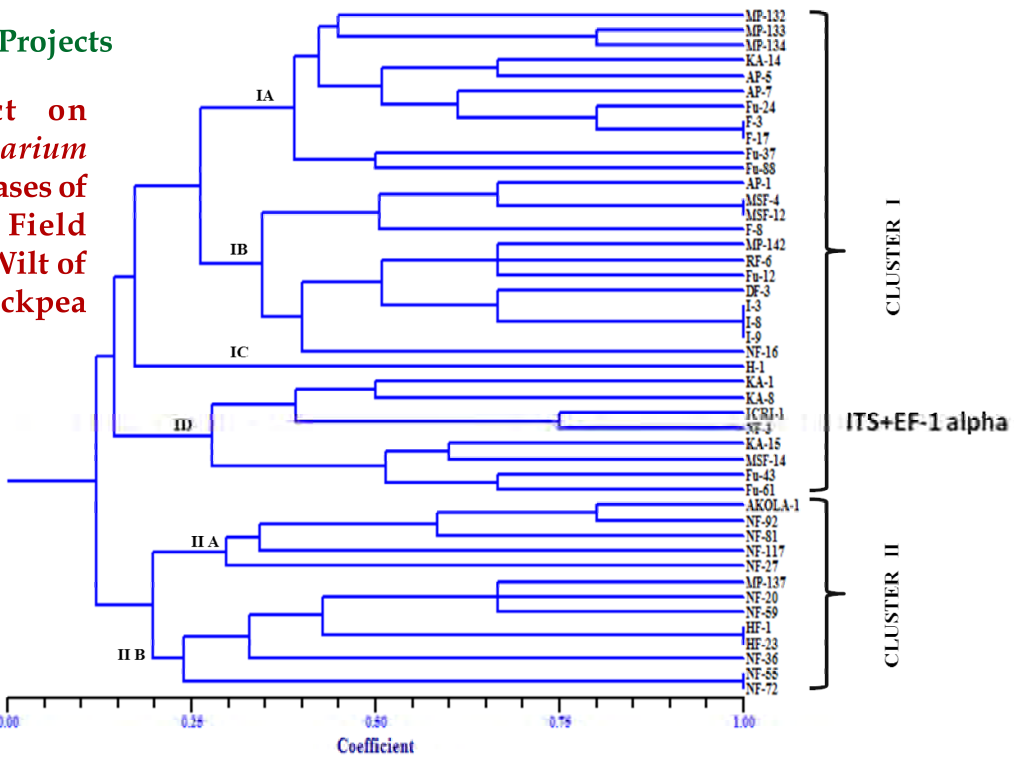


Fig. 32: UPGMA dendogram showing genetic relationship among 45 isolates of *Fusarium udum* based on ITS and EF-1á analysis

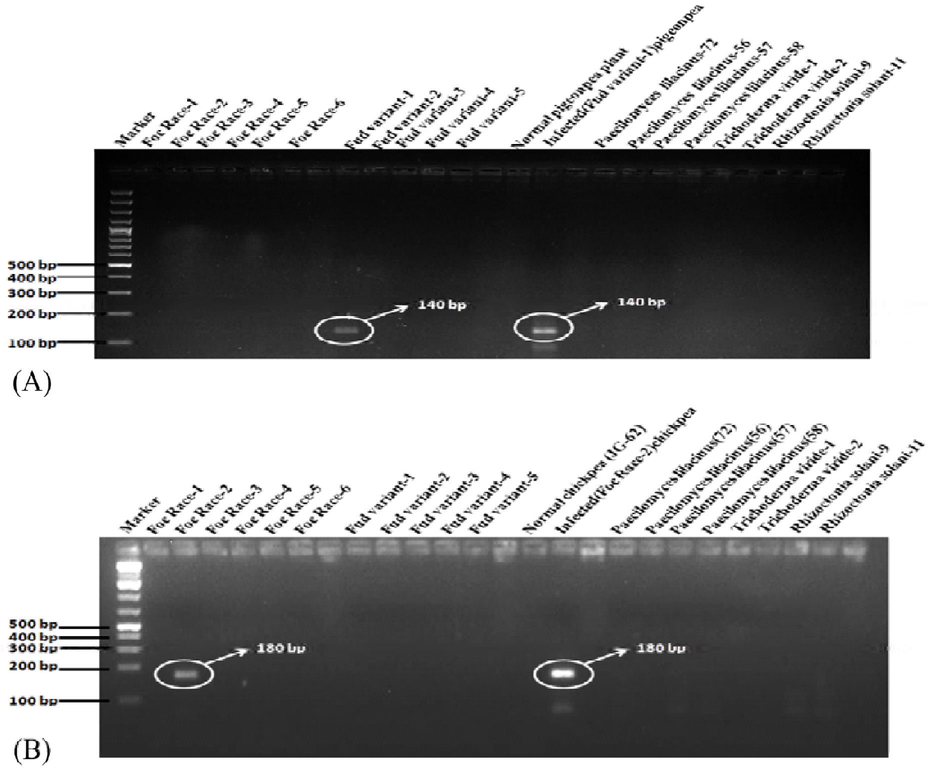


Fig. 33: Gel photograph showing diagnostic marker profile for Race-2 (A) and variant-1 (B)

used for study. RAPD markers were used to amplify the unique band from races and variants. Six unique bands for different races and nine for variants were found. The unique bands (amplicons) for race 2 of *Fusarium oxysporum* f. sp. *ciceri* (800bp) and variant 1 of *Fusarium udum* (480bp) were cloned and sequenced. Using these sequences, primers specific to race 2 and variant 1 were designed and validated. Race specific primers amplified a DNA fragment of 180bp where as variant 1 specific primers amplified a DNA fragment of 140bp. The specificity of these primers was confirmed by cross checking infected plants and other fungal genomic DNA (Fig. 33).

Total fifteen *Fusarium* specific markers were deployed where two markers which gave specific band for race-2 of *F. oxysporum f.* sp. *ciceri* (1400bp) and variant 1 of *F. udum* (260bp) were identified by random amplification of polymorphic DNA (RAPD). Simultaneously, two sequence characterized amplified region (SCAR) markers were further developed from the two RAPD markers. The amplification using race-2 and variant 1 specific SCAR marker showed amplification only in that particular race and variant, not in others. It was also cross checked with some other fungi. In order to reconfirm the specificity of the marker, DNA from infected plant with specific race was isolated and PCR amplification was performed. In which we amplified these two primers for the particular race-2 (180bp) and variant 1 (140bp) infected plant DNA and we got the same size of band. The results showed that this newly developed marker could be considered as a convenient and reliable method for identification of *Fusarium oxysporum* f. sp. *ciceri* race-2 as well as variant 1 of *F. udum*.

Host resistance

Total 328 genotypes comprising of wilt donors, differentials, promising lines and hybrids were screened in wilt sick field for identification of resistant genotypes. Twenty one donors *viz.*, KPL 44, ICP 8862, ICP 8863, IPA 38 A, IPA 38B, GPS 33, BSMR 736, KPBR 80-2-1, PI 397430Sel., KPL 43, IPA 40, ICP 8858, Banda Palera, BWR 377, ICP 89046, ICP 89012, ICP 89049, ICP 3011, AWR 74/15, BDN 1, JAW 5-6A and BDN 1 were found resistant. None of the hybrid lines tested was found resistant, however, one (AKPHM 11303) showed moderately resistant reaction. Among IIPR promising lines, nine *viz.*, DPPA 85-11, -12, -13, -14, IPA 38, ICP 7200, ICP 0174, ICP 8863 and KPL 44 showed resistant reaction. Of the 14 MDR lines, ten *viz.*, MAL 10, GPS 30, ICP 8859, PH 1063, PH 4816, BSMR 843, P 96169, KPL 45, GPS 36 and IPA 6-1 were found resistant. Eleven genotypes *viz.*, ICPL 749, -20094, -20108, -20109, -20115, , -20129, -20139, BWR 133, BSMR 846, MAL 13 and Phule T-0012 showed resistant reaction not only this year but also in the last 3-4 years. Among 100 breeding lines, only five (IPAC 4, IPAC 8, IPAC 18, IPAC 68 and IPAC 151) showed resistant reaction.

Chickpea wilt (*F. oxysporum* f. sp. *ciceri*)

Diversity

A partial distribution map of *F.oxysporum* f.sp. *ciceri* races identified in different states of India was prepared. Presence of 5 races have been recorded in Uttar Pradesh and Rajasthan, followed by M.P. and Karnataka (4 each), Haryana (3), A.P., Punjab and Gujarat (2 each) and Chhattisgarh, Delhi and Maharashtra (one each). Race 3 showed highest frequency with its presence in all the states, followed by race 5 (5 states), race 0, 1, 2 and 4 (4 states each) and race 6 in 3 states.

Molecular diversity

Sequence related amplified polymorphism (SRAP) markers as well as SRAP-RGA primer combinations were used for the first time to determine genetic diversity among 59 Indian isolates of *Fusarium oxysporum* f. sp. *cieri* from 12 chickpea growing states. Of the 42 SRAP and 38 SRAP-RGA primer pairs used, only 15 (4 from SRAP-SRAP and 11 from SRAP-RGA primer combinations) showed good amplification. In UPGMA cluster analysis, isolates were aligned into two main clusters (I and II) at a similarity index value of 0.22. The first main cluster was further divided into two sub-clusters (I A and I B) at a similarity index value of 0.25. Sub-cluster IA consisted of 38 isolates which were further delineated into two sub-sub clusters *viz.*, IA-1 which contained 20 isolates, of which most are from Uttar Pradesh and Rajasthan and IA-2 contained 18 isolates, of which most are from Karnataka. The cluster II was also divided into two sub-clusters (IIA and IIB) at a similarity index value of 0.27. Sub-cluster IIA consisted of 4 isolates, of which one was from Uttar Pradesh and three from Madhya Pradesh. Sub-cluster IIB consisted of 14 isolates, of which most were from Madhya Pradesh. Isolate K 68 from Andhra Pradesh held a separate position (Fig. 34).

Host resistance

Total 40 lines found resistant in wilt sick field were screened against *F.oxysporum* f.sp. *ciceri* race 1, 2, 3, 4, 5 and 6 in the sick tanks. IPC lines *viz.,* 2004-3, -8, -52, 2005-15, -19, -27, -30, -35, -37, -41(A), -41(B), -43, -44, -52, -62, -64 and GNG 1861 and CPS1 were resistant to moderately resistant to race 1,2,3,4,5 and 6 in 3rd year of screening.

Disease management

A pot experiment was conducted with national collection of 15 *Trichoderma* strains and 10 ppm salicylic acid. *Trichoderma* strains with code nos. 5, 9, 10, 13 and 14 were highly efficient giving <10% wilt incidence, followed by 3, 4, 11 and 12 (>10-15%). Least effective strains were 1, 2, 6, 7, 8, 15 and salicylic acid (>15-21%) as against 26.3% in control.

Antagonistic potential of other *Fusarium* strains

Four strains of *Fusarium* received from Programme Coordinator, Phytofura were evaluated against *F. udum* and *F. oxysporum* f. sp. *ciceri* (*Foc*) for their inhibitory effects in dual culture. The interactive response of *F. udum* and *F. oxysporum* f. sp. *ciceri* (*Foc*) to four fusaria

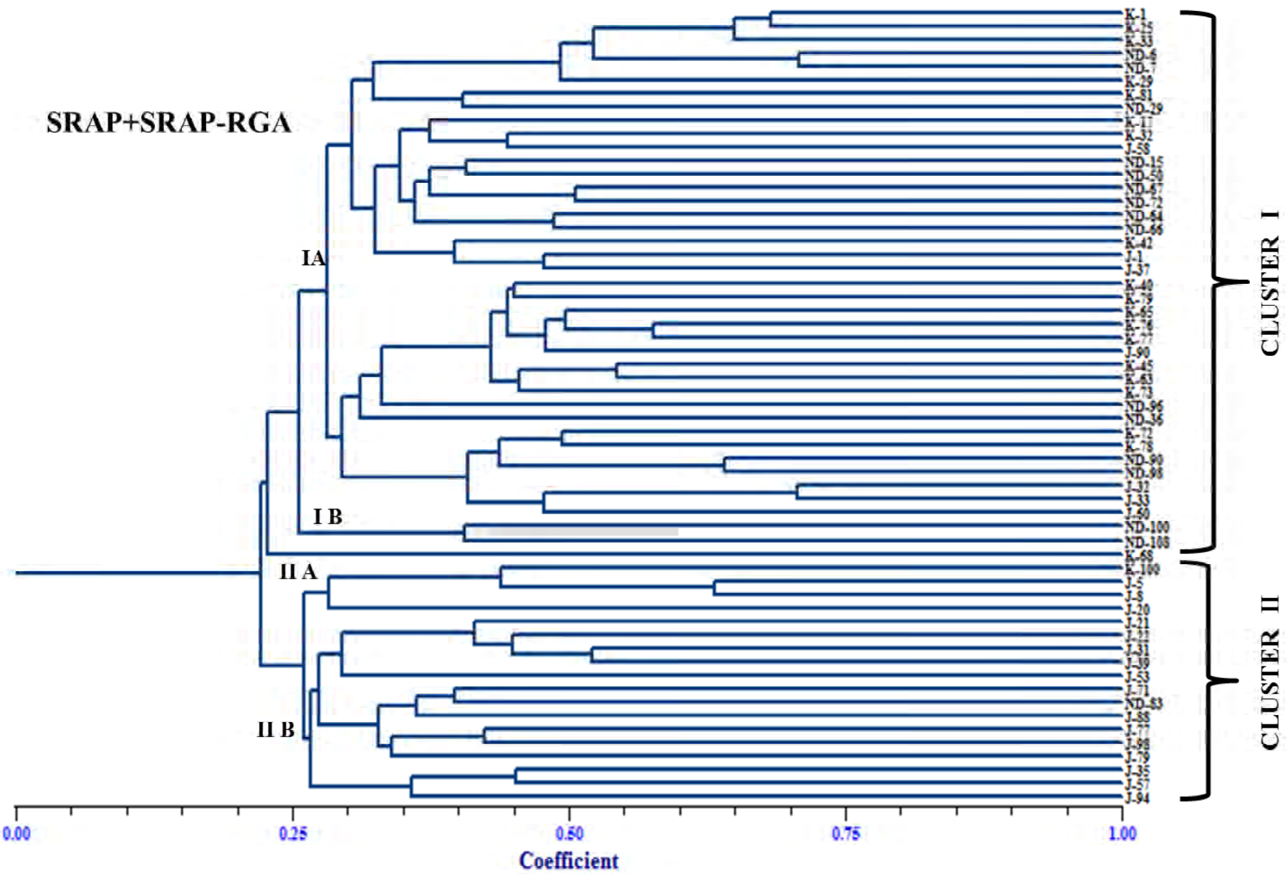


Fig. 34: UPGMA dendogram showing genetic relationship among 59 isolates of *Fusarium oxysporum* f. sp. *ciceri* based on SRAP and RGA analysis

was highly variable. Overall, strains of *Fusarium* inhibited *F. udum* by 42.2% and *F. oxysporum ciceri* by 23.5%. Some selectivity in the inhibition of wilt pathogens was also observed. However, these *Fusarium* strains were found pathogenic on pulse crops hence cannot be further exploited.

Multiplication and survival of *Trichoderma harzianum*

Eight organic substrates *viz.*, sorghum grain, chickpea straw, pigeonpea straw, sugarcane chaff (after juice extraction), whole neem seed, cow dung (dried), farm yard manure and goat dung were evaluated *in-vitro* for their potentiality to multiply *Trichoderma harzianum* strain IPT 31. Observations on the length of the column in the test tubes colonized by *Trichoderma* was recorded at 72 h. Sugarcane chaff supported best growth (11.0 cm.), followed by chickpea and pigeonpea straw, sorghum grain and neem seed (7.0 cm.) and slow growth (3.6-5.9 cm.) on farm yard manure, cow dung and goat dung. Observations on the survival of *Trichoderma* strain on these substrates (cfu/g dry substrate) after six months of inoculation showed 3.3-8.3x 10^{10} cfu/g powder. Though highest population was achieved in sorghum grain, sugarcane, chickpea and pigeonpea straw, FYM and neem seed showed at par population among the crop residues and other organic substrates, followed by goat dung. Cow dung showed poor population of *Trichoderma.*

Outreach Programme on Diagnosis and Management of Leaf Spot Diseases of Field and Horticultural Crops - Cercospora Leaf Spot of Mungbean and Urdbean

Variability in colony growth of *Cercospora canescens* isolates as influenced by temperature

Fourteen isolates of *Cercospora canescens* were grown at three different temperature regimes (24, 34, 40°C). None of the isolates could grow at 40°C. However, all isolates grew at 34°C, but with reduced growth, colony diameter ranging between 7.1-14.2 mm. Highest growth was in CLS 34, while least in CLS 77. The optimum temperature was 24°C. At this temperature maximum growth of 24.7 mm was observed in CLS 72, followed by 22.5 mm in CLS 27. Least of 14.5 mm was in CLS 79. This indicated its chances of survival in crop residues only in sub soils but not on soil surface during the hot summer.

Pathogenic variability of *Cercospora* isolates

Detached leaves surface sterilized with 5% sodium hypochlorite solution were inoculated with 2.5 mm mycelial disc and incubated at 25.0 ± 1.0°C temperature, >95% RH and 12 hrs light and darkness cycle. In detached leaf pin head spots appeared at the end of 3rd day that further enlarged and became fully developed spots on 7th day. All isolates produced similar and typical angular small spots resembling *C. canescens*. However, the isolates varied in their pathogenic ability measured in terms of number of lesions per leaflet.

Induction of sporulation in *Cercospora* sp. in culture

To induce sporulation in culture, isolate CLS 79 was grown on various organic substances *viz.*, wheat straw, carrot, water agar sucrose medium (20%, 30% sucrose), potato dextrose agar medium. Sporulation was observed only in water agar sucrose media (30%).

Development of liquid formulation of efficient *Trichoderma* strains for spray

To identify a suitable carrier/medium for liquid and solid formulation of *Trichoderma*, eight carriers, organic substrates and liquid media were evaluated for the bio-agent survival. After four months of storage in these media, there was no significant reduction in the spore count. Studies indicated that 5% jaggery solution and potato dextrose broth were best, followed by vermi wash, vermi compost and talc. Thus, these can be used to develop liquid/powder based formulations of *Trichoderma*.

Influence of weather on disease development

CLS disease development was studied in two mungbean varieties *viz.*, Kopergaon and Narendra Mung 1. Observations on disease development were recorded at weekly intervals. The disease was not observed till 19th September. CLS was first noticed on 26th September in both the genotypes and gradually increased and by the end of October it reached 23.2 and 18.8% respectively in Kopergaon and Narendra Mung 1 (Fig. 35).

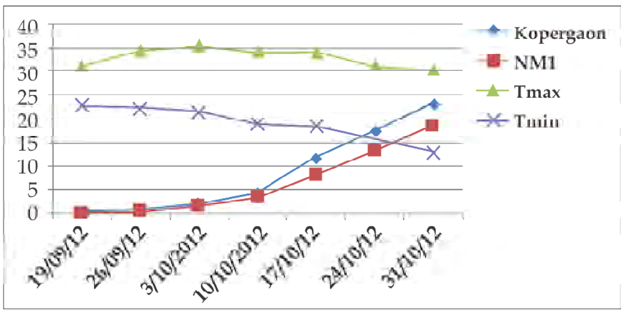


Fig. 35: Effect of temperature on CLS development in mungbean

Screening of germplasm

One hundred three genotypes of mungbean and urdbean were screened against CLS in the field. CLS infected leaves ground in water were used as inoculum and sprayed over genotypes to increase disease build up. None of the mungbean genotypes was found resistant. However five genotypes *viz*., HUM 16, GG 46, AKM 8803, Co 4 and BM 11 were found moderately resistant. Six urdbean lines *viz*., EL 48, 15/7, PLU 707, IPU 99-219, NP 19 and IPU 98/136 showed resistant reaction. Disease reaction of rest of the genotypes was susceptible to highly susceptible.

Effect of non-target pesticides on foliar diseases of mungbean

Effect of some weedicides and insecticides including NSKE was studied on foliar fungal diseases of mungbean. Fungicide carbendazim was also included in the treatment as check. Two foliar sprays were applied at 30 and 45 DAS. Carbendazim was found best in controlling not only CLS but also anthracnose and powdery mildew diseases. However, grain yield obtained (515 kg/ha) though significantly superior than in control (384 kg/ha) but was lower than the treatments involving foliar sprays of insecticides. The treatment involving two sprays, first of NSKE (5%) at 30 DAS and second of indoxacarb (0.86ml/l) at 45 DAS was best in obtaining maximum grain yield (1222 kg/ha), but the reduction in CLS was non-significant. Similarly, two sprays, first of dimethoate (1 ml/l) at 30 DAS and second of emamectin benzoate (0.40g/l) at 45 DAS also proved good in obtaining maximum grain yield (1034 kg/ha) and also reduced CLS significantly.

Application technology of efficient *Trichoderma* isolates

Efficacy of bio-agent *Trichoderma* isolates as seed treatment and foliar spray singly or in consortium mode in managing the CLS was worked out. Three isolates of *Trichoderma* IPT 10, IPT 11 and IPT 21 were used. Elicitors like salicylic acid and amino-butyric acid were also evaluated for their role in disease (CLS) management in mungbean. Seed treatment with IPT 10 and 2 foliar sprays (at 30 and 45 DAS) of the same increased grain yield significantly (73%). The reduction in CLS though significant but was only 21%. In treatments involving isolates IPT 11 and IPT 21 there was no significant change in grain yield, but a significant reduction in CLS disease was recorded. Combination of two isolates of *Trichoderma* (consortium mode) used as seed treatment or foliar spray *viz*., IPT 10+IPT 11, IPT 10+IPT 21 and IPT 11+IPT 21 resulted in marginally significant reduction in CLS disease, but the % increase in grain yield was highly significant (165-245% over control).

Development of IDM strategies

Experiment was conducted to integrate chemical and biological approaches for development of an integrated management strategy for fungal foliar diseases of *kharif* mungbean. Treatments involved seed treatment either with bio-agent (*Trichoderma* isolate IPT 10) or with carbendazim. Treatment involving seed treatment with *Trichoderma* and two foliar sprays of the same at 30 and 45 DAS, did not reduced CLS disease significantly but increased grain yield by 48.76%. Seed treatment with carbendazim followed by two sprays of the same at 30 and 45 DAS significantly reduced not only CLS disease but anthracnose also and increased grain yield by more than 127%.

Seed treatment with carbendazim followed by one spray of the same chemical at 45 DAS was also found equally effective in reducing CLS disease and increasing grain yield more than double than in the control. Seed treatment with IPT 10, followed by one spray of Imazethapyr at 30 DAS and one spray of dimethoate or IPT 31 at 45 DAS gave highest grain yield (911 kg/ha), though reduction in CLS disease was only marginally significant in the former and non-significant in the latter.

In treatment combinations where carbendazim was used as foliar spray at 45 DAS, not only CLS disease was reduced but anthracnose and powdery mildew were also reduced significantly. Grain yield was also significantly increased (80-100%).

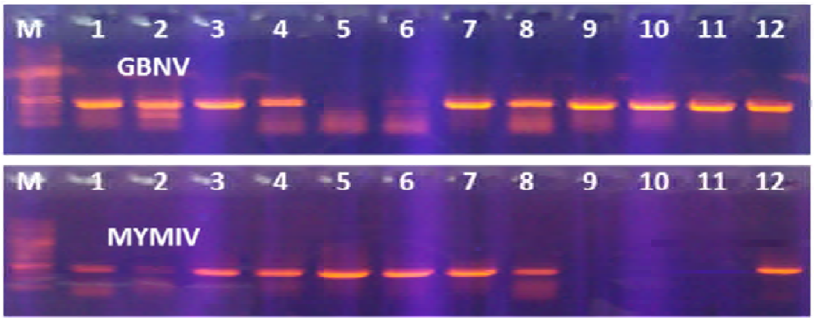
Development and Validation of PCR Based Diagnostics for Major Viral Diseases of Some Important Pulse Crops

Symptomatology

Symptoms like, tip necrosis and bunching, brown streak on petiole and lamina in pea, chlorotic spots, necrotic spots surrounded by chlorosis on leaves, downward curling of leaves in mungbean, urdbean and rajmash are the diagnostic symptoms of groundnut bud necrosis virus infection. Symptoms of stunt disease in chickpea included excessive branching, reduction in leaf lamina and overall stunting of affected plants. The infected plants looked pale yellow in case of *kabuli* chickpea, whereas in *desi* type red pigmentation was observed in leaves. The symptoms caused by yellow mosaic viruses (MYMIV, MYMV and HgYMV) in different hosts (mungbean, urdbean, rajmash, pigeonpea and soybean) are similar type and include yellow spots on leaves. Identification of virus(es) causing yellow mosaic disease is not possible on the basis of symptoms.

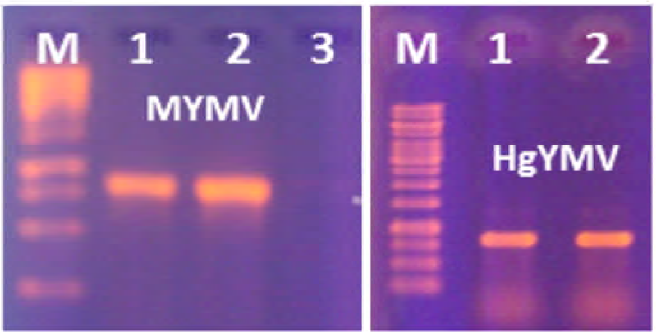
Simplex-PCR

Eleven pairs of species specific primers were designed and got synthesized for the accurate detection of GBNV, MYMIV, MYMV, TSV, HgYMV, BCMV, PSMV, PSBMV, CCSV, CCDV and BLRV. Simplex-PCR protocols for detection of four viruses (MYMIV, MYMV, HgYMV and GBNV) have been standardized. The primer pairs (MYMIV-CPfF/ MYMIV-CPfR, MYMV-CPF/MYMV-CPR, HYMV-CPF/HYMV-CPR and GBNV-NPF/GBNV-NPR) were found suitable for accurate detection of the viruses GBNV, MYMIV (Fig. 36), MYMV and HgYMV (Fig. 37), hence they may be used in screening of genotypes for resistance in breeding programme.



(Lane M= 1kb DNA ladder, Lane 1-4= rajmash, Lane 5-8= pea, Lane-9-10 mungbean and Lane 11-12=urdbean.) and MYMIV-CPF/MYMIV-CPR (Lane 1-4=mungbean, Lane 5-8=urdbean and Lane 9-12=rajmash)

Fig. 36: Gel photograph of RT-PCR of GBNV and PCR products of MYMIV amplified using GBNV-NPF/GBNV-NPR



(Lane M= 1kb DNA ladder, Lane 1-3= soybean and HgYMV-CPF/ HgYMV CPR (Lane 1-2= horsegram (samples collected from Coimbatore). A sharp DNA bands indicates that these samples were infected with MYMV and HgYMV

Fig. 37: Gel photograph of PCR products of MYMV and HgYMV amplified using MYMV-CPF/MYMV-CPR

Basic Science

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

Promising genotypes with initial high biomass and leaf area index (LAI) were identified under drought. Water availability at different soil depths was monitored in relation to crop growth, rooting intensity and senescence. Few genotypes enhanced root length and total root biomass when subjected to low soil moisture at 60-90 cm depth (Table 6). Genotype ICCV 92944 with deep roots extracts moisture efficiently down below 60-90 cm. depth and prevents senescence during terminal drought and heat > 35^{0}C (Fig. 38).

Fig. 38: Chickpea genotype ICCV 92944 grown under two soil moisture condition (top 7% and bottom 13%) showing visible sign of drought due to water scarcity (top)

Table 6: Promising chickpea genotypes identified with initial high LAI and biomass

Genotype	LAI	Biomass (g/five plants)
Katila	1.30	213.60
Avrodhi	0.95	266.40
Vaibhav	0.90	113.97
GCP 105	0.80	164.10
JG 11	0.75	151.73
BG 396	0.70	155.20
DCP 92-3	0.65	214.17
Vijay	0.60	195.93
RSG 888	0.60	190.63
BDG 72	0.60	178.17
GNG 469	0.55	197.87
GNG 1958	0.50	209.93
Vishal	0.50	203.50
ICC 15614	0.50	156.93

Fig. 39: Genotype PDG 4 identified having tolerance to both high temperature and drought

Field screening with receding soil moisture and high day temperature of >35^{o}C enabled to identify contrasting genotypes with slow leaf senescence and faster maturity. Fig. 39 shows chickpea genotype with slow leaf senescence with high podding branches even at high temperature and drought condition

The optimum temperature for photosynthesis was worked out to be at 30^{o}C (Fig. 40) showing high quantum yield (Fv/Fm) with intense blue fluorescence images in comparison to other sub-optimal and supra-optimal temperature showing lower value of quantum yield with green to yellow images.

Photo-thermo-periodic response was observed in two known heat tolerant genotypes. Heat tolerant genotype ICCV 92944 flowered and set pods both under 10h (short day) and 16h day length (long day) at temperature beyond 35^{o}C, whereas thermotolerant genotype ICC 1205 flowered only under long day length (16h). The results indicated that germplasm having both photo- and thermo-insensitivity are well adapted to diverse climatic conditions.

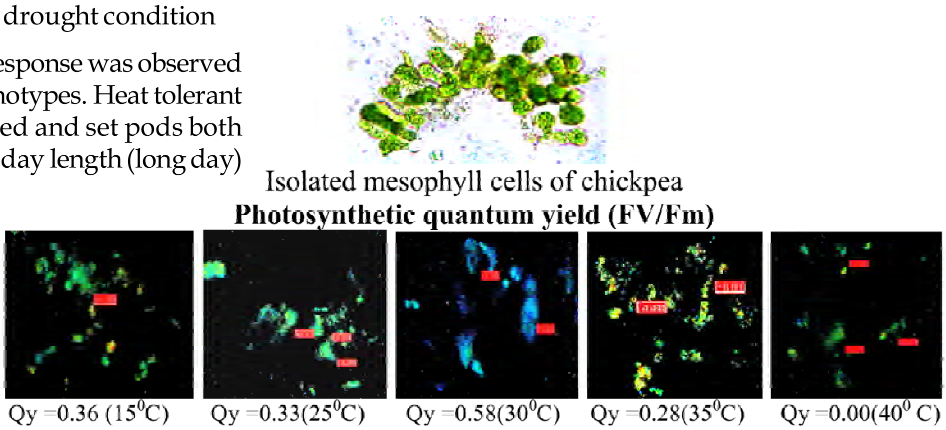


Fig. 40: Fluorescence images of isolated mesophyll cells pre-treated with different temperature

The SDS-PAGE of isolated thylakoid membrane preparation indicated missing of major thylakoid membrane proteins and stromal carboxylating enzymes which were prominent in heat tolerant genptypes (Fig. 41).

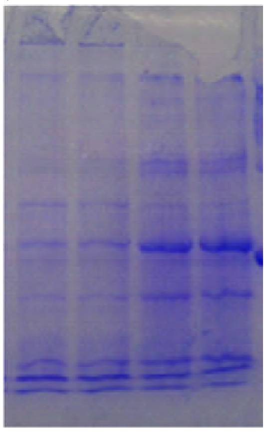


Fig. 41 : SDS PAGE of Heat sensitive (left) and heat tolerant (Right) genotypes

Screening of Fieldpea Genotypes against Heat Stress and Morpho-Physiological Traits Associated with Heat Tolerance

A field experiment was conducted with fourteen fieldpea genotypes with contrasting characteristics under irrigated condition. To study the effect of high temperature on various physiological parameters, seeding was done at two dates *viz.*, 10th November and 11th January.

Under late sowing, the per cent pollen germination decreased as compared to the normal sowing. On the basis of yield and yield attributing traits, few genotypes *viz.*, KPF 103, DMR 15, Pant 5 and IPFD 3-6 were selected for their physiological tolerance to high temperature. At 38^{0}C pollen grains germinated fast and pollen tubes grew rapidly in heat tolerant genotypes particularly KPF 103 and DMR 15 (Fig. 42). At high temperature (>40^{0}C) short pollen tube was observed (Fig. 43).

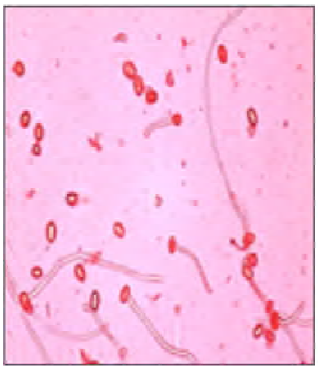


Fig. 42 : Pollen germination and pollen tube growth in heat tolerant KPF 103

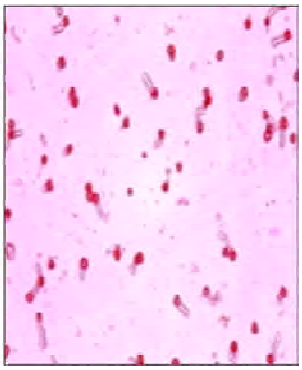


Fig. 43: Poor pollen germination in heat sensitive genotype IPFD 1-10

Effect of Low Soil Moisture and High Temperature on Morphological, Physiological and Biochemical Traits in Relation to Total Biomass and Seed Yield in Lentil

To study the effect of high temperature on various physiological parameters and seed yield, ten lentil genotypes with contrasting characteristics were sown under irrigated and non-irrigated condition at two dates *viz.*, 10th November and 11th January. Different phenological, physiological and yield attributing traits were recorded along with seed yield. Generally, late sown condition advanced flowering compared to normal sown. Similar pattern was observed in days to 50% flowering, days to first podding, days to 50% podding and days to maturity.

Identification of Source of Tolerance to Temperature Extremities in Long Duration Pigeonpea and Analysis of Physiological Traits Conferring Tolerance

Challenging and optimum induction temperatures were standardized to screen pigeonpea genotypes for high temperature tolerance by using temperature induction response technique (TIR). Challenging temperature is the temperature, which causes more than 90% reduction in growth in the non-induced seedlings and is the lethal temperature. The challenging temperature for pigeonpea was optimized at 54°C for 3 hours (Fig. 44). Temperature was increased from 30°C to 43°C in 3 hours and maintained at 43°C for 2 hours then transferred to challenging temperature (54°C, 3 hours).

Fig. 44: Standardization of challenging temperature (54°C, 3 hours)

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

The protein content of 82 germplasm accessions of lentil was determined by using Kjeldhal's method.

The mean seed protein content of the accessions was 30.09%, whereas, the protein content varied from 21.5% to 36.02%, which showed wide variability in lentil germplasm for this important quality trait. However, further studies are required on its heritability and interactions with environment, as well as its genetic determinants to devise the strategy to improve the seed protein content in lentil.

Total phenolic content and antioxidant activity

Pulses are important due to their antioxidant activity (AOA) attributed to the phenolics which are known to protect organisms against harmful effects of free radicals. The mean total phenol content was 5.63 mg gallic acid equivalent/100 g, whereas, the values ranged between 2.96 to 11.96 mg /100 g in the lentil germplasm. Maximum phenol content was recorded in ILWL 147 and ILWL 136608. The antioxidant activity ranged between 1.4 to 3.82 mmol Trolox/100g with maximum AOA in ILWL 147.

Trypsin inhibitor activity

The protease inhibitors present in pulses can have a major impact on nutritional value as they inhibit pancreatic serine proteases, thus impairing protein digestion. Thus, the trypsin inhibitor activity (TIA) was determined in mature seeds of lentil germplasm using á-N-benzoyl-DL-arginine-p-nitroanilidede-hydrochloride (BAPNA) as trypsin substrate. Mean TIA content in lentil germplasm was 7.49 TIU/mg protein and varied from 3.67 to 13.30 TIU/mg in lentil germplasm.

Dietary fibre

Dietary fiber is recognized as a healthy food component consisting of a mixture of polymeric non-starch substances. Pulses in general are high in fiber, with approx. 15–32% total dietary fiber. Of this, approximately one-third to three-quarters is insoluble fiber and the remaining is soluble fiber. Lignin, cellulose and some hemi-cellulose typically constitute the insoluble dietary fiber (IDF), whereas, pectin, some hemi-cellulose and other non-starch dietary fiber and poly-saccharides make up the soluble dietary fiber (SDF). The present work was undertaken to assess the dietary fiber profile of lentil accessions using procedure [AOAC Method 985.29 (1997)] for rapid determination of total dietary fiber content in mature lentil seeds using a combination of enzymatic and gravimetric methods. The total dietary fiber (TDF) content tested in 17 different accessions of lentil varied from 10.26 to 21.69% (Fig. 45). The mean TDF content of lentil (14.96%) as found in this study fairly agrees to that of earlier published reports (15.8 % TDF).

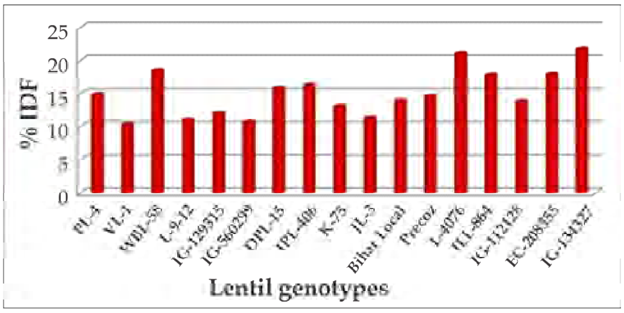


Fig. 45: Total dietary fibre in lentil genotypes

Anti-nutritional Components of Lathyrus and their Removal by Processing

Wide variability was observed in BOAA/ODAP in 80 lentil genotypes. BOAA was present in the range of 0.51–1.06 mg/g with an average of 0.70 mg/g (Table 7).

Table 7: Variability in BOAA (mg/g) of lathyrus genotypes

Genotype	BOAA (mg/g) (Range)	Mean (mg/g)
RLK (42)	0.51 – 0.81	0.64
Pusa (2)	0.51 – 0.56	0.53
AKP (2)	0.59 – 0.69	0.64
VKS (13)	0.65 – 1.05	0.82
VKG (4)	0.64 – 0.79	0.72
PBJ (3)	0.67 – 0.73	0.70
JBT (4)	0.83 – 0.98	0.88
IC (4)	0.66 – 0.75	0.72
EC (3)	0.83 – 1.06	0.95
ET (1)	1.03	1.03
LSD (1)	0.83	0.83
Sel 504 (1)	0.66	0.66
Overall Range/Mean	0.51 – 1.06	0.70

(Figure in parenthesis indicate number of genotypes)

Seeds of different genotypes of lathyrus were subjected to traditional processing *viz.*, soaking and dehusking. The range of BOAA in dehusked grain was 0.27–1.45 mg/g. The oxalate content of seeds decreased during soaking and dehusking, and a loss of 58.4% in oxalate content was recorded on dehusking of grains. The range of oxalate was 0.34-0.96 mg/g in dehusked grain. Total phenols and tannins also decreased remarkably during dehusking and a loss of 61.3 and 47.3%, respectively was registered. The phytates content in lathyrus seed was found in the range of 15.4 to 16.5 mg/g and a loss of 6.02% was observed during dehusking of seeds (Fig. 46).

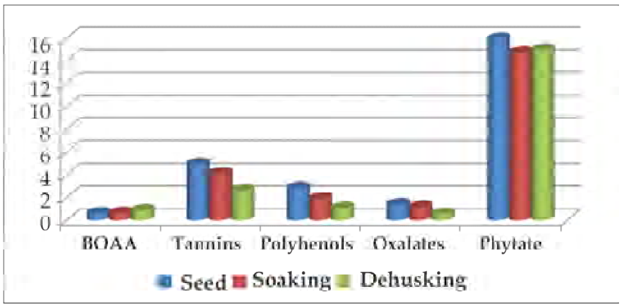


Fig. 46: Changes in anti-nutrients of lathyrus during processing

Efforts were made to reduce BOAA in dehusked grain (*dal*) of lathyrus. Soaking in acidic solution (pH 4.0) reduced 92.62%, whereas alkaline solution (pH 9.2) reduced 82.43% of BOAA for 30 and 60 minutes soaking at 80ºC and 100ºC caused a loss of 91.92% and 83.14%, respectively in BOAA content. Seven lathyrus varieties *viz*., Ratan, Nirmal, Pusa 24, Sihara local, Prateek, Mahateora and Kanpur Local showed the variation in the range of 0.034 to 0.218 mg/g of BOAA after processing.

Increasing Nodulation and Nitrogen Fixation in Chickpea under Moisture Stress

Benefits of *Mesorhizobium ciceri* strains on nodulation and grain yield in chickpea were evaluated under field trials. In addition, genotypes were grown on low and high soil phosphorus availability for comparing nodulation, VAM infection, isolation and characterization of P-solubilizing microorganisms from the roots and plant biomass accumulation.

Preliminary evaluation of different strains of *M. ciceri* in field

Three *M. ciceri* strains *viz*., strain 19, 29 and 45 improved nodulation and increased grain yield by 30% over uninoculated control (15 q/ha). In another field trial, five efficient strains of *M. ciceri* were used for comparing their performance. Maximum increase of 22% over un-inoculated control was observed with strains nos. CRS 3 and CR 45.

A field study was initiated to evaluate growth and nutrients uptake in chickpea genotypes grown on soils with low and high P levels. Soil with low P contained 1937 mycorrhizal spores/100 g soil, which were two fold higher as compared to the population in soil with high P. Chickpea genotypes belonging to early and late maturity groups were sown along with a check JG 16.

In general, nodule numbers and plant weight at 30 days differed among genotypes at low P level of 7 ppm as compared to 23 ppm. At low P level, VAM infection in root among the genotypes was higher (60 to 90%) than high soil P level (40-50%). There were significant variations in per cent reduction in above ground plant biomass accumulation due to deficiency of P in soil among different genotypes. In JG 16, there was 50% reduction in plant biomass due to low P availability in soil. Lowest reduction of less than 10% in plant biomass was recorded in IPC 2009-197 and IPC 2006-127. Phosphate solubilizing bacteria were isolated from the roots of varieties showing lowest per cent reduction in biomass production at low P as compared to high soil P. These microorganisms are being characterized for their efficiency in P-solubilization and possible role in P nutrition of chickpea.

Exploring Genetic Diversity of ACC Deaminase Producing Bacteria for Moisture Stress Management in Chickpea

Total 127 bacteria with ACC (amino cyclo-propane carboxylate) deaminase were isolated from chickpea roots and rhizosphere soils of IIPR research farms, Kanpur. PCR-RFLP pattern of rDNA and *acd*S genes from selected isolates were generated for understanding the phylogenetic relationship among the ACC deaminase producing isolates. Isolate No. ACC-75a recorded highest ACC deaminase activity. Out of 26 ACC deaminase producing isolates, best four isolates *viz*., ACC-2a, ACC-7b, ACC-7a and ACC-16b enhanced chickpea nodulation and plant biomass at 90 DAS in the range of 40-138.6% and 30-67%, respectively under moisture stress. Co-inoculation of ACC deaminase producing bacterium (isolate No. ACC-3) with *Mesorhizobium* enhanced chickpea nodulation up to 62.5% compared to un-inoculated plants under moisture stress (Fig.47).

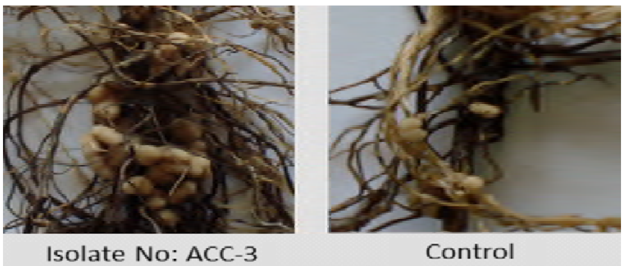


Fig. 47: Enhanced nodulation of *Mesorhizobium* by ACC deaminase producing bacterium over control

Isolation and Screening of Efficient AM Fungi for Lentil and Chickpea

To study the effect of arbuscular mycorrhizal (AM) fungi on plant growth, nutrition and yield of chickpea *cv*. DCP 92-3 was grown under different P levels (P_0, P_{40} and P_{80}). The plant height did not differ with different P levels and inoculation at vegetative and flowering stages. AM colonization in roots was recorded at vegetative stage and was in the range of 22 to 32 per cent. P_{80} level recorded least AM colonization than P_0 and P_{40} levels. Flowering stage recorded maximum (62%) AM colonization at P_{40} level. AM inoculation recorded mean of 17.3 to 20.3 and 25.4 to 31.7 per cent increase in plant biomass and AM colonization, respectively, over uninoculated control at flowering phase under three levels of P (Table 8).

Table 8. Effect of AM fungi on plant biomass under three levels of P in chickpea *cv*. DCP 92-3

	Plant biomass (g plant^{-1})							
Crop stage	Vegetative stage				Flowering stage			
P levels (kg/ha)	P 0	P 40	P 80	Mean	P 0	P 40	P 80	Mean
T1-Uninoculated	0.47 (0.0)	0.61 (0.0)	0.53 (0.0)	0.54 (0.0)	3.09 (0.0)	2.86 (0.0)	3.29 (0.0)	3.08 (0.0)
T2-*Rhizobium*	0.50 (5.9)	0.62 (2.3)	0.57 (7.2)	0.56 (5.0)	3.18 (3.0)	3.02 (5.7)	3.41 (3.7)	3.21 (4.1)
T3-*Rhizobium*+PSB	0.49 (5.1)	0.68 (12.1)	0.63 (19.7)	0.60 (12.6)	3.27 (6.1)	3.80 (33.0)	4.00 (21.5)	3.69 (19.9)
T4 –*Rhizobium* + AM fungi	0.49 (5.1)	0.77 (26.2)	0.70 (31.8)	0.65 (21.9)	3.29 (6.5)	3.68 (28.7)	3.87 (17.5)	3.61 (17.3)
T5 – *Rhizobium* + PSB + AM fungi	0.55 (17.5)	0.84 (37.7)	0.73 (37.9)	0.73 (31.9)	3.33 (8.0)	3.90 (36.4)	3.88 (17.9)	3.70 (20.3)

Note: Parenthesis values are per cent increase over respective control

Identification and Characterization of Biochemical Compounds Imparting Resistance to Fungal Pathogens and *Helicoverpa armigera* in Chickpea

Chemical characterization of active compounds

Individual compounds were isolated from very active antifungal fractions of highly non-polar groups by following the preparative TLC and crystal growth approaches. The compounds of KWR 108 and IPC 2004-52 were structurally identified as closely related Isoflavone by comparison of their spectral data with that of the published standard values of already known compounds of this group. Comparison of IR spectrum of chemical compound of JG 62 (wilt susceptible) with that of KWR 108 and IPC 2004-52 (both wilt resistance), though showed similarities at various IR, functional regions but differing only between IR region of IR max Cm^{-1} 1200-700 (Fig. 48). Unlike JG 62, in case of compounds of both of the wilt resistant varieties *i.e.*, KWR 108 and IPC 2004-52 four extra peaks appeared at IR max Cm^{-1}: 1261, 1091, 803 and 719 that indicates some extra functional substituents on the Isoflavone

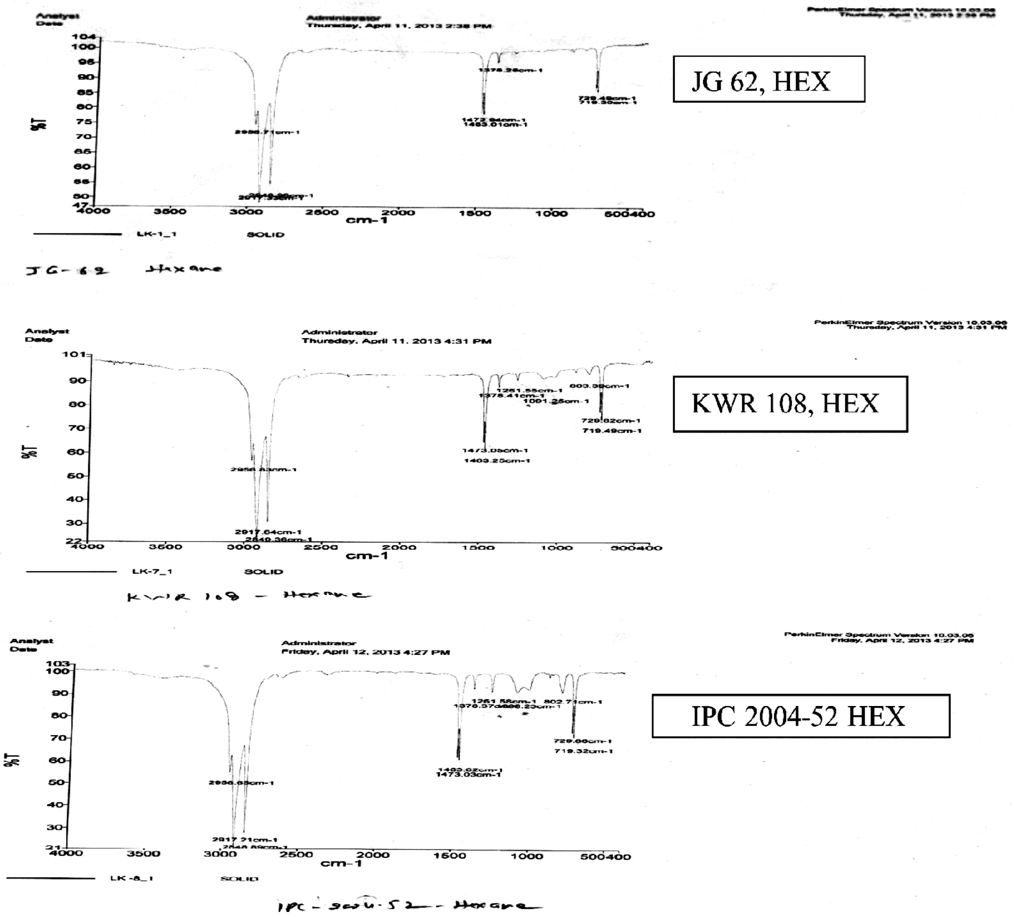


Fig. 48: IR spectrum of highly non-polar fractions based compounds of three chickpea varieties

chemical structure moiety as compared to the susceptible variety JG 62. ^{1}HNMR and ^{13}CNMR spectrums of the three compounds are also in good support with that of IR analysis and also revealed both *i.e.*, the pattern as structurally assigned and expected by Isoflavone chemical structures and the extra peaks for H and C for the extra functional substituents on the Isoflavone chemical structure moiety in case of both wilt resistance varieties.

Externally Funded Project

Application of Microorganisms in Agriculture and Allied Sector: Plant Growth Promoting Rhizobacteria (PGPR) for Chickpea and Pigeonpea

Inoculation with *Mesorhizobium ciceri* and PGPR strains improved plant growth and grain yield of chickpea (DCP 92-3). Combined inoculation with *M. ciceri* and PGPR strains produced higher growth response as compared to inoculation with individual strains (Table 9). Inoculation with mixture of microorganisms along with compost increased grain yield by 29% as compared to un-inoculated control. There was increase of 18 to 25% over control due to inoculation with rhizobium as well as PGPR strains individually, but the maximum response was obtained due to inoculation with mixture of all the three beneficial microorganisms.

In another field experiment, inoculation benefits were evaluated with two chickpea varieties JG 16 and Subhra grown after maize residue incorporation and use of rock phosphate as P source. In both the varieties, combined inoculation with PGPR strains CP 11, PSB 11 and J 7 was superior as compared to the individual strains.

Table 9. Effect of inoculation with PGPR strains on grain yield of chickpea cv. DCP 92-3

Treatment	Grain yield (q/ha)	% increase
Un-inoculated	13.71 ± 0.755	
M. ciceri	16.79 ± 1.74	22.54
PGPR strain J-7 + *M. ciceri*	16.31 ± 0.777	18.96
PGPR strain PSB-11+ *M. ciceri*	17.17 ± 2.132	25.23
Mixture of Strain J-7 + PSB-11 + *M. ciceri* + Compost	17.79 ± 0.977	29.76
Compost only	14.10± 2.24	2.84
CD (0.5)	3.06	-

Inoculation with PGPR strains and use of compost as source of plant nutrients produced better response as compared to the chemical fertilizers either applied alone or in conjunction with compost.

A field experiment was laid to assess genotypic variations among sixty advanced breeding lines of chickpea on nodulation, VAM infection, plant growth and grain yield under low and high soil P availability with JG 16 as check. Nodulation decreased while VAM infection in roots increased at low as compared to high soil P status. Root endophytic microorganisms capable of solubilizing the insoluble P were isolated from different varieties. The Mesorhizobium strains isolated from nodules of different varieties were purified and characterized for different phenotypic characters. Deficiency of soil P resulted in reduction in plant biomass production and grain yield of all varieties, but reduction in grain yield was only 20% in IPC 2005-44 as compared to 35% in JG 16. Maximum reduction of 92% in grain yield was however obtained in IPC 2009-197.

Social Science

Analysis of Gender Roles in Pulses Production and Processing in Bundelkhand Region

Role of men and women in different activities, decision making, drudgery perceived, source of information, adoption of modern technologies and constraints perceived in pulse production and processing was studied in Sagar, Damoh, Panna, Chhatarpur, Mahoba, Chitrakut and Jalaun districts of Bundelkhand region. The data were collected from the 1350 men and women by interview, group discussion and observation methods.

Majority of women belonging to small and medium farmers category perform activities as land preparation (38%), seed sowing (60%), weeding (72%), harvesting (70%), plucking of pods (80%) and storage (68%), whereas men participate in weedicide spray (75%), land preparation (36%), harvesting of crop (52%) and selling of produce in market (80%). The *dal* making is exclusively done by the women. Majority (78%) of decisions are taken jointly except purchase of seeds, selection of varieties and selling of bulk produce in market. Women belonging to small category contribute 60 to 70% in decision making on different aspects of pulse production. Majority of women perceived very high level drudgery in sowing (75%), hand weeding (100%), harvesting and threshing (70%), whereas men perceived very high level drudgery in land preparation, harvesting and threshing. The majority of women (90%) depend for information on their husbands related to agriculture, while men get information from KVK, market and neighbours and progressive farmers. It was expressed by the farmers that they get information from training programme and farmers' fairs organized by KVKs and state department of agriculture.

Women belonging to large category participate in land preparation (16%), hand weeding (22%), harvesting (55%) and storage (65%), where as men participate in land preparation (60%), carrying of compost (30%), spray of weedicide (65%) and harvesting (70%). The large category farmers get work done by hired labours also. Women belonging to large category perform similar operations as small and medium farmers, but per cent allocation varies. Majority of farmers get information from KVK, agriculture department, market and private seed traders.

Major pulses grown by the farmers were urdbean, chickpea (*Desi* and *kabuli*), lentil, and pigeonpea in the region. Majority of farmers (80%) were using old improved seeds of pulses susceptible to various diseases. The cultivation is done by the seed drill, use of DAP fertilizer (60%) and weedicide (60%). Majority of farmers were using machines for land preparation, sowing and threshing. Major constraints perceived by the farmers were yellow mosaic virus disease, weed infestation in *kharif* pulses, wilt in lentil and chickpea and insect problem in chickpea.

Validation of Farmer to Farmer Model of Extension for Dissemination of Pulse Production Technologies in Jalaun District

Farmer to farmer informal diffusion of profit enhancing technologies/practices takes place through social interactions in all the farming communities. The basic objective of the project was to assess the option of utilizing this informal mechanism of diffusion for transfer of improved pulse production technologies to wider farming community through structuring the process of diffusion. Fifteen key farmers were identified for structured diffusion of improved chickpea varieties (JG 16 and DCP 92-3). The key farmers were provided seeds for one acre each and they were encouraged to diffuse the seeds. The area expansion under improved chickpea varieties was recorded for two consecutive years (2011-12, 2012-13) through structured as well as unstructured manner and is presented in Fig. 49.

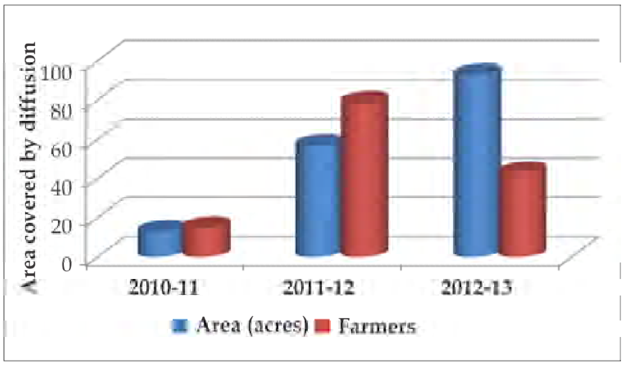


Fig. 49 : Area expansion and farmers coverage under improved chickpea varieties from 2010-11 to 2012-2013

During 2011-12, improved varieties of lentil (DPL 62), chickpea (DCP 92-3) and fieldpea (IPFD 1-10) were demonstrated in 10, 21 and 12.5 acres, respectively in project villages. The area expansion of the demonstrated varieties from 2011-12 to 2012-13 is presented in Fig. 50.

During the year, 21 key farmers were identified and provided seeds of improved chickpea variety (KGD 1168) for 10.5 acres. The farmers were motivated to diffuse the produce in the structured and unstructured manner to new farmers. After the crop harvest, the key farmers pooled 300 kg of seed of improved chickpea

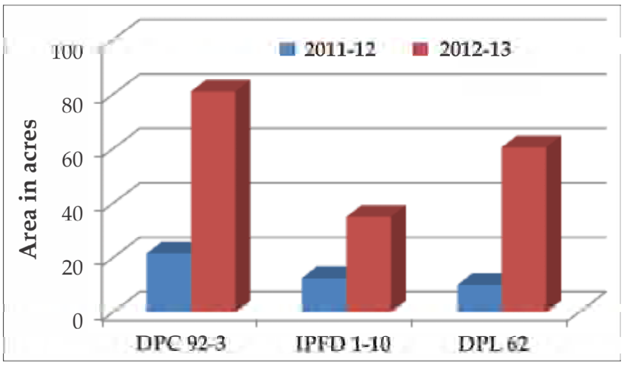


Fig. 50 : Area expansion under demonstrated pulse varieties from 2011-12 to 2012-13

variety Alok for further dissemination to farmers for sowing in 2013-14. The obtained yield of the demonstrations fields of key farmers was recorded to be 769 kg/ha as against the 655 kg /ha in local variety. The key farmers received yield advantage of 114 kg/ ha and income advantage of Rs. 3450 due to the improved variety (Fig. 51).

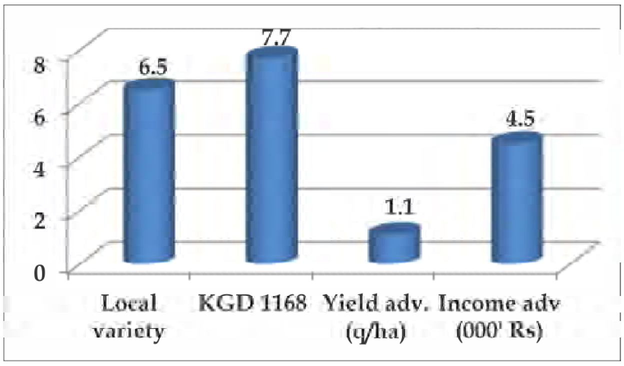


Fig. 51 : Yield and income advantage of KGD 1168 over local variety (2012-13)

Entrepreneurship Development through Pulses Production and Processing Technologies among Rural Youths for Income and Employment Generation

Seventy respondents as farmers, farm women entrepreneur, Govt. personnel and *para*-extension agents were surveyed through individual and group discussion, interview schedule, site observations and cross check survey. The potential pulse based enterprises were identified and ranked first like pulses cultivation as cash crop, followed by *dal* mill, quality seed production, basket making from pigeonpea, organic farming of pulses, innovative marketing (e-marketing of processed pulses), promotion of seed processing plants, grading and packaging of pulses, bakery/*namkeen* product, sprouted pulses and pulses soup, *dal* mill design and manufacturing.

Pulses grading at farmers' level is also useful for better market price, reduction of milling cost thus dropping the *dal* price. The rate of adulteration/ impurities/immature seeds in pulses is a problem for pulse industry. Pigeonpea milling needs to be taken on priority for processing over other pulses due to its higher consumption and difficult milling.

The farmers and farm women were empowered on participatory seed production, pulses processing and value addition with coordination of grass root level organization. The message on pulses technologies were also broadcasted through community radio station namely '*Vakhat Ke Aawaj*' which covered a dozen of villages of selected district. To reduce women drudgery, one hand operated IIPR *Dal Chakki* was supplied to women group/SHGs. Quality seed of mungbean (PDM 139, IPM 02-3, IPM 2-14) and urdbean (Uttara, IPU 2-43) was also provided on payment basis for seed production in 7.0 ha area.

Development of Appropriate Training Modules on Pulses Production Technologies

This study was carried out with objective to analyze the training process under the pulses training programmes and to work out the training needs of the trainees and trainers of Jalaun and Kanpur Dehat districts. Analysis of training process at district levels revealed that trainings on pulses are organized under various central and state funded schemes. The training component under these schemes is 'training and exposure' visits. These training programmes are conducted at district headquarter, KVK, block and village levels in coordination of SAUs and ICAR institutions. The exposure visits of the farmers are also organised at state and national level where farmers and extension agents are empowered by 'learning by doing and seeing is believing' and interact with experts. It was revealed that selection of trainees for these programmes and exposure visits is improper and needs change. Further, it was observed that training facilities *i.e.*, physical facilities and audio-visual aids, *etc.*, were inadequate at the district level and also training curriculum is not updated since long. There is urgent need for farmers' friendly extension literature in print and digital form as per location specific agro-climatic conditions of districts.

Training needs of farmers from village Parosa, Hrichandpur and Nisva of Jalaun district were prioritized on recommended pulses varieties, root rot and wilt in lentil and chickpea, plant density in pigeonpea and irrigation schedule. It was observed that there is sufficient area under canal irrigation in Jalaun district where mungbean in spring/summer season can largely replace *Mentha* cultivation as the later crop demands more water. Thus, the training module for canal irrigated area farmers will emphasise spring/summer mungbean cultivation. Whereas training module for the farmers located under ravine and undulated land will be based on pigeonpea+sorghum and chickpea. Similarly, the training needs of the farmers under irrigated conditions in village Kumbhi, Lahrapur, Baletha, Bariey, Goriapur and Rura in Kanpur Dehat district were identified on improved varieties and their availability, seed rate, time of sowing, post-emergence herbicide, insect and diseases identifications and management. The training need in Yamuna belt of Kanpur was different from other parts of the Kanpur Dehat. There are variations in training modules for rainfed and irrigated area.

Development of A Prototype Expert System for Identification and Control of Insect-Pests/Diseases in Chickpea and Pigeonpea

Questionnaires for data collection were developed in Hindi language with the help of domain experts for development of PulsExpert in Hindi language. Data were collected from variety of sources including books, bulletins, reports, domain experts for major diseases and insect-pests of chickpea and pigeonpea and designed the structure of acquired knowledge/information. Knowledge has been elicited through the knowledge acquisition tool to provide user-friendly interface to domain expert(s) for entering the information. Knowledge base for disease/insect-pest identification symptoms and their control measures has been developed in Hindi. A Hindi-based user-friendly interface has been developed for farmers and extension workers to get the results for their queries, to update information or to view the knowledge. Thus, complete Pulse-Expert System is being developed in Hindi to provide diseases/insect-pests identification and control advice to farmers.

Development of Database and Information Retrieval System for Pulses Genetic Resources

Collection and organization of different characteristics of germplasm data for mungbean and urdbean has been completed and stored in proper computerized format for creation of genetic resource database. A home page for Germplasm Information System has been designed to facilitate the authenticate users for login-id and password. An interface for data entry has been developed for entry of data related to different characters of germplasm. Total two main reports were designed for retrieval of information: 1. Germplasm character-wise report, 2. Germplasm attribute-wise report. In germplasm character-wise report, report in tabular form and report in graphical form were displayed on the screen. However, in case of germplasm attribute-wise report, qualitative and quantitative characters report were designed for retrieval of germplasm information.

Analysis of Consumption Pattern and Prices of Major Pulses in India

The data on prices of pulses for the last two years were collected. In most of the pulses, prices have shown a positive trend except for urdbean. In case of urdbean, the average prices were below the minimum support price of Rs. 4300. Seasonality indices were calculated based on the average prices of pulses from six major states. In case of chickpea, the seasonality indices of prices were lower during January to May and the lowest value of seasonal index (0.85) was in April. In case of pigeonpea, the seasonal indices were lower during April to June, the lowest being in June (0.92). The data on market wise prices of pulses and arrivals are being collected for further analysis on variability and seasonality.

Analysis of Growth and Instability in Major Pulses of India

Decade wise analysis of total pulses (1950-2010) showed that during 1960-70 the instability in area decreased, but instability in production and yield increased as compared to previous decade. Also there were quite fluctuations in the yield during 1960-70 which was the main reason behind the instability in production.

Decade wise analysis of chickpea showed that during 1960-70 the instability in production increased which was mainly due to productivity/yield as compared to previous decade. During the decades from 1950-60 to 1970-80 the instability in yield was almost twice the instability in area. In case of pigeonpea, the instability in area kept on fluctuating from .01 to .03. During 1960-70 the instability in yield increased drastically from .06 to .11 and reduced during 1980-90 from .08 to .04 as compared to previous decade and its effect was realized in production component.

In case of lentil, analysis showed that during 1980-90 the instability in area and production reduced, while yield remained constant as compared to previous decade. The instability in area was quite high during 1970-80 (.06), but later it came to .02 and remained constant thereafter. So the change in stability in production is mainly due to yield effect after 1980-90.

Externally Funded Projects

Enhancing Lentil Production for Food, Nutritional Security and Improved Rural Livelihood in North-eastern India

For improving nutritional and food security, agricultural sustainability, farmers' income and rural livelihood through increased production of lentil, total 18 villages (11 in Ballia and 7 in Fatehpur) covering

180 farmers were covered during *rabi* 2012-13. Farmers, Participatory Varietal Selection Trials involving improved varieties *viz.*, PL 6, NDL 1, HUL 57 and DPL 62 along with local variety were laid out in two farmers' fields in each selected villages. Based on the farmers' preferences on different traits related to selection of appropriate varieties of lentil, participatory seed production were undertaken by registered farmers associations *viz.*, *Medaura Kisan Sewa Samiti* in Ballia and *Beej Vikas Samiti*, Tutuwari, Fatehpur on large scale. A close linkages with National Seed Corporation, Kanpur and Varanasi, U.P. Seed Certification Agency, Allahabad and Mau, District Agril. Office, NABARAD has been established for quality seed production of lentil. The project has empowered farmers in taking decision on selection of appropriate technologies and self-sufficient in seed production of improved varieties through promotion of formal and informal seed systems at village level. Adoption of technological packages of lentil has provided boost to farmers in lentil in both districts. A Participatory Rural Appraisal (PRA) Survey was conducted to assess farmers' aspiration and opportunities to establish a functional model for promotion of lentil cultivation under rice dominating cropping pattern. The economic gain (net profit/ha) of grain *vis-à-vis* seed production in Ballia and Fatehpur districts has been given in Fig. 52 and 53.

Promotion of formal and informal seed system(s) through registered farmers' associations helped in ensuring availability of quality seed of preferred varieties of lentil at village level and enhanced net

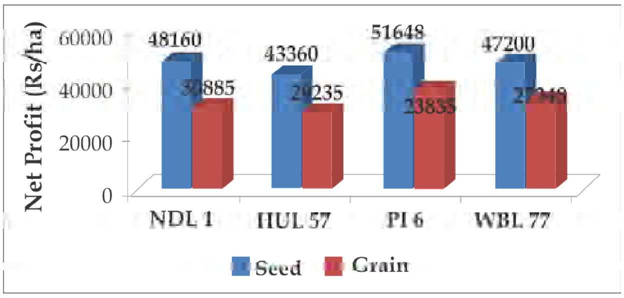


Fig. 52: Net profit of grain *vis –a- vis* seed production in Ballia district

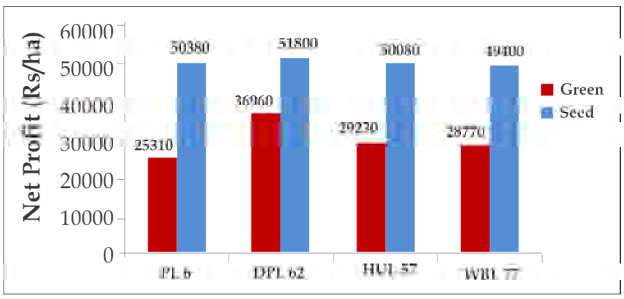


Fig. 53: Net profit of grain *vis –a- vis* seed production in Fatehpur district

income of participating farmers. Farmers obtained highest net profit/ha (Rs. 51648.00) from PL 6. Farmers obtained 30 to 50 per cent higher profit from seed sale in comparison to grain in nearby markets of Ballia and Fatehpur districts. Farmers opined that initial benefit in the form of higher profit and income were invested in order to obtain long term benefit and to stabilize farming system(s).

Increasing Chickpea and Pigeonpea Production through Intensive Application of Integrated Pest Management

The objective of the project under Accelerated Pulse Production Programme (A3P) is to demonstrate plant nutrient and protection technologies and management practices in a compact block for pigeonpea and chickpea. Participatory demonstrations on integrated pest management (IPM) were laid out in Bahuwa block of Fatehpur involving 325 farmers and covering 126 ha in 11 villages under short duration and long duration pigeonpea. Farmers were advocated for application of Indoxacarb (15.8% EC) at the time of 50% podding and majority of farmers (more than 225) applied it for effective management of pod borer. Economic gain by application of Indoxacarb (15.8% EC) in short duration pigeonpea is depicted here under:

Particular	2012-13	
	A3P	Non-A3P
Yield (q/ha)	11.53	8.55
Gross return (Rs.)	48000	35240
Cost of plant protection (Rs.)	3955	1740
Other costs (Rs.)	10120	10120
Total cost (Rs.)	14075	11860
Net return (Rs.)	33925	23380
C: B ratio	**1 : 2.41**	**1 : 1.97**

Ten units (50 farmers per unit) were identified in Bahuwa block of Fatehpur for intensive application of IPM modules in chickpea. A cluster of 15 villages including 450 farmers was selected and chickpea sowing covered 475 ha under rainfed, monocropped and partial irrigated double cropped situations. Quality seeds of improved varieties DCP 92-3 and KGD 1168, pheromone traps, Indoxacarb (15.8% EC) and other insecticides were applied under IPM. Based on sowing time under rainfed and partial irrigated farming situations, efficacy of insecticide was assessed for management of pod borer in chickpea (Table 10).

Rains during February affected plant growth, flower dropping, pod-formation, grain filling, *etc.*, in October sown crop. The larvae population of *Helicoverpa* was less in October sown crop in comparison to I[st] fortnight of November sown crop. Application of Indoxacarb (15.8 % EC) reduced larval population at the time of pod formation. Farmers obtained 2.5 q to 4.5 q additional yield through management of pod borer.

Table 10. Effect of application of IPM for management of pod borer in chickpea

Village	Date of sowing	Variety	No. of *H. larvae*/ 10 randomly selected plants	Yield (q/ha)		Increase in yield	
				IPM	Non-IPM	q/ ha	%
Nandlalpur	20-30 Oct	KGD 1168	1	17.6	13.5	4.1	30.4
	1-15 Nov	DCP 92-3	2	18.1	13.5	4.6	34.1
Mohanpur	20-30 Oct	KGD 1168	1	16.8	12.8	4.0	31.3
	1-15 Nov	DCP 92-3	2	18.6	13.5	5.1	37.8
Gazipur	20-30 Oct	KGD 1168	3	16.5	12.5	4.0	32.0
	1-15 Nov	KGD 1168	1	16.1	12.5	3.6	28.8
Bawara	20-30 Oct	KGD 1168	3	15.5	11.8	3.7	31.4
	1-15 Nov	KGD 1168	1	16.4	12.0	4.4	36.7
Phulwamau	20-30 Oct	DCP 92-3	2	16.7	12.5	4.2	33.6
	1-15 Nov	DCP 92-3	1	17.1	12.5	4.6	36.8
Lamehata	20-30 Oct	DCP 92-3	2	14.5	12.0	2.5	20.8
	1-15 Nov	DCP 92-3	3	15.6	12.0	3.6	30.0
Jamuha	20-30 Oct	DCP 92-3	1	14.8	12.0	2.8	23.3
	1-15 Nov	DCP 92-3	3	16.2	13.2	3.0	22.7
Brahmantara	20-30 Oct	DCP 92-3	1	16.4	12.8	3.6	28.1
	1-15 Nov	DCP 92-3	2	17.1	12.8	4.3	33.6

Popularization of Biorationals for Management of *H. armigera* for improving Chickpea Productivity in Jalaun District of Bundelkhand Region of Uttar Pradesh

Biorational module comprising of pheromone traps, NSKE, HaNPV and Spinosad offer environmental friendly alternative for effective management of pod borer *Helicoverpa armigera* in chickpea ecosystem. The use of biorationals was popularized in Jalaun district on 17.4 ha area with participation of 87 farmers in four selected villages. This module was also supported with improved chickpea varieties *viz*., DCP 92-3, JG 16, Shubhra and KGD 1168. On farm training programme was organized for the participating farmers to enhance their skill levels on production and utilization of various components of the module like use of pheromone trap, NSKE and HaNPV.

It was observed that the biorational module used with three components *i.e*., NSKE, HaNPV and Spinosad recorded lower pod damage (7.29 %) as compared to use of NSKE and HaNPV (14.4%). The per cent pod damage was recorded highest (16.37%) in the control plots.

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

Total 11 tribals dominated districts including 6 in M.P., 4 in Chhattisgarh and Lakhimpur in U.P. were identified for carrying out different activities for upliftment of socio-economic conditions of tribal farmers to bridge the gap between the scheduled tribes and general population with respect to all socio-economic development indicators in time bond manner. Ten KVKs *viz*., KVK Mandala, Dindori, Shahdol, Jhabua, Badwani, Dhar in M.P. and Baster, Dantewada, Kawardha and Kanker districts in Chhattisgarh were selected for implementation of activities. Special programme for Tharu Tribals was undertaken by IIPR in Lakhimpur district in U.P. For empowerment of tribal farm families and sustaining the programme outcome, 650 storage bins (2.0 q capacity) and 100 KNAP SACK sprayers were distributed among selected farm families in 11 districts. During *kharif* 2012, total 201 on-farm demonstration including pigeonpea (75), urdbean (113) and mungbean (13) were laid in selected 6 districts of M.P. and 4 district of Chhattisgarh by KVKs. JU 86 and TU 94-2 varieties of urdbean alongwith other INM and IPM components were demonstrated. Total 15 training courses were organized during *kharif*. The average yield of urdbean obtained at tribal farmers' fields was 972 kg/ha with net profit of Rs. 19670/ha. Highest yield of urdbean reported by KVK Shahdol (M.P.) was 1385 kg/ha. TJM and JM 37 varieties of mungbean alongwith other components were used in demonstrations. Tribal farmers obtained 1062 kg/ha with net benefit of Rs. 25994/ha.

Total 740 on-farm demonstrations including chickpea (480), lentil (120), fieldpea (130) and horse gram (10) were laid during *rabi* 2012-13. Field days were organized in last week of February, 2013 in each location. It has been reported by all partner KVKs that tribal farmers stored more than 65000 kg of previous year produce of chickpea, lentil, fieldpea in steel storage bins provided as community input. Seed sufficiency of improved varieties has been created at villages. KNAP SACK sprayers are also being used on large scale for management of insect pests.

Six villages *viz*., Bandar Bharari, Dhyanpur, Gubraila, Saunaha, Dhuskiya and Chandan Chauki were selected for implementation of the programme in Lakhimpur. Total 5600 kg seed (chickpea DCP 92-3: 500 kg, lentil IPL 81 : 2600 kg and fieldpea Vikas and KPMR 522 : 2500 kg) was distributed among 800 farmers. The insecticide was provided to the farmers for controlling insect. The severe rust problem in fieldpea was observed by scientists in the demonstration fields. The average yield of chickpea was obtained up to 2400 kg/ha and lentil 1800 kg/ha from improved varieties, against 950 kg/ha from local seed of lentil. Similarly, with fieldpea varieties yield was obtained 1800 kg/ha against 1200 kg/ha from local seed of fieldpea.

Biotechnology Unit

Identification of Molecular Markers Linked to *Fusarium* Wilt Race -2 Resistant Genes in Chickpea

To map *Fusarium* wilt resistance genes, two mapping populations (JG 62 x WR 315 and K 850 x IPC 2004-52) were advanced to F_4 generation. F_2 mapping population derived from cross JG 62 x WR 315, representing 178 individuals was phenotyped for *Foc* race 1 under pot conditions and genotyped with 84 polymorphic markers. A set of ten molecular markers reported to be linked to wilt resistance were also validated on 16 chickpea genotypes involving resistant, susceptible and wild genotypes.

Development of Transgenic Chickpea (*Cicer arietinum* L.) for Drought Tolerance

Genetic transformation of chickpea (cv. DCP 92-3) with AtDREB1A gene and 1,167 explants were co-cultivated. Three resistant shoots identified against the selecting agent *i.e.*, kanamycin monosulphate were established and seeds were harvested from all of them. To discriminate transgenics from non-transgenics, 48 T_1 progenies (from 3 T_0) were screened with new set of oligos for the presence of gene.

Externally Funded Projects

Development of Pod Borer Resistant Transgenic Pigeonpea and Chickpea

Genetic transformation (*Agrobacterium* mediated and micro-projectile) in chickpea and pigeonpea using the *Bt* gene (*cry1Ac*) was done with 73,309 and 31,187 explants, respectively. This resulted in establishment of 32 and 211 independent primary transgenics of chickpea and pigeonpea, respectively.

Total 2633 chickpea T_1 plants (from 58 independent T_0) and 677 pigeonpea T_1 plants (from 23 independent T_0) progenies were screened using PCR (two primer pairs covering the *cry1Ac* expression cassette), qualitative ELISA, Bt Strips for quick identification of positive lines. Confirmed lines were further screened by Western Blot analysis (Fig. 54 & 55).

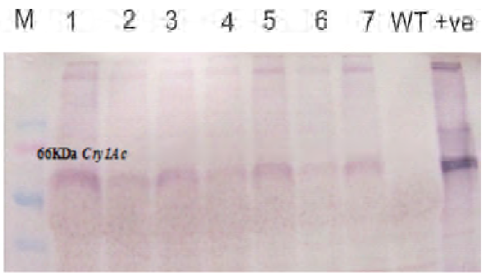


Fig. 54: Western Blot analysis to detect expression of *cry1Ac* protein in chickpea (T_1) leaves using chromogenic substrate

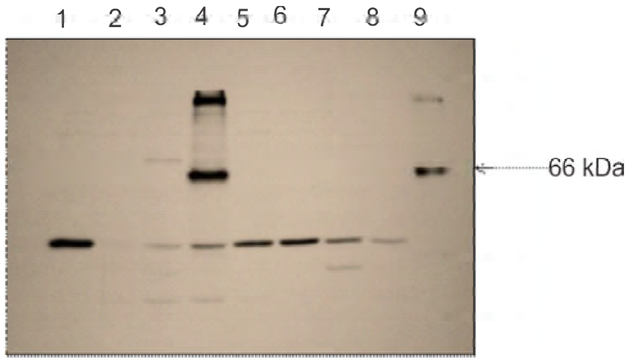


Fig. 55: Western Blot analysis to detect expression of *cry1Ac* protein in pigeonpea (T_1) leaves using chemiluminiscent substrate

Identified T_1 lines of chickpea and pigeonpea were subjected to bio-assay using detached leaf technique employing laboratory reared neonate larvae of gram pod borer, *Helicoverpa armigera*. In both the cases, variable mortality (20-100%) was obtained. In pigeonpea, a line exhibited 100% mortality (Fig. 56), while most of the screened lines of chickpea exhibited mortality of 20-60%.

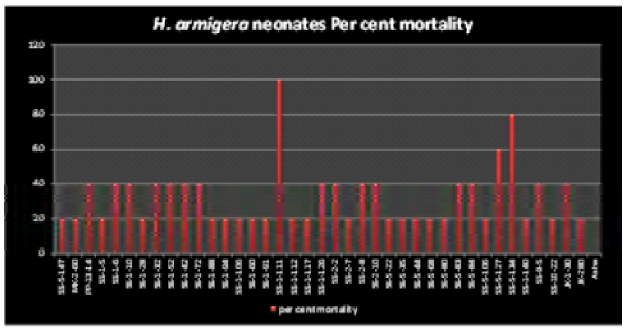


Fig. 56: Insect bioassay of pigeonpea (T_1) lines

Transgenic Development in Chickpea and Pigeonpea for Resistance to Pod Borer

Pigeonpea (Asha) and chickpea (DCP 92-3) were transformed using *Agrobacterium tumefaciens* harboring a synthetic *Bt* gene (*cry1Aabc*). Total 11 kanamycin resistant pigeonpea shoots and 33 chickpea shoots were established. Further, generation advancement of pigeonpea lines (T_0 to T_1, T_1 to T_2 and T_3 to T_4 progenies) and chickpea lines (T_0 to T_1 and T_1 to T_2) was accomplished. Molecular analysis (PCR, ELISA, Western hybridization) indicated integration and expression of *Bt* gene in selected lines (Fig. 57). Insect bioassay indicated variable mortality (20-100%).

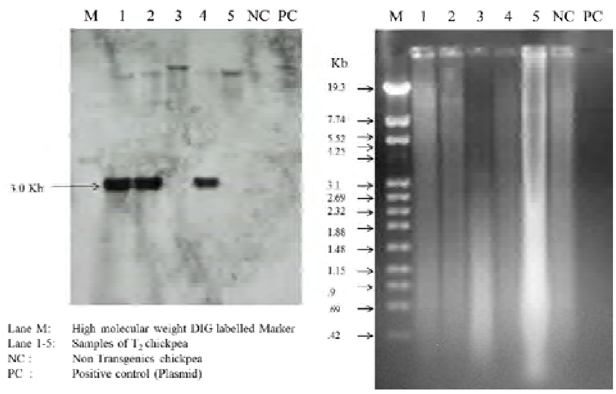


Fig. 57: Southern hybridization of PCR & ELISA chickpea (T_2) plants

Functional Genomics in Chickpea

The F_7 RIL population (195 individuals) derived from cross BG 256 x WR 315 was advanced and 30 polymorphic markers were identified between parents. These markers are being utilized for mapping QTL/ genes for yield trait and linkage map construction. Also, 100 cDNA clones derived from drought stress library were sequenced and nine EST-SSRs were synthesized and validated in chickpea. Genetic diversity study was performed in 221 chickpea genotypes (common cultivars and wild races).

Centre of Excellence for High Throughput Allele Determination for Molecular Breeding

In MABC 12 F_1 plants confirm true hybrids on the basis of molecular marker were backcrossed and 57 BC_1F_1 seeds were obtained. Similarly, 7 true BC_1F_1 plants derived from KWR 108 x ICC4 958 cross were backcrossed and 35 BC_2F_1 seeds were harvested. Also, 76 BC_1F_1 pods were harvested from fresh backcrossing on heterozygote F_2 plants. In MARS, 15 true hybrids derived from DCP 92-3 x ICCV 10 were advanced to F_2. In pigeonpea, mapping population comprising of 191 F_5 lines (Asha x UPAS 120) for wilt resistance was advanced and 24 SSR markers were identified polymorphic between parents.

Regional Station *cum* Off-Season Nursery, Dharwad

This Regional Station was established recently and it started functioning from April, 2012. During the year following activities were undertaken:

Farm development

During the year, following activities related to farm development were initiated/accomplished:

- One rain-out shelter was fabricated
- Trees, shrubs and bushes (~ 1.2 ha) were removed from the Farm
- Boundary repair work within the premises was completed
- Land leveling work was undertaken.

Breeder seed production/seed multiplication

Total 600 kg breeder seed of chickpea variety JG 11 and ~200 kg breeder seed of two *kabuli* chickpea varieties *viz*., Shubhra and Ujjawal was produced. Total 120 single plant progenies of each variety of *kabuli* chickpea were kept separately for their maintenance.

Research activities

Total 135 lines of *desi* chickpea including 3 checks JG 11, JG 16 and DCP 92-3 and 130 lines of *kabuli* chickpea including 2 checks IPCK 2002-29 and IPCK 2004-29 were evaluated of their performance under rainfed condition. Nine lines of *desi* chickpea *viz*., IPC 2007-28, IPC 2011-51, -66, -110, -115, -224, -228, -229, and IPC 2011-230 (> 1700 kg/ha) and 12 lines of *kabuli* chickpea *viz*.,IPCK 2006-143, IPCK 2011-40, -56, -166, -171, -174, -175, -179, -181, -183, -185 and IPCK 2011-183 (>1800 kg/ha) were found promising for yield, seed size and maturity duration. *Kabuli* chickpea entry IPCK 2011-179 (54 g/100 seed) excelled the check (39 g) for 100 seed wt.

Two crosses were attempted to transfer wilt resistance in the background of JG 11 and ICC 13124 from the donor WR 315. Similarly, two other crosses (BGD 103×TLII 109 and BGD 103×TLII 112) were also made to transfer traits that could facilitate mechanical harvesting.

In addition to above, facilitated off-season generation advancement of chickpea crosses.

All India Coordinated Research Projects

CHICKPEA

Varieties identified

GNG 1958 : This variety has been developed from cross GNG 1365 x SAKI 9516 and identified for North West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi. It has profuse branching and semi-erect growth habit. It has good level of resistance against wilt and tolerance to root rot, stunt and collor rot diseases. Its average yield is 2600 kg/ha with attractive large seeds (25.4 g/100 seeds) and average maturity period of 146 days.

Phule G 0027 : This variety has been developed from cross (ICCV 95412 x Phule G 92307) x ICCV 95412 and identified for hilly areas of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region. It has extra large seed size (37.7 g/100 seeds). It showed tolerance to wilt disease. Its average yield is 1200 kg/ha. It matures in 196 days in NHZ.

CSJK 6 : This variety has been developed from cross RSGK 628 x BG 1053 and identified for Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region. It matures in 188 days (average) and seed size is large (32.8 g/100 seeds). It is moderately resistant to root rot and tolerant to wilt.

GLK 26155 : This variety has been developed from cross BG 1088 x MPJG 2 and identified for North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi. It is tolerant to wilt. It is semi-erect and tall with light green foliage. It matures in 146 days and average yield is 2300 kg/ha. It has large seed size (27.8 g/100 seeds).

GNG 1969 : This variety has been developed from cross IPCK 96-3 x GNG 1382 and identified for North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi**.** This variety has attractive large seeds (26.2 g/100 seeds) with profuse branching and semi-erect plant. It is tolerant to wilt and root rot. Its average yield is 2200 kg/ha and matures in 146 days.

National crossing programme

To develop pool of segregating material, various centres *viz*., CCSHAU, Hisar (4), JNKVV, Jabalpur (4), PRSS, Samba (4), ARS, Kota (5), ARS, Sriganganagar (5), MPKV, Rahuri (8), JAU, Junagadh (5), RARS, Nandyal (2), ARS, Durgapura (30) and COA, Sehore (30) attempted crosses under national crossing programme as per need of the region. The seeds of these crosses will be advanced and segregating material will be shared among various centres for varietal development.

Genetic resource management

Total 14136 germplasm accessions were maintained at 18 centres. These accessions were evaluated for morphological traits and are maintained.

Breeder seed production

Total 11141.21 q breeder seed of 90 varieties was produced against DAC indent of 9367.94 q.

Research achievements

- Sowing of chickpea on broad bed and furrow (BBF) increased the seed yield by 18.86, 22.39 and 33.76 %, respectively, at Faizabad, Ranchi and Rahuri centres over flat methods .
- Two irrigations (one at branching and other at pod development stage) responded better and gave 15.37-75.50% higher yield at different locations. However, one irrigation at pod development stage was also beneficial.
- Conventional tillage was found promising at Dholi, Ranchi, Rahuri and Gulbarga over zero and reduced tillage. However, reduced tillage was found better at Pantnagar, Jhansi and Bangalore.
- Manual weeding was better over use of pendimethalin at all the locations except Gulbarga where both methods were at par.
- Rotation of chickpea once in a year or once in a two year cropping system proved beneficial over cereal/oilseed–cereal rotation at Kota and Sehore centres, while cereal/oilseed–cereal rotation was better at Samba centre.
- Use of inorganic fertilizer at Sehore and Samba and integrated use of fertilizer (organic/vermicompost+biofertilizers) at Kota was found better than rest of the fertilizer treatments. Use of 5 t FYM +60 kg P_2O_5+20 kg S/ha gave significantly higher yield at Samba, Berhampore and Gulbarga over their control.
- Use of 15-20 g Imazethapyr at 10-20 DAG was found better. However, all centres reported highest yield in weed free or hand weeding treatment. Many centres *viz*., Ludhiana, Samba and Junagadh have also reported phytotoxic effect of Imazethapyr on chickpea.
- Use of RDF+1 g Mo/kg seed with Rhizobium + PSB at Kota and Junagadh centres increased

the seed yield by 19.58 and 24.28 %, respectively, over RDF alone.

- Genotypes KWR 108 and PG 5 showed higher root penetration as well as higher root length density (RLD)., whereas K 850 had deep root, higher RLD and root length. Genotypes K 850, GCP 101, Virat, BG 256. RSG 963, PG 96006, JG 315, BGD 72 and RSG 807 consistently showed drought tolerance over five years based on lower drought susceptibility index (DSI)
- Genotypes ICCV 92944, ICC 4958, JG 218, PG 5 and PG 96006 were identified for heat tolerance on the basis of stability in reproductive components, membrane injury and chlorophyll fluorescence imaging for photosynthetic capacity.
- Genotype ICCV 88503 showed highest pollen germination (73%), followed by Vaibhav, ICCV 88505 and PDG 84-16 at lower tempeture (5^0C).
- Testing of six *Mesorhizobium* strains at 10 different locations showed that reference strain UASB 835 from Bangalore out yielded all other strains with an increase of 20.5%. Another strain RVSGRS 114 from Sehore recorded 18.9% increase in grain yield. With rhizobial inoculation, there is minimum saving of 40 kg N/ha.
- Inoculants of UASB 835 preserved in talc showed highest survival of rhizobia upto 3 months of storage, followed by lignite.
- PGPR strain LK 786 from chickpea rhizosphere recorded 13.7% increase in grain yield over uninoculated control.
- The infectivity of cultureable endophytic fungus *Piriformaspora indica* in chickpea roots varied from 25 to 75%. Inoculation with all the inoculants (*Piriformaspora indica* + *Mesorhizobium*+PSB + PGPR) with 30 kg P_2O_5 /ha increased the grain yield upto 20.2% over uninoculated control.
- The study on plant growth promoting endophytes from roots and nodules of chickpea showed that nodule endophytic isolate CNE 1 alongwith mesorhizobial inoculation recorded highest increase in grain yield (19.3%), followed by 16.1% by another nodule endophyte CNE 2.
- PSB strain from Rahuri alongwith mesorhizobial inoculation increased grain yield to the extent of 32.7%. PSB inoculant strain PSB 3 from Rahuri registered highest increase of 27% yield along with mesorhizobial inoculation over the years.
- Genotype GJG 0814 of *desi* chickpea and CSJK 54 of *kabuli* chickpea were found resistant against wilt.
- Entry JGK 13 was found resistant against dry root rot.
- Two entries *viz*., GNG 1581 (AVT 1-D) and GLK 28127 (AVT 1 -ELSK) were R/MR to collor rot at > 60% locations.
- Entries *viz*., IPC 2006-84 (R), JG 14, IPC 2006–77 (R), RSG 963, and GNG 1996 were found resistant (>10%) against wet root rot under field condition.
- Entry PBG 5 of AVT 1 (*desi*) was found resistant against ascochyta blight.
- Following genotypes were identified as resistant against multiple diseases:

GLK 28127	Wilt, dry root rot and collar rot
GLK 26167	Dry root rot and Ascochyta Blight
GNG 1996	Wet root rot and dry root rot
PBG 5, IPC 08-11	Wilt and Ascochyta Blight
BG 3004 (R), BDNG 2010-1, IPC 08-11, IPC 08-68, GJG 9022, GJG 0904, BCP 60, JG 24	Wilt and Botrytis grey mould

- Seed treatment with Pusa 5SD (*Trichoderma harzianum*)+vitavax power @ 4g+1g/kg seed, followed by carbendazim+thiram (1 : 1) was found effective in boosting the yield at almost all the locations.
- Among the new molecules, Emamectin benzoate 5SG @ 11 g.a.i/ha, Flubendiamide 480 SC @ 60 g.ai./ha, Rynaxypyr @ 18 g.a.i./ha were found better than currently recommended chemicals like Indoxacarb, Profenophos.
- Entries *viz*., GL 26054, Phule G 95311 (K), PBG 5, GL 27104, H 07-163, Phule G 0027 and HK 06-152 showed moderately resistant reaction against *Meloidogyne incognita.*

Front line demonstrations

- Improved varieties recorded 20% higher mean yield over local varieties.
- Application of 20 kg sulphur along with 100 kg of DAP/ha gave 9.0% higher mean yield than local practices (without sulphur) and application of zinc resulted in 15.9% increase in the grain yield.
- Foliar application of 2% urea solution at flower initiation stage and 10 days thereafter

increased grain yield by 11.5% and net return by 9.5%.

- Insect pest management revealed 16.0% increase in yield and net returns increased by 22.0%.
- Improved package of technologies gave 26.5% higher than the yield obtained by farmers' practices.
- Use of *Rhizobium* resulted in 13.0% increase in grain yield and net return by 14.0%.
- Weed control gave yield increase of 22.0% over the unsprayed plot with net return increase of 21.0%.
- Control of diseases like wilt and root rot by different fungicides gave 10.0% higher yield and net return increased by 12.0%.

PIGEONPEA

Varieties identified

IPH 09-5 (Hybrid): This cytoplasmic genetic male sterility (CGMS) based early duration pigeonpea hybrid developed at IIPR, Kanpur from a cross between PA 163 A (CGMS line or 'A' line or female parent) and 261322 R (restorer line or 'R' line or male parent) has been identified for eastern Uttar Pradesh, Bihar, Jharkhand, Orrisa, West Bengal and Assam. This hybrid possesses >33% superiority in grain yield over the best variety UPAS 120 and matures 8-10 days earlier than it. Its average yield is 1864 kg/ha. It is resistant to *Fusarium* wilt and sterility mosaic diseases. Its seed colour (Brownish red), shape (round) and size (9.3g/100 seed) is more attractive.

IPA 203: This long duration variety has been developed at IIPR, Kanpur, from a cross Bahar x AC 314-314. It showed yield superiority by 11.2% over the best check MA 6, 15.5% over Narendra Arhar 1, 24.9% over Bahar and 28.5% over MAL 13. Its average yield is 1949 kg/ha and matures in 246 days. Seed colour of this variety is brown and attractive, seed size is extra large (12.4 g/100 seed) and seed protein content is 23.02%. This variety is resistant to sterility mosaic disease, tolerant to *Phytophthora* stem blight and resistant to most of the variants of *Fusarium* wilt. It has been identified for eastern Uttar Pradesh, Bihar, Jharkhand, Orrisa, West Bengal and Assam.

Phule T 0012: This variety has been developed from the cross ICP 332 x BSMR 736. It is early maturing (150days) and 100 seed weight is 10.7g. Its average yield is 1547 kg/ha with yield superiority of 22.6% over the best check UPAS 120. It is moderately resistant to wilt, SMD and tolerant to pod borer and pod fly. It has been identified for Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Maharashtra.

Promising genotypes

Genotypes *viz*., Pusa 2012-1(NWPZ), AKTE 11-1, GRG 333, NTL 900, SKNP 610 (CZ), AKTE 11-1, GRG 33, PT 04-307, NTL 900 (SZ) in IVT (Early), BRG 11-01(SZ) in AVT1 (Early) and RVKT 260, BRG 10-02, RVKT 261(SZ) in AVT 2 (Early) were found promising.

Breeder seed production

Total 781.60 q breeder seed was produced against the indent of 514.89 q.

Research achievements

- Inter-pigeonpea spacing of 90-120 cm was found optimal for intercropping.
- Intercropping cereals *viz*., maize and bajra with pigeonpea integrated with organic, inorganic and biofertilizers was found more remunerative.
- Combined application of recommended dose of fertilizers (inorganics), organics (FYM @ 5 t/ha or vermicompost @ 2.5 t/ha) and biofertilizers increased pigeonpea equivalent yield than their individual effects.
- Pre-emergence herbicide pendimethalin @ 0.75 kg a.i./ha+early post-emergence application of imazethapyr @ 100 g a.i./ha on 10-15 DAS (2-3 leaf stage of weed)+one hand weeding at 50 DAS registered more weed control and increased pigeonpea yield.
- Application of early post-emergence herbicide molecule quizalofop ethyl @ 100 g a.i./ha on 10-15 DAS+one hand weeding at 50 DAS performed better.
- Pigeonpea was found suitable for drip irrigation.
- Rhizobial strains *viz*., AKPR-101, GRR 8-10 performed better for grain yield.
- Combined inoculation of *Rhizobium* + PSB + PGPR+Metyhylobacterium+AM fungi enhanced nodulation and grain yield of pigeonpea.
- PGPR strains PGPR-8 CRB-5 in combination with *rhizobium* enhanced the grain yield.
- Genotypes *viz*., BRG 2, JKM 204 and GT 101 were consistently found better root types suitable for drought situations.
- Genotype P 994 and IC 245504 had good growth characteristics in terms of root surface area, root dry mass, root to shoot dry weight ratios and good amount of shoot biomass.

- Among the new insecticides, Rynaxipyr 18.5 SC @ 30 g a.i./ha. was found effective in management of podfly.
- Application of neem soap or Pongamia or NSKE, followed by two applications of indoxacarb was as effective as three applications of indoxacarb for control of pod borers.
- Following genotypes were identified as resistant against respective diseases:

BSMR 2, BSMR 571, BSMR 579, BSMR 853, IPA 204 and KPL 44	Wilt
BRG 1, BRG 2, BRG 5 BSMR 528, IPA 204 and KPL 43	Sterility mosaic
WRG 65, AKT 8811, BRG 2, BDN 711, BSMR 853, JKM 189, KPL 43, MA 6, RVSA 07-10, RVSA 07-29 and RVKT -260	Phytophthora stem blight
IPA 204	Macrophomina stem Blight

- Two sprays of dicofol @ 0.2% and Propargite @ 0.1%, first spray at 25 DAS and second at 15 days after first spray were found effective in reducing the incidence of SMD and increasing the grain yield, followed by fenazaquin @ 0.1%.
- Varieties *viz*., Azad, MA 3 and NDA 1 were found moderately resistant against *M. javanica*

Front line demonstrations

- Improved varieties of early, medium and long duration recorded 18.7%, 32.10% and 22.22% higher grain yield, respectively, with 18.7% (Early) and 33.97% (Medium) higher net return than local varieties.
- Application of 20 kg S/ha with 100 kg DAP/ ha enhanced the productivity by 17.35%.
- Insect (Pod borer) management recorded 27.7% higher grain yield with 30.7% higher net return over control.
- Integration of all components of production technology enhanced the productivity of pigeonpea by 30.38% with 33% higher net return in 425 demonstrations

MULLaRP

Promising genotypes

- In *kharif* mungbean, DGGS 4 (1634 kg/ha) and NDMK 10-35 (1623 kg/ha) in NHZ and ML 1628 (786 kg/ha) and ML 1666 (771 kg/ha) were promising in AVT in SZ. In IVT, IPM 306-2 (1082 kg/ha) and ML 1464 (1003 kg/ ha) were promising in NEPZ. For *rabi* cultivation, Pusa 9072 (804 kg/ha) was found promising.
- In *kharif* urdbean, KPU 01-10 (1486 kg/ha) and NDU 11-202 (1384 kg/ha) were promising in IVT in NWPZ and ACM 05007 (1062 kg/ha), AKU 10-1 (974 kg/ha) and KKP 05011 (958 kg/ha) were promising in SZ.
- In lentil, large seeded genotypes VL 521 (1123 kg/ha) and SKUA 12-96 (1039 kg/ha) in NHZ and RVL 48 (1060 kg/ha) were promising in CZ. Small seeded genotypes LL 1114 (1134 kg/ha) in NHZ and IPL 221 (1706 kg/ha) in NWPZ and NEPZ were promising.
- Tall fieldpea genotype RFP 2009-1 (2309 kg/ ha) was found promising in NEPZ and CZ. Among dwarf fieldpea, HFP 715 (1498 kg/ ha) in NHZ and IPFD 10-12 (2509 kg/ha) in CZ were promising.

Breeder seed production

Total 1381.20 q breeder seed of mungbean (61 varieties), 1030.65 q of urdbean (45 varieties), 717.77 q of lentil (38 varieties), and 959.34 q of fieldpea (27 varieties) was produced against the indent of 1243.80 q, 845.96 q, 643.60 q and 838.45 q, respectively.

Research achievements

- For effective control of weeds during *kharif* season, pendimethalin 30 EC+Imazethapyr 2 EC (Vellore 32) @ 100 g/ha and Imazethapyr 55 g/ha were found promising in both sole crop as well as in intercrop in NEPZ, NWPZ and CZ.
- Inoculation of *Rhizobium* (AUBR 10) with PGPR (CRB 2 of *Pseudomonas* spp.) registered 40% increase in yield over uninoculated control (384 kg/ha).
- In acid soils, application of lime @ 200 kg/ ha, 100% RDF and seed treatment with Mo @ 4 g/kg seed along with foliar spray of 2% urea significantly maximized the yield.
- Pre-emergence herbicide, pendimethalin 30 EC+Imazethapyr 2 EC at 0.75 to 100 g/ha effectively managed the weeds in lentil, fieldpea and rajmash.
- Post-emergence herbicide Imazethapyr @ 50-75 g/ha applied at 30 DAS was found effective in controlling weeds in fieldpea in all zones and Rajmash in NEPZ.
- Paired planting of value added maize (baby corn) with fieldpea in 2:2 ratio recorded maximum fieldpea equivalent yield in intercropping.

- Combined inoculation of *Rhizobium* (LN 20) and PSB (PSB 3) was found best for increasing nodulation and grain yield in lentil. *Rhizobium* combined with PGPR (CRB 2) strains improved the nodulation and grain yield in Rajmash.
- Lentil genotypes *viz*., LH 07-27 and IPL 321 showed multiple resistance against wilt, rust and Ascochyta blight, while IPL 321 and PL 104 against wilt and rust and IPL 315, IPL 321, PL 122 and IPL 318 were found resistant against rust and Ascochyta blight.
- Fieldpea genotype Pant P 74 showed multiple and multi-locational resistance against powdery mildew, rust and downy mildew, Pant P 184 against powdery mildew and Ascochyta blight, HFP 919 against rust and downy mildew and Pant P 172 was found resistant against powdery mildew and rust.
- Mungbean genotype MH 2-15 showed multiple resistance to all prevalent diseases of *kharif i.e*., MYMV, CLS, anthracnose, leaf crinkle virus, leaf curl, stem necrosis and macrophomina blight. IPM 02-3 showed multiple resistance to MYMV, root rot, leaf crinkle virus and stem necrosis. IPM 02-15-4 was found resistant to MYMV in *rabi* season.
- Urdbean genotype UH 7-13 showed multiple resistance against MYMV, Cercospora leaf spots, root rot and leaf crinkle. IPU 10-17 also showed multiple resistance against MYMV, ULCV and anthracnose. TU 10-13 was found resistant to MYMV in *rabi* season.
- Seed treatment with carbendazim @ 2 g/kg along with foliar spray of fungicides propiconazole and difenconazole was effective in reducing the severity of foliar diseases *viz*., CLS, anthracnose, PM and/or web blight.
- Lentil genotypes, *viz*., LL 1114, KLS 113, KLB 345, PL 104, PL 099, IPL 319, LL 931, IPL 313, L 4591, HIL 57, VL 521, L 4707, L 4147, L 4588, VL 143 and IPL 81 showed promise against pod borer (*Etiella zinckenella*). Fieldpea genotypes *viz*., RFP 63, Pant P 180 and IPFD 99-13 were found resistant against pod borer (*Etiella zinckenella*).
- Seed treatment with imidacloprid and application of botanical (NSKE 5% 30 kg) were important component of IPM module for controlling major insect pests.
- Urdbean genotypes CoBG 703, AC 43, AC 150, Co2-13 and ADT 5 proved promising against stemfly.
- Seed treatment with imidacloprid+ carbosulfan 3 ml/kg seed+trichoderma 4 g/kg+ Rhizobium+PSB 5 g/kg seed reduced nematode population upto 1.25 juveniles/cc soil.
- Lentil genotypes *viz*., PL 117, RL 4-109, NDL 11-2, LH 84-8, LH 08-10, L 4591, DPL 15 and IPL 532 and pea genotypes *viz*., Pant P 184, Pant P 180, NDP 11-101, Pant 177, VL 55 and HFP 919 were found resistant or moderately resistant against *Meloidogyne incognita*.
- Seed treatment with carbosulphan @ 1% was better than seed dressing with neem, mahua and jatropha kernel extract @ 10% for controlling *M. javanica*, whereas seed treatment with NSKE @ 10% was better than carbosulfan @ 0.5%, mahua and jatropha extract @ 10% for controlling *M. incognita*.
- Cropping sequence of non-host crops *viz*., wheat-bajra-wheat reduced the root knot nematode population by 45%, whereas wheat-mungbean-wheat reduced the nematode population by 35%.

Front line demonstrations

- Improved varieties of *kharif* mungbean recorded 13.63% higher mean yield and 12.54% higher net returns over local varieties. Similarly, an increase of 22.88% in grain yield and 14.01% in net return was achieved through use of package technology.
- Improved varieties of *rabi* mungbean recorded 15.19% and 28.24% higher yield and net returns, respectively over local varieties. Similarly, an increase of 32.05% in grain yield 38.09% in net return was achieved through use of package technology.
- Improved varieties of *kharif* urdbean recorded 15.37% higher mean yield and 14.60% higher net returns over local varieties. Similarly, an increase of 29.49% in grain yield and 35.29% in net return was achieved through use of package technology.
- In *rabi* urdbean, an increase of 29.38% in grain yield and 34.18% in net return was achieved through use of package technology.
- With the adoption of improved technologies, 21% and 15% increase in yield was observed in lentil and fieldpea, respectively.

Transfer of Technology

Following Training and Extension activities were organized during the period:

Activity	Date	No. of participants	Background of participants	Venue/Place
International Training Course	Mar. 29 –Apr. 18, 2013	29	Officials of Ministry of Agriculture, Irrigation and Live Stock of Afghanistan	IIPR, Kanpur
Model Training Course	Nov. 18-25, 2012	16	Joint Director (Agril.) Deputy Director (Agril.) Distt. Agril. Officers of different states	IIPR, Kanpur
	Feb. 8-15, 2013	16	Joint Director (Agril.) Deputy Director (Agril.) Distt. Agril. Officers of different states	IIPR, Kanpur
State-level Training Course under UP DASP	Nov. 27, 2012	65	State/Division/District level consultants, Technical Assistants of U.P.	IIPR, Kanpur
Training of Farmers				
Uttar Pradesh	June 26, 2012	31	Farmers of Fatehpur	IIPR, Kanpur
	Oct. 4, 2012	16	Farmers of Kanpur Dehat	
	Oct. 4-6, 2012	10	Farmers of Fatehpur	
	Dec. 26-27, 2012	20	Farmers of Allahabad	
	Dec. 28-30, 2012	20	Farmers of Jalaun	
	Feb. 25-26, 2013	26	Farmers of Fatehpur	
	March 15, 2013	58	Farmers of Fatehpur and Kanpur Dehat	
Other States	May 15-16, 2012	14	Farmers of Jharkhand	
	Aug. 17-19, 2012	28	Farmers of Jharkhand	
	Sept. 13-17, 2012	30	Farmers of Odisha	
	Oct. 9-11, 2012	18	Farmers of Jharkhand	
	Dec. 19-20, 2012	17	Farmers of Bihar	
	Jan. 3, 2013	21	Farmers of Chhattisgarh	
	Jan. 6-7, 2013	21	Farmers of Jharkhand	
	Feb. 12, 2013	9	Farmers of Shyopur (M.P.)	
		39	Farmers of Bharatpur (Raj.)	
	Feb. 18-21, 2013	8	Farmers of Siwan (Bihar)	
Field Days	Jan 4, 2013	86	Farmers of Fatehpur	Project site in Fatehpur district
	Feb 1, 2013	125	Farmers of Jalaun	Project site in Jalaun district
	Feb 27, 2013	200	Farmers of Ballia	Project site in Ballia district
Farmers' Day	March 15, 2013	120	Farmers of Kanpur Dehat and Fatehpur	IIPR, Kanpur
Participation in Kisan Mela	Oct. 3-6, 2012	-	Farmers, Extension Personnel, Scientists, Students, *etc.*	CSAU&T, Kanpur

Activity	Date	No. of participants	Background of participants	Venue/Place
National Convention	Sept. 3-6, 2012	-	Trader, Entrepreneurs, Researchers, Industrialist, Farmers, *etc.*	Ahmedabad, Gujarat
XI[th] Indian Agril. Science Congress	Fab. 7-9, 2013	-	Researchers, Development Authority, Industrialist, Entrepreneurs, Students, *etc.*	OUA&T, Bhubaneswar (Odisha)
Exposure Visits	Oct. 4, 2012	3	Farmers of Ballia, U. P.	IIPR, Kanpur
	Nov. 8, 2012	32	Farmers of Sahjahanpur, U.P.	
	Dec. 15, 2012	30	Farmers of Rajasthan	
	Dec. 20, 2012	50	Farmers of Fatehpur, U.P.	
	Jan. 4, 2013	40	Farmers of Shivpuri (M.P.)	
	Jan. 7, 2013	42	Farmers of Tikamgarh (M.P.)	
	Feb. 20, 2013	15	Farmers of Reewa (M.P.)	
	Feb. 21, 2013	37	Farmers of Fatehpur (U.P.)	
	Feb. 27, 2013	105	Farmers of Raibareli (U.P.)	
	Mar. 1, 2013	25	Farmers of Pali (Raj.)	
	Mar. 6, 2013	20	Farmers of Badaun (U.P.)	
	Mar. 7, 2013	30	Farmers of Anoop Pur (M.P.)	
	Mar. 8, 2013	30	Farmers of Satna (M.P.)	
	Mar. 11, 2013	10	Farmers of Tikamgarh (M.P.)	
	Mar. 14, 2013	20	Farmers of Reewa (M.P.)	
	Mar. 18, 2013	10	Farmers of Sajapur (M.P.)	
Industry Day	June 23, 2012	117	Farmers of Fatehpur and Kanpur Dehat	
TV Talk	12 (7 Live Telecast)		Doordarshan Kendra, Lucknow	

Broadcasting of Pulses Technology through All India Radio

A joint programme "*Dalhan Kisan Ke Liye*" was developed on contract basis with IIPR and AIR, Kanpur. Total 26 Episode related to pulses improvement, production, protection and post-harvest management technology were broadcast on weekly basis from September 5, 2012 to February 27, 2013. Broadcasting was done on every Wednesday at 06:05 to 06:35 p.m. by AIR, Kanpur.

Publications

Research papers

Agbagwa, I.O., Datta, S., Patil, P.G., Singh, P. and Nadarajan, N. (2012). A protocol for high quality genomic DNA extraction from legumes. *Genetics and Molecular Research* **11**: 4632-4639.

Akram, M. and Naimuddin (2012). Biological characterization and variability of the nucleocapsid protein gene of groundnut bud necrosis virus isolates infecting pea from India. *Phytopathologia Mediterranea* **51**:266-275.

Ali, M., Kumar, Narendra and Ghosh, P.K. (2012). Milestones on agronomic research in pulses in India. *Indian Journal of Agronomy* **57**: 52-57.

Bohra, A., Saxena, R.K., Gnanesh, B.N., Saxena, K.B., Byregowda, M., Rathore, A., Kavi Kishor, P.B., Cook, D.R., Varshney, R.K. (2012). An intra-specific consensus genetic map of pigeonpea [*Cajanus cajan* (L.) Millspaugh] derived from six mapping populations. *Theoretical and Applied Genetics* **125**:1325-1338.

Choudhury, P.R., Singh, I.P., George, B., Verma, A.K., Gupta, G. and Singh, N.P. (2012). Efficiency of RAPD primers in estimating the genetic relationship and development of DNA finger print in popular pigeonpea [*Cajanus cajan* (L.) Millsp.] cultivars. *Indian J. Genet.* **72**(3) 309-317.

Datta, S., Gangwar, S., Kumar, S., Gupta, S., Rai, R., Kaashyap, M., Singh, P., Chaturvedi, S.K., Singh, B.B. and Nadarajan, N. (2012). Genetic diversity in selected Indian mungbean [*Vigna radiata* (L.) Wilczek] cultivars using RAPD markers. *American Journal of Plant Sciences* **3**: 1085-1091.

Datta, S., Singh, P., Mahfooz, S., Patil, P., Chaudhary, A.K., Agbagwa, I.O. and Nadarajan, N. (2013). Novel genic microsatellite markers from *Cajanus scarabaeoides* and their comparative efficiency in revealing genetic diversity in pigeonpea. *Journal of Genetics* **92**: e24–e30.

Ghosh, A., Saxena, Hem, Singh, Garima, and Samanta, A. (2012). Metaflumizone: A novel insecticide against *Helicoverpa armigera*. *Indian Journal of Plant Protection* **40**(2):160-161.

Ghosh, P.K., Venkatesh, M.S., Hazra K.K. and Kumar, Narendra (2012). Long term effect of pulses and nutrient management on soil organic carbon dynamics and sustainability on an Inceptisol of Indo-Gangetic plains of India. *Experimental Agriculture* **48** (4): 473-487.

Kudapa, H., Bharti, A.K., Cannon, S.B., Farmer, A.D., Mulaosmanovic, B., Kramer, R., Bohra, A., Weeks, N.T., Crow, J.A., Tuteja, R., Shah, T., Datta, S., Gupta, D.K., Singh, A., Gaikwad, K., Sharma, T.R., May, G.D., Singh, N.K. and Varshney, R.K. (2012). A comprehensive transcriptome assembly of pigeonpea (*Cajanaus cajan* L.) using Sanger and second generation sequencing platforms. *Molecular Plant* **5**: 1020-28.

Kumar, J., Basu, P.S., Srivastava, E., Chaturvedi, S.K., Nadarajan, N. and Kumar, S. (2012). Phenotyping of traits imparting drought tolerance in lentil. *Crop and Pasture Science* **63**: 547–554.

Kumar, Rajesh, Singh, S.K., Purushottam and Sah Uma (2012**).** Dissemination of pulse production technologies in Uttar Pradesh: A micro-level analysis. *Journal of Food Legumes* **25** (4): 340-343.

Mishra, J.P., Praharaj, C.S. and Singh, K.K. (2012). Enhancing production potential and water use efficiency of chickpea and fieldpea through seed bed configurations and irrigation regimes in North Indian plains. *Journal of Food Legumes* **25** (4): 310-313.

Mishra, J.P., Praharaj, C.S., Singh, K.K. and Kumar, Narendra (2012). Impact of conservation practices on crop water use and productivity in chickpea under middle Indo-Gangetic plains. *Journal of Food Legumes* **25**(1): 41-44.

Naimuddin and Akram, M. (2012). Sequence comparison of coat protein gene of mungbean yellow mosaic India virus isolates infecting mungbean and urdbean crops in field. *Journal of Food Legume* **25**:286-290.

Naimuddin, Akram, M., Pratap, A. and Yadav, P. (2013). Characterization of a new begomovirus and a beta satellite associated with the leaf curl disease of frenchbean in northern India. *Virus Genes* **46**:120-127 (DOI 10.1007/s11262-012-0832-8).

Patil, P., Datta, S., Singh, I.P., Das, A., Soren, K.R., Kaashyap, M., Choudhary, A.K., Chaturvedi, S.K. and Nadarajan, N. (2012). Phylogenetic analysis of pigeonpea (*Cajanus cajan*) genotypes using Panzee retrotransposon based SSAP markers. *Indian Journal of Agricultural Sciences* **82:** 1016–21.

Prajapati, R.K., Chaudhary, R.G., Singh, S.R. and Gupta, P.K. (2012). Evaluation of locally available substrates for mass multiplication and shelf life of *Trichoderma harzianum*. *Indian Phytopathology* **65** (3):303-304.

Pratap, A., Gupta, D.S., Singh, B.B. and Kumar, S. (2013). IPM 205-7 (IC0589309-IC0589310; INGR11043-INGR11044), a mungbean (*Vigna radiata* (L.) Wilczek) germplasm with super early maturity. *Indian J Plant Genet Resources* **26**: 89-90.

Saabale, P.R. and Dubey, S.C. (2012). Quantitative analysis of defense related genes of chickpea against *Fusarium* wilt. *Bioinfolet* **9**:722-725.

Saxena, H., Duraimurugan, P. and Iquebal, M.A. (2012). Seasonal parasitism and biological characteristics of *Habrobracon hebetor* (Hymenoptera: Braconidae) – A potential larval ectoparasitoid of *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea ecosystem. *Biocontrol Science and Technology* **22**: 305 -318.

Singh, Jagdish and Basu, P.S. (2012). Non-nutritive bioactive compounds in pulses and their impact on human health: An Overview. *Food and Nutrition Sciences* **3**: 1664-1672.

Singh, K.K., Srinivasarao, C.H., Swarnalaxmi, K., Ganeshamurthy, A.N. and Kumar, Narendra (2012). Influence of legume residues management and nitrogen doses on succeeding wheat yield and soil properties in Indo-Gangetic plains. *Journal of Food Legumes* **25**(2): 116-120.

Singh, M.K., Kumar, Narendra, Verma, P. and Garg, S.K. (2012). Performance evaluation of mechanical planters for planting of chickpea and pigeonpea. *Journal of Food Legumes* **25**(2): 131-134.

Srivastava, Jaya, Das, Alok, Soren, K.R., Chaturvedi, S.K., Nadarajan, N. and Datta, S. (2012). Ontogeny of *in vitro* shoot organogenesis from axillary meristem explants in chickpea (*Cicer arietinum* L.). *Journal of Crop Science and Biotechnology* **15**(3): 53-57.

Upadhyaya, H.D., Kashiwagi, J., Varshney, R.K., Gaur, P.M., Saxena, K.B., Krishnamurthy, L., Gowda, C.L.L., Pundir, R.P.S., Chaturvedi, S.K., Basu, P.S. and Singh, I.P. (2012). Phenotyping chickpea and pigeonpea for adaptation to drought. *Frontiers in Physiology*. (Doi 10.3389/fphys. 2012.00179).

Varshney, R.K., Mohan, S.M., Gaur, P.M., ……… Pratap, A., Tripathi, S., Datta, S., Chaturvedi, S. K., ………Choudhary, A.K., ……… Liang, X., Nadarajan N. and Gowda, C.L.L.. (2013). Achievements and prospects of genomics-assisted breeding in three legume crops of the semi-arid tropics. *Biotech. Advances*. (http://dx.doi.org/10.1016/j.biotechadv.2013.01.001).

Varshney, Rajeev K., Chi Song, Saxena, Rachit K. ……… Gowda, C.L.L., Singh, Narendra P. , ……… Nadarajan, N. ……… Datta, Swapan K. ……… and Cook, Douglas R. (2013). Draft genome sequence of chickpea (*Cicer arietinum*) provides a resource for trait improvement. *Nature Biotechnology*. DOI:10.1038/nbt.2491.

Vasishtha, H. and Srivastava, R.P. (2012). Changes in lipids and fatty acids during soaking and germination of chickpea (*Cicer arietinum*). *Indian J Agric Biochem* **25**(1): 14-19.

Vasishtha, H. and Srivastava, R.P. (2012). Genotypic variations in protein, dietary fibre, saponins and lectins in rajmash beans (*Phaseolus vulgaris*). *Indian J Agric Biochem* **25**(2): 150-153.

Vasishtha, H. and Srivastava, R.P. (2013). Effect of soaking and cooking on dietary fibre components of different type of chickpea genotypes. *J Food Sci Technol.* **50**(3):579-584.

Vasishtha, H., Srivastava, R.P. and Verma, P. (2012). Effect of dehusking and cooking on protein and dietary fibre of different genotypes of *desi*, *kabuli* and green type chickpeas (*Cicer arietinum*). *J Food Sci Technol.* (DOI 10.1007/s13197-012-0909-3).

Vasishtha, H., Srivastava, R.P. and Verma, P. (2012). Milling and cooking effect on dietary fibre, protein and lectins of pigeonpea (*Cajanus cajan*). *Current Advances in Agric Sci* **4**(2):134-138.

Venkatesh, M.S., Basu, P.S. and Vedram (2012). Foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions. *Legume Research* **35**(3): 231-234.

Venkatesh, M.S., Hazra, K.K., Ghosh, P.K., Praharaj, C.S. and Kumar, Narendra (2013). Long term effect of pulses and nutrient management on soil carbon sequestration in Indo-Gangetic plains of India. *Canadian Journal of Soil Science* **93**(1): 127-136.

Vijay Laxmi and Bhattacharya, A. (2012). Photosynthetic rates of mungbean leaves as affected by morphological leaf traits. *Journal of Food Legumes* **25**(1): 50-53.

Papers presented in seminars/symposia

Akram, M., Naimuddin, Pratap, A., Malviya, N. and Yadav, P. (2012). Intra-field sequence diversity in NP gene of GBNV population infecting wild *Vigna* in India. VI[th] International Conference on Legume Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Basu, P.S., Singh, Jagdish and Gupta, Sanjeev (2012). Developing pulses for extreme weather conditions. 100[th] Indian Science Congress, held on January 3-7, 2013 at University of Calcutta, Kolkata.

Bohra, A., Saxena, R.K., Gnanesh, B.N., Saxena, K.B., Byregowda, M., Rathore, A., Kavi, P.B.K., Cook, D.R., Varshney, R.K. (2012). The *first* consensus genetic map for cultivated pigeonpea [*Cajanus cajan* (L.) Millsp.] based on SSR markers. VI[th] International Conference on Legume Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Chaturvedi, S.K. and Mishra, Neelu (2013). Pulses genetic resources to mitigate impact of climate change. National Conference on Crop Improvement and Adaptive Strategies to Meet Challenges of Climate Change. held on February 22-24, 2013 at University of Agricultural Sciences, Bangalore.

Das, A., Datta, S., Soren, K.R., Mohapatra, S.D., Chaturvedi, S.K. and Nadarajan, N. (2013). Expression of a synthetic *Bt* gene in pigeonpea (*Cajanus cajan* L.) confers resistance to gram pod borer (*Helicoverpa armigera* H.). 100[th] Indian Science Congress, held on January 3-7, 2013 at University of Calcutta, Kolkata.

Das, A., Nandeesha, P., Datta, S., Singh, B., Subramaniam, K., Chaturvedi, S.K. and Nadarajan, N. (2012). Towards plant parasitic nematode control using RNAi technology in fieldpea (*Pisum sativum* L.) VI[th] International Conference on Legume Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Datta, S., Baek, J.M., Woodward, J.M., Carrasquilla, N. and Cook, D.R. (2013). Genome wide characterization of resistance genes through resequencing of chickpea genomes. Plant and Animal Genome XXI, held on January 12-16, 2013 at San Diego, CA.

Gaur, P.M., Chaturvedi, S.K., Shiv Kumar, Basu, P.S., Nayyar, H., Babbar, A., Jayalakshmi, V., Srinivasan, S., Mallikarjuna, N., Krishnamurthy, L. and Gowda, C.L.L. (2013). Pulses high temperature tolerance in food legumes to mitigate impact of climate change. National Conference on Crop Improvement and Adaptive Strategies to Meet Challenges of Climate Change, held on February 22-24, 2013 at University of Agricultural Sciences, Bangalore.

Ghosh, P.K., Kumar, N., Hazra, K.K. and Venkatesh, M.S. (2012). Carrying capacity of untrapped rice fallows for pulse production. 3[rd] International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held on November 26-30, 2012 at New Delhi.

Ghosh, P.K., Narendra, Kumar and Hazra, K.K. (2012). Appropriate soil water conservation practices can mitigate abiotic stress and promote pulse in rice fallows in India. World Water Week held on August 26-31, 2012 at Stockholm.

Kumar, N., Ghosh, P.K., Singh, M.K., Hazra, K.K. and Venkatesh, M.S. (2013). Boost rice fallow chickpea production system in India through suitable soil moisture conservation practices. 100[th] Indian Science Congress, held on January 3-7, 2013 at University of Calcutta, Kolkata.

Kumar, Narendra, Singh, M.K., Ghosh, P.K. and Hazra, K.K. (2012). Soil moisture conservation in chickpea through tillage and mulching in rice fallows. 3[rd] International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held on November 26-30, 2012 at New Delhi.

Naimuddin, Akram, M., Pratap, A. and Yadav, P. (2012). Characterization of a new begomovirus and associated beta satellite causing leaf curl disease in frenchbean. VI[th] International Conference on Legume, Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Penmetsa, R.V., Carrasquilla Garcia, N., Bergmann, E.M., Vance, L.C., Castro, B.M., Dubey, A., Gujaria, N., Sarma, B.K., Kassa, M.T., Kaashyap, M., Gaur, P.M., Datta, S., Baek, J.M., Woodward, J.E., Farmer, A.D., Coyne, C.J., Wettberg, E.J.B., Varshney, R.K. and Cook, D.R. (2013). Multi-locus molecular phylogeny and allelic variation in a transcription factor gene suggest the multiple independent origins of *kabuli* chickpea. VI[th] International Conference on Legume Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Pratap, A., Chaturvedi, S.K., Neha Rajan, Chaitali Sen, Rakhi Tomar and Varshney, R.K. (2013). Development of fusarium wilt resistant genotypes through marker assisted backcross breeding. 100th Indian Science Congress, held on January 3-7, 2013, at University of Calcutta, Kolkata.

Pratap, A., Gupta, D.S. and Rajan, N. (2012). Development of extra short duration genotypes in greengram (*Vigna radiata* L. Wilczek). VIth International Conference on Legume Genetics and Genomics, held on October, 2-7, 2012, at Hyderabad.

Praharaj, C.S. and Kumar, Narendra (2012). Efficient management of water and nutrients through drip-fertigation in long duration pigeonpea under Indian plains. 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held on November 26-30, 2012 at New Delhi.

Purushottam, Verma P., Singh S.K. and Kumar R. (2012). Agri-preneurship development through pulses for livelihood security. International Conference on Extension Education in the Perspectives of Advances in Natural Resource Management in Agriculture, held on December 19-21, 2012 at SKRAU, Bikaner, Rajasthan.

Saxena, Hem (2012). Changing scenario of insect pests of pulses due to climate change. 3rd National Symposium on Agriculture Production and Protection in Context of Climate Change, held on November 3-5, 2012 at Ranchi Agriculture College, Ranchi, Jharkhand.

Shivay, Y.S. and Singh, Ummed (2013). Bio-fortification: An easy approach to reduce hidden hunger of micronutrients in malnourished population. First International Conference on Bio-Resource and Stress Management, held on February 6-9, 2013 at Kolkata.

Singh, Bansa, and Singh, K.K. (2013). Combined infectivity of root-knot nematode (*Meloidogyne javanica*) and pigeonpea cyst nematode (*Heterodera cajani*) in different black gram varieties and their management. National Conference on Crop Improvement and Adaptive Strategies to Meet Challenges of Climate Change, held on February 22-24, 2013, at UAS, Bangalore.

Singh, Jagdish, Aski, M.S. and Basu, P.S. (2013). Biofortification in pulses for nutritional security and micronutrient malnutrition. 100th Indian Science Congress, held on January 3-7, 2013, at University of Calcutta, Kolkata.

Singh, M.K., Kumar, Narendra and Ghosh, P.K. (2012). Performance of maize and chickpea under permanent raised bed system. 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held on November 26-30, 2012 at New Delhi.

Singh, M.K., Kumar, Narendra and Ghosh, P.K. (2013). Productivity of maize-chickpea cropping system under permanent raised bed. 100th Indian Science Congress, held on January 3-7, 2013, at University of Calcutta, Kolkata.

Singh, P., Mahfooz, S., Patil, P.G., Choudhary, A.K., Agbagwa, I.O., Chaturvedi, S.K., Nadarajan, N. and Datta, S. (2012). Development of expressed sequence tags based microsatellite markers from *Cajanus scarabaeoides* for the assessment of genetic diversity in genus *Cajanus*. VIth International Conference on Legume Genetics and Genomics, held on October 2-7, 2012 at Hyderabad.

Singh, Ummed, Singh, S.R., Saad, A.A. and Singh, J.K. (2012). Yield, reciprocity functions and energy functions of lentil intercropping as influenced by row ratio and P management. 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held on November 26-30, 2012, at New Delhi.

Soren, K.R., Patil, P., Das, A., Chaturvedi, S.K. and Nadarajan, N. (2012). Reverse northern: A novel tool for differential expression analysis of drought stress induced related genes in chickpea (*Cicer arietinum* L). VIth International Congress on Legume Genetics and Genomics, held on October 2- 7, 2012 at Hyderabad.

Srivastava, R.P. and Vishwa Dhar (2012). Biochemical basis of resistance in pigeonpea (*Cajanus cajan* L.) against *Fusarium* wilt. 3rd National Symposium on Agriculture Production and Protection in Context of Climate Change, held on November 3-5, 2012, at Birsa Agricultural University, Ranchi.

Book

Datta, S., Patil, P.G., Soren, K.R., Das, A., Chaturvedi, S.K., Nadarajan, N. (2012). Techniques in Plant Biotechnology. Agrotech Publishing Academy, Udaipur, Rajasthan.

Book chapters

Chand, R., Singh, V., Chaudhary, R.G., Naimuddin and Chowdappa, P. (2013). Cercospora Leaf Spot of Grain and Vegetable Legumes. **In:** Leaf Spot Diseases of Annual and Perennial Crops (Eds. P. Chowdappa and H.P. Singh), Westville Publishing House, New Delhi.

Ghosh, P.K. and Kumar, Narendra (2012). Improved Management Practices for Carbon Management and Mitigation of Climate Change. **In:** Carbon Management in Agriculture for Mitigating Greenhouse Effect (Eds. Singh, A.K., Ngachan, S.V., Munda, G.C., Mohapatra, K.P., Choudhary, B.U., Das, Anup, Rao, Ch Srinivasa, Patel, D.P., Rajkhowa, D.J., Ramakrushna, G.I. and Powar, A.S.). ICAR Research Complex for NEH Region, Umiam, Meghalaya, India.

Pandey, M., Tripathi, A.K., Dwivedi, P.K., Misra, R.P. and Chaudhary, R.G. (2012). Biocontrol: An Eco-friendly Plant Disease Management for Sustainable Agriculture. **In:** Ecofriendly Innovative Approaches in Plant Disease Management (Eds. V.K. Singh, Yogendra Singh and Akhilesh Singh). International Book Distributors (IBD) Publishers and Distributors, New Delhi.

Singh, Bansa, Nagesh, M., Saleem Javeed and Balachander, M. (2012). Prospects of *Paecilomyces lilacinus* in Nematode Management. **In**: Status and Prospects for Enhancing the Uptake of Antagonistic Organisms for Nematode Management in India (Eds. M. Nagesh, Rajkumar, B.S. Bhumannavar and N.K. Krishna Kumar). National Bureau of Agriculturally Important Insects, Bangalore.

Swarnalakshmi, K., Senthilkumar, M., and Sachan, S. (2013). Microbial Inoculation Through Endophytic Bacteria for Sustainable Agriculture. **In**: Modern Technologies for Sustainable Agriculture. (Eds. Sunil Kumar and Birendra Prasath). New India Publishing Agency, New Delhi.

Popular articles

Chaturvedi, S.K. (2013). *Moong Evam Urd Ki Vaigyanik Kheti. Jagran- Khet Khaliyan,* March, 2013.

Chaturvedi, S.K., Mishra, Neelu and Muraleedhar Aski (2012). *Chana Ek Labhkari Fasal. Jagran- Khet Khaliyan,* October, 2012.

Datta, Dibendu, Chaturvedi, S.K. and Mishra Neelu (2012). *Ageti Arhar Ki Utpadan Taknik. Jagran- Khet Khaliyan,* June, 2012.

Naimuddin, Akram, M. and Chattopadhyay, C. (2012). *Mung Evam Urd Ke Vishadun Rog Evam Unse Bachav. Krishak Bharti (Kharif Visheshank*), CSAUAT, Kanpur.

Narendra Kumar and Ghosh, P.K. (2012). *Rabi Dalhano Ki Safal Kheti*. *Khad Patrika,* September 2012. **53**(9):6-13.

Purushottam (2012). *Dalhani Phaslo Main Trichoderma Ka Prayog, Paidawar* **5**(7):4-5.

Purushottam (2013). *Moong Ki Phasal Dwara Krishi Vividhikaran. Upbhokta Kranti* **12**(26):9.

Purushottam and Kumar, L. (2013). *Garmi Main Boyen Moong. Paidawar* **5**(9):9-11.

Purushottam and Verma P. (2012). *Dalhan Dwara Gramin Udymita Ka Vikas. Upbhokta Kranti* **6** (9): 20-21.

Institute Publications

- Annual Report 2011-12
- वार्षिक प्रतिवेदन 2011-12 (Annual Report in Hindi)
- Pulses Newsletter Vol. 23 Nos. 1, 2, 3 and 4.
- दलहन आलोक – राजभाषा पत्रिका
- Technology for Increasing Pulses Production in India
- भारत में दलहन उत्पादन बढ़ाने की प्रौद्योगिकी
- Gene Technology for Pulses Improvement [Das, Alok, Datta, S., Soren, K.R., Patil, P.G., Chaturvedi, S.K. and Nadarajan, N.]
- *Krishak Bhagidari Dwara Masoor Ka Beej Utpadan* [Singh, S.K., Chaturvedi, S.K.; Ojha, V.S., Yadav, S., Riazuddin and Nadarajan, N.]
- Advances in Pulses Genomic Research [Soren, K.R., Patil, P.G., Das, A., Bohra, A., Datta, S., Chaturvedi, S.K. and Nadarajan, N.]
- *Kabuli Chana Ki Unnat Kheti* [Uday Chand, Govind Ram, Chaturvedi, S.K. and Nadarajan, N.]
- Resource Conservation Technology in Pulse-based Cropping Systems [Narendra Kumar, M.K. Singh, P.K. Ghosh, K.K. Hazra, M.S. Venkatesh and N. Nadarajan]
- *Dalhani Phaslon Ke Pramukh Keet Evam Vyadhiyon Ka Samekit Prabandhan* [Chaudhary, R.G., Saxena, H., Naimuddin, Singh, B., Mohapatra, S.D., Singh, S.K., Akram, M. and Chattopadhyay, C.]

Human Resource Development

Deputation Abroad

- Dr. S. Datta, Senior Scientist (Plant Biotechnology) was deputed to attend one year training under Boys Cast Fellowship of DBT from January 20, 2012 to January 19, 2013 at University of California. Davis, USA.
- Dr. M. Aski, Scientist (Plant Breeding) was deputed to attend the Generation Challenge Programme (GCP) sponsored training on Integrated Breeding-Multiyear Course-1 (IB-MYC-1) held on October 15-27, 2012 at The Netherlands.
- Dr. Jitendra Kumar, Senior Scientist (Plant Breeding) was deputed to attend ICARDA sponsored training course on "Quantifying epidemiology and forecasting risks of crop disease on lentil stem phylium blight" at BARI, Bangladesh on February 3-10, 2013 under ICAR-ICARDA collaborative programme.

Participation in Training/Workshop, etc.

Dr. N. Nadarajan, Director attended/participated in the following :

- Workshop on "Tracking adoption of improved chickpea and pigeonpea cultivars in India" held at ICRISAT, Hyderabad on April 11, 2012.
- Annual workshop on the DAC-ICARDA-ICAR Collaborative Projects under NFSM-Pulses, held at NASC Complex, New Delhi on May, 23-24, 2012.
- Knowledge Meet, held at NASC Complex, New Delhi on August 21-22, 2012.
- Brainstorming Meeting on Pulses Production, held at NASC Complex, New Delhi on September 12, 2012.
- Steering Committee meeting of DAC-ICARDA-ICAR collaborative projects (NFSM-Pulses), held at NASC Complex, New Delhi on September 14, 2012.
- XXIst Regional Committee Meeting, held at ICAR-RCER, Patna on September 21-22, 2012.
- VIth International Conference on Legume Genetics, held at ICRISAT, Hyderabad, on October 2-6, 2012.
- Steering Committee Meeting of DAC-ICARDA-ICAR collaborative Project on Pre-breeding, held at NASC Complex, New Delhi on October 12, 2012.
- Foundation Day function of IGFRI, Jhansi as Guest of Honour on November 1, 2012.
- National Conference on KVK-2012, held at PAU, Ludhiana on November 22, 2012.
- Meeting on ICAR-ICARDA collaborative programme, held at NASC Complex, New Delhi on 29.11.2012.
- Presented a paper in 100th Indian Science Congress, held at Kolkata on January 3-5, 2013.
- Launch Meeting of CRP on Pulses, held at ICRISAT, Hyderabad on February 6-7, 2013.

Drs. M.S. Venkatesh, Lalit Kumar and M.K. Singh attended Technology Management Workshop at Zonal Technology Management and Business Planning and Development (ZTM-BPD) Unit at IVRI, Izatnagar on 16, March, 2013.

Dr. M.S. Venkatesh attended mid-term review meeting of Results Frame Work Document (RFD) at New Delhi on 20th November 2012.

Drs. Narendra Kumar and M.K. Singh attended the review meeting of national fund project on 'Mitigating abiotic stresses and enhancing resource use efficiency in pulses in rice fallows through innovative resource conservation practices' held at IGKV Raipur on October 8, 2012.

Dr. Narendra Kumar attended national training on "Advances in weed management" at DWSR, Jabalpur, during 31 October–9 November, 2012.

Dr. Ummed Singh attended workshop on 'Foresight and future pathways of agricultural research in India' held at NASC Complex, New Delhi on March 1-2, 2013.

Dr. Ummed Singh attended refresher course on 'Agricultural research management' held at NAARM, Hyderabad on January 7-19, 2013.

Dr. Ummed Singh attended NAIP sponsored training workshop on 'Scientific report writing and presentation' held at NAARM, Hyderabad on September 25-28, 2012.

Dr. Devraj attended NAIP Workshop on "Development of digital knowledge repositories" held at ICRISAT, Hyderabad on January 24-25, 2013.

Dr. Devraj attended XIth Agricultural Science Congress held at OUAT, Bhubaneswar, Odisha on February 7-9, 2013.

Dr. Devraj attended Brainstorming Workshop on "Setting up a rural technology action group (RuTAG)" held at IIT, Kanpur on March 14, 2013.

Dr. Aditya Pratap attended Accelerated Crop Improvement Programme Review and Planning Meeting held at Department of Biotechnology, New Delhi on April 2-3, 2012.

Dr. Aditya Pratap attended 'Refresher course on agricultural research management' held at NAARM, Hyderabad on January 7-21, 2012.

Dr. Dhanjay Gawande attended Training on DUS test (Chickpea) and PPV&FR, held at IIPR, Kanpur on March 7-8, 2013.

Dr. S.K. Chaturvedi attended "Review and planning meeting of KVKs" organized by ZPD (ICAR) held at Krishi Vigyan Kendra, Pratapgarh (U.P.) on October 18, 2012.

Dr. S.K. Chaturvedi attended 'Advance training for Programme Coordinators for better management of KVKs activities' held at CSAUA&T, Kanpur on February 1, 2013.

Dr. Dibendu Datta attended workshop on 'Tracking of chickpea and pigeonpea improved varietal adoption in India' held at ICRISAT, Hyderabad on April 9-10, 2012.

Dr. Jitendra Kumar attended meeting of ICAR-ICARDA network project "Breaking yield barriers in lentil through introgression of desirable genes from landraces and wild species" held at IIPR, Kanpur on September, 23, 2012.

Dr. S.K. Chaturvedi attended training on Management Development Programme at NAARM, Hyderabad on December 3-7, 2012.

Dr. Jagdish Singh attended the RFD review Meeting of Directors and RFD Nodal officers at DMR, New Delhi on January 14, 2013.

Dr. Jagdish Singh attended Meeting of Heads of Divisions, PCs and Directors of the Institute with Secretary DARE and DG, ICAR at NASC Complex, New Delhi on March 11, 2013.

Dr. Vijay Laxmi participated in training programme on 'Role of Woman Scientists in Community Resource Management', at Indian Institute of Forest management, Bhopal on February 12-16, 2013.

Dr. Lalit Kumar participated in 'Chemists Conclave-Brain Storming Session' held at IARI, New Delhi on January 14-15, 2013.

Award and Recognition

Dr. Narendra Kumar, Sr. Scientist (Agronomy) has been conferred with Dr. P.S. Deshmukh Young Agronomist Award 2009 by Indian Society of Agronomy, New Delhi at 3rd International Agronomy Congress on "Agriculture diversification, climate change management and livelihoods" held at New Delhi, on November 26-30, 2012.

On-going Research Projects

CROP IMPROVEMENT

S.N.	Title of the project	Principal Investigator	Associate
1.	Genetic enhancement of pulses through distant hybridization	Dr. Aditya Pratap	Dr. S.K. Chaturvedi Dr. I.P. Singh Dr. Jitendra Kumar Dr. P. Nandeesha Dr. Alok Das
2.	Quality breeding in lentil	Dr. Jitendra Kumar	Dr. M.S. Venkatesh
3.	Pre-breeding in pigeonpea for yield enhancement	Dr. D. Datta	Dr. Alok Das
4.	Development of cytoplasmic genetic male sterility based hybrids for enhancement of productivity and stability of yield in pigeonpea	Dr. I. P. Singh	Mr. Abhishek Bohra Dr. Prakash G.Patil Dr. D. Dutta
5.	Genetic resources of mungbean and urdbean: Collection, evaluation and conservation	Dr. Revanappa	Dr. P.K. Katiyar
6.	Genetic improvement of mungbean [*V. radiata* (L.) wilczek] for yield enhancement and resistance to multiple stresses	Dr. Aditya Pratap	Dr. Revanappa Dr. MohdAkram
7.	Identification and evaluation of herbicide resistant/tolerant genotypes in pigeonpea	Dr. N.D. Majumder	--
8.	Genetic improvement for yield and multiple stresses in lentil	Dr. Jitendra Kumar	Dr. Naimuddin
9.	Genetic resources management in lentil	Dr. Jitendra Kumar	Dr. A.K. Parihar
10.	Combining *Fusarium* wilt and dry root rot resistance in chickpea by integrated breeding approach	Dr. M.S. Aski	Dr. K.R. Soren Mr. P.R. Saabale
11.	Development of chickpea genotypes to mitigate terminal heat and drought stress for enhancing productivity	Mr.U.C. Jha	Dr. P.S. Basu
12.	Genetic resources management in chickpea	Dr. D.N. Gawande	Dr. Shiv Sewak
13.	Breeding for enhanced yield potential and Phytophthora stem blight resistance in short duration pigeonpea.	Dr. A. Bohra	Dr. C. Chattopadhyay
14.	Genetic improvement for plant type and grain yield in fieldpea	Dr. A.K. Parihar	Dr. G.P. Dixit
15.	Genetic improvement for plant type and grain yield in chickpea	Dr. S.K. Chaturvedi	Dr. D.N. Gawande Mr. P.R. Saabale
16.	Genetic improvement for yield and disease resistance in long duration pigeonpea	Dr. D. Datta	Dr. C. Chattopadhyay
17.	Genetic resources management in pigeonpea	Dr. D. Datta	Dr. Farindra Singh
18.	Genetic resources of rajmash : Collection, evaluation and conservation	Dr. P.K. Katiyar	--
19.	Molecular mapping of resistance genes against variant 1 and variant 2 of pigeonpea wilt (*Fusarium udum*)	Mr. Prakash G. Patil	Dr. A. Bohra Dr. R.G. Chaudhary
20.	Genetic improvement for yield and resistance to multiple diseases in blackgram	Dr. D.J. Sengupta/ Dr. Basudeb Sarkar	Dr. Revanappa Dr. Mohd. Akram

CROP PRODUCTION

S.N.	Title of the project	Principal Investigator	Associate
1.	Long term effect of pulses in cropping systems on soil health and crop productivity	Dr. M.S. Venkatesh	Dr. Narendra Kumar Mr. K.K. Hazra Dr. C.S. Praharaj Dr. Bansa Singh Dr. M. Senthil Kumar Dr. Naimuddin Dr. S. Paulraj Dr. P.K. Ghosh
2.	Studies on post-emergence herbicides in pulse based cropping system	Dr. Narendra Kumar	Mr. K.K. Hazra
3.	Resource conservation technology in pulse based cropping system	Dr. Narendra Kumar	Dr. M.K. Singh Dr. M.S. Venkatesh
4.	Carbon dynamics and carbon sequestration potential in pulse based production system under long term experiment	Dr. P.K. Ghosh Dr. M.S. Venkatesh	Mr. K.K. Hazra Dr. K.K. Singh Dr. C.S. Praharaj Dr. Mohan Singh
5.	Improvement in IIPR mini Dal Mill and development of allied milling machinery	Dr. M.K. Singh Mr. Prasoon Verma	Mr. S.K. Garg
6.	Development and evaluation of suitable sowing equipment for pulses	Dr. M.K. Singh	Dr. Narendra Kumar Mr. Prasoon Verma Mr. S.K. Garg
7.	Prediction of changes in soil organic carbon in long term experiments through carbon modelling	Mr. K.K. Hazra	Dr. M.S. Venkatash
8.	Sulphur management in pulse based cropping system	Dr. M.S. Venkatesh	Dr. Ummed Singh
9.	Efficient management of water for higher productivity in pulses	Dr. C.S. Praharaj	Dr. M.K. Singh
10.	Carryover effect of pulse intercrop on nutrient and moisture conservation in chickpea	Dr. Ummed Singh	Dr. Narendra Kumar
11.	Demonstration of IIPR technologies at farmers' fields	Dr. K.K. Singh	Dr. Rajesh Kumar Dr. Mohd. Akram Mr. U.C. Jha
12.	Up scaling and commercialisation of value added products from pigeonpea milling by-product	Mr. Prasoon Verma	Dr. R.P. Srivastava

CROP PROTECTION

S.N.	Title of the project	Principal Investigator	Associate
1.	Studies on variability in *Rhizoctonia bataticola* and identification of race specific and multi-race donors for wilt and dry root rot resistance in chickpea	Dr. R.G. Chaudhary	Dr. S.K. Chaturvedi Mr. P.R. Saabale
2.	Identification of sources of resistance/tolerance against root-knot nematodes in pulses	Dr. Bansa Singh	Dr. R. Jagdeeswaran
3.	Identification of sources of resistance to bruchids in mungbean and urdbean and its management	Dr. Shiva Kant Singh	Dr. Lalit Kumar Dr. S.K. Singh

S.N.	Title of the project	Principal Investigator	Associate
4.	Bio-ecological studies of lesion nematodes, *Pratylenchus* spp. in chickpea and their management	Dr. Bansa Singh	Dr. R.G. Chaudhary Dr. R. Jagdeeswaran
5.	Development of management strategies against thrips infesting mungbean	Dr. Hem Saxena Dr. S.D. Mohapatra	Dr. Mohd. Akram
6.	Identification of sources of resistance against Phytophthora blight of pigeonpea and its management	Dr. C. Chattopadhyay	Dr. Mohd. Akram
7.	Management of viral disease of mungbean	Dr. Mohd. Akram	Dr. Naimuddin
8.	Biological control of *Meloidogyne javanica* and *Hetrodera cajani* by *Paecilomyces ilacinus* in *Vigna* crops and chickpea	Dr. R. Jagdeeswaran	Dr. Bansa Singh Dr. R.G. Chaudhary
9.	Evaluation of new generation insecticides and non-pesticidal practices for insect-pest management in chickpea	Dr. Hem Saxena	Dr. S.D. Mohapatra
10.	Variability among geographical isolates of *Fusarium oxysporum* f. sp. *lentis* and management of lentil wilt	Dr. Naimuddin	Dr. Mohd Akram

BASIC SCIENCE

S. N.	Title of the project	Principal Investigator	Associate
1.	Effect of high temperature and low soil moisture on different morphological, physiological and biochemical parameter(s) in relation to total dry matter and seed yield of lentil	Dr. Vijaya Laxmi	Mr. Alagu P. Solai
2.	Screening of fieldpea genotypes against heat stress and morphophysiological traits associated with heat tolerance	Dr. Vijaya Laxmi	Dr. G. P. Dixit
3.	Increasing nodulation and nitrogen fixation in chickpea under moisture stress	Dr. Mohan Singh	
4.	Isolation and screening of efficient AM fungi for lentil and chickpea	Dr. S. Paulraj Dr. M. Senthil Kumar	--
5.	Identification and characterization of biochemical compounds imparting resistance to fungal pathogens and *Helicoverpa armigera* in chickpea	Dr. Lalit Kumar	Dr. R.G. Choudhary Dr. S.D. Mohapatra Dr. Jagdish Singh
6.	Anti-nutritional components of lathyrus and their removal by processing	Dr. R.P. Srivastava	Dr. Jagdish Singh
7.	Quantification of biologically active components in pulses having potential impact in human health	Dr. Jagdish Singh	Dr. Jitendra Kumar Dr. Muraleedhar S. Aski Dr. R.P. Srivastava
8.	Exploring the genetic diversity of ACC deaminase producing bacteria for moisture stress management in chickpea	Dr. M. Senthil Kumar	Dr. Mohan Singh
9.	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 Mr. Alagu P. Solai
10.	Identification of source of tolerance to temperature extremities in long duration pigeonpea (*Cajanus cajan*) and analysis of physiological traits conferring tolerance	Dr. Alagu P. Solai	Dr. D. Datta

SOCIAL SCIENCE

S. N.	Title of the project	Principal Investigator	Associate
1.	Validation of farmer-to-farmer model of extension for dissemination of pulses production technology	Dr. Uma Sah	Dr. S.K. Singh Dr. Hem Saxena Dr. Narendra Kumar
2.	Analysis of gender roles in pulses production and processing in Bundelkhand Region	Dr. Rajesh Kumar	Dr. S.K. Singh Dr. Uma Sah
3.	Entrepreneurship development through pulses production and processing technologies among rural youths for income and employment generation	Dr. Purushottam	Dr. Rajesh Kumar Mr. Prasoon Verma
4.	Development of prototype expert system for identification and control of insect pest/diseases in chickpea and pigeonpea	Dr. Devraj	Dr. R.G. Chaudhary
5.	Development of appropriate training modules on pulses production technologies	Dr. Purushottam	Dr. Rajesh Kumar
6.	Analysis of consumption pattern and prices of major pulses in India	Mr. Shripad Bhat	Mr. Deepak Singh
7.	Development of database and information system for pulses genetic resources	Dr. Devraj	Mr. Deepak Singh
8.	Analysis of growth and instability in major pulses of India	Mr. Deepak Singh	Mr. Shripad Bhat

BIOTECHNOLOGY

S. N.	Title of the project	Principal Investigator	Associate
1	Development of chickpea (*Cicer arietinum* L) transgenic for drought tolerance	Dr. Alok Das	Dr. S. Datta Dr. P.S. Basu
2.	Identification of molecular markers linked to *Fusarium* wilt race 2 resistance genes in chickpea (*Cicer arietinum* L)	Dr. K.R. Soren	Dr. M.S. Aski Dr. R.G. Chaudhary

Externally Funded Projects

Crop Improvement

S. N.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Seed production in agricultural crops	DAC	Dr. I.P. Singh (w.e.f Jan. 2013) Dr. S.K. Chaturvedi (Till Dec. 2012)	------
2.	Implementation of PVP legislation of chickpea (DUS)	PPV & FRA	Dr. N.P. Singh	Dr. Shiv Sewak
3.	Implementation of PVP legislation of pigeonpea (DUS)	PPV & FRA	Dr. N. Nadarajan	Dr. Farindra Singh
4.	Implementation of PVP legislation of MULLaRP (DUS)	PPV & FRA	Dr. Sanjeev Gupta	Dr. G.P. Dixit (*Rabi*) Dr. P.K. Katiyar (*Kharif*)
5.	BSP (NSP) crops	DAC	Dr. I.P. Singh (w.e.f. Jan. 2013) Dr. S.K. Chaturvedi (Till Dec. 2012)	------
6.	Construction of a linkage map and tagging of resistance to MYMV and powdery mildew in urdbean (*Vigna mungo* (L.) Hepper)	DBT	Dr. Sanjeev Gupta	------
7.	Improving heat tolerance in chickpea for enhancing its productivity in warm growing conditions and mitigating impact of climate change	DAC (TMOP)	Dr. S.K. Chaturvedi	Dr. P.S. Basu Dr. S.K. Singh (Ext.)
8.	Deployment of molecular markers in chickpea breeding for developing superior cultivars with enhanced disease resistance	DBT	Dr. Aditya Pratap	Dr. S.K. Chaturvedi Dr. S. Datta Dr. R.G. Chaudhary
9.	Pre-breeding and genetic enhancement in breaking yield barriers in *kabuli* chickpea and lentil	DAC-ICARDA-ICAR	Dr. S.K. Chaturvedi Dr. Jitendra Kumar	Mr. Udai Chand Jha
10.	National initiative on climate resilient agriculture (NICRA)	ICAR	Dr. N. Nadarajan (Coordinator) Dr. Sanjeev Gupta (P.I.)	Dr. P.S. Basu Dr. Aditya Pratap Dr. Dibendu Datta Mr. Alagu P. Solai
11.	Evaluation and production of cytoplasmic genetic male sterility (CGMS) based hybrids for enhancement of productivity and stability of yield in pigeonpea	DAC	Dr. N. Nadarajan (National Cordinator) Dr. I.P. Singh (PI of Institute)	Dr. Abhishek Bhora
12.	Selection and utilization of water logging tolerant cultivars in pigeonpea	ICRISAT (NFSM)	Dr. N. Nadarajan (National Cordinator) Mr. D.N. Gawande (PI of Institute)	Dr. S.K. Chaturvedi

Crop Production

S.N.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices	ICAR (NFBSFARA)	Dr. P.S. Basu Dr. P.K. Ghosh (Till Aug. 2012)	Dr. Narendra Kumar Dr. M.S. Venkatesh Dr. C.S. Praharaj Mr. K.K. Hazra Dr. M.K. Singh Dr. M. Senthil Kumar Dr. Ummed Singh

Basic Science

S.N.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Plant growth promoting rhizobacteria (PGPR) for chickpea and pigeonpea	ICAR	Dr. Mohan Singh	Dr. R.G. Chaudhary

Crop Protection

S. N.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Outreach programme on "*Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops" – *Fusarium* wilt of pigeonpea and chickpea	ICAR (through IISR, Calicut)	Dr. R.G. Chaudhary	Dr. K.R. Soren
2.	Outreach programme on "Diagnosis and management of leaf spot diseases of field and horticultural crops" – Cercospora leaf spot of mungbean and urdbean	ICAR (through IIHR, Bangalore)	Dr. R.G. Chaudhary	Dr. Naimuddin
3.	Studies on the variability in *Fusarium oxysporum* f.sp. *ciceri* for identification of race-specific donors for resistance to chickpea wilt and its management	DST	Dr. Subha Trivedi	---
4.	Crop pest surveillance and advisory project (CROPSAP)	RKVY, Maharashtra	Dr. Shiva Kant Singh	---
5.	National initiative on climate resilient agriculture (NICRA)	ICAR	Dr. Shiva Kant Singh	---
6.	Development and validation of PCR based diagnostic for major viral diseases of some important pulses crops	Council of Science & Technology, UP	Dr. Mohd. Akram	Dr. Naimuddin

Social Science

S.N	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Strengthening breeder seed production and training infrastructure and organization of trainings	DAC (NFSM)	Dr. S.K. Singh	-----
2.	Increasing chickpea and pigeonpea production through intensive application of integrated pest management (A3P project)	DAC	Dr. S.K. Singh	
3.	Enhancing lentil production for food, nutritional security and improved rural livelihoods in NE India	DAC-ICARDA-ICAR	Dr. S.K. Singh	----
4.	Popularization of biorationals for management of *Helicoverpa armigera* for improving chickpea productivity in Jalaun District of Bundelkhand Region of U.P.	DBT	Dr. Uma Sah	Dr. Hem Saxena Dr. Rajesh Kumar

Biotechnology

S.N	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Development of pod borer resistant transgenic chickpea and pigeonpea	NPTC (ICAR)	Dr. S. Datta	Dr. Alok Das
2.	Functional genomics in chickpea	NPTC (ICAR)	Dr. S. Datta	Dr. S.K.Chaturvedi Dr. K.R. Soren Dr. Prakash G. Patil
3.	Centre of Excellence for high throughput allele determination for molecular breeding	DBT	Dr. K.R. Soren Dr. S. Datta	Dr. S.K. Chaturvedi Dr. Prakash G.Patil
4.	Development of pod borer resistant transgenic in pigeonpea and chickpea (CORE GROUP 1)	NFBSFARA (ICAR)	Dr. N. Nadarajan	Dr. S.K. Chaturvedi Dr. Alok Das Dr. S. Datta Dr. K.R. Soren Dr. Prakash G.Patil Dr. G.K. Sujayanand

Institute Management Committee

As on 31.3.2013

Dr. N. Nadarajan Director Indian Institute of Pulses Research, Kanpur	Chairman
Joint Director (Pulses) Directorate of Agriculture Krishi Bhawan, Lucknow	Member
Joint Director of Agriculture (Pulses) Directorate of Agriculture Vindhyachal Bhawan, Bhopal	Member
Director of Research NDUA&T, Kumarganj Faizabad (UP)	Member
Dr. B.B. Singh Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
Dr. Anupama Singh Sr. Research Officer Department of Post Harvest Process and Food Engineering GBPUA&T, Pantnagar	Member
Dr. Jyoti Kaul Principal Scientist (Plant Breeding) Directorate of Maize Research, Pusa, New Delhi	Member
Dr. Jitendra Kumar Principal Scientist IARI, New Delhi	Member
Dr. A.K. Patra Principal Scientist IARI, New Delhi	Member
Dr. V.V. Ramamoorthy Principal Scientist IARI, New Delhi	Member
Mr. K.N. Gupta Finance & Accounts officer IIPR, Kanpur	Member
Mr. Panchoo Lal Administrative Officer IIPR, Kanpur	Member Secretary

Research Advisory Committee

As on 31.3.2013

Dr. S.A. Patil Former Director IARI, New Delhi	Chairman
Dr. D.P. Singh Former Director Research GBPUA&T, Pantnagar	Member
Dr. S.V. Sarode Director Research Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola	Member
Dr. Bijay Singh ICAR National Professor, Dept. of Soils PAU, Ludhiana	Member
Dr. Karabi Datta Coordinator Biotechnology Support Programme (DBT) Botany Deptt. Calcutta University, Kolkata	Member
Dr. B.B. Singh Assistant Director General (O&P), ICAR Krishi Bhawan, New Delhi	Member
Dr. N. Nadarajan Director IIPR, Kanpur	Member
Dr. Mohan Singh Principal Scientist, Division of Basic Science IIPR , Kanpur	Member Secretary

Institute Research Council

As on 31.3.2013

Dr. N. Nadarajan 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 31.3.2013

1. Monthly Review Committee

Dr. N. Nadarajan, Director, Chairman
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
Dr. Naimuddin, Member Secretary

2. Farm Advisory Committee

Dr. S.K. Chaturvedi, Chairman
All HoDs
Farm Manager
I/c Security
Dr. K.K. Singh, Member Secretary

3. Estate Management Committee

Dr. Mohan Singh, Chairman
Dr. S.K. Singh
Dr. S. Datta
Mr. Omkar Nath
Administrative Officer
Finance & Accounts Officer
Mr. D.N. Awasthi, Member Secretary

4. Publication Committee

Dr. N. Nadarajan, Director, Chairman
Dr. P.S. Basu
Dr. M.S. Venkatesh
Dr. Jitendra Kumar
Dr. Naimuddin
Mr. Diwakar Upadhyaya, Member Secretary

5. Purchase Committee

Dr. Jagdish Singh, Chairman
Dr. R.G. Chaudhary
Dr. K.K. Singh
Dr. Jitendra Kumar
Dr. M. Senthil Kumar
Finance & Accounts Officer
Administrative Officer, Member Secretary

6. Institute Technology Management Committee

Dr. N. Nadarajan, Director, Chairman
Dr. Aditya Pratap
Dr. Lalit Kumar
Dr. M.S. Venkatesh
Dr. Bansa Singh, Member Secretary

7. Resource Generation and Farm Produce Price Fixation Committee

Dr. R. G. Chaudhary, Chairman
Dr. S.K. Singh (Extn.)
Dr. Jitendra Kumar
Finance & Accounts Officer
Administrative Officer
I/c Library
Dr. Narendra Kumar, Member Secretary

8. Prioritization, Monitoring and Evaluation Cell

Dr. N. Nadarajan, Director, Chairman
Dr. P.S. Basu
Dr. M.S. Venkatesh
Dr. Md. Akram
Dr. Aditya Pratap, Member Secretary
Mr. Diwakar Upadhyaya
Mr. D.K. Sharma
Dr. R.K. Srivastava
Mr. Kanhaiya Lal
Mr. Hasmat Ali

9. Library Committee

Dr. N. Nadarajan, Director, Chairman
All HoDs
Finance & Accounts Officer
Administrative Officer
Dr. I.P. Singh, Member Secretary

10. Institute Biosafety Committee

Dr. N. Nadarajan, Director, Chairman
Dr. S.K. Chaturvedi
Dr. S.K. Goyal (IITR, Lucknow)
Dr. P.K. Singh (GSVM Medical College, Kanpur)
Dr. Alok Das, Member Secretary

11. Academic Committee

Dr. C.S. Praharaj, Chairman
Dr. Alok Das
Dr. M. Senthil Kumar
Dr. Naimuddin, Member Secretary

12. Germplasm Identification Committee

Dr. N. Nadarajan, Director, Chairman
Dr. Shiv Sewak
Dr. S.K. Singh (Ento.)
Dr. Md. Akram
Dr. G.P. Dixit
Dr. S.K. Chaturvedi, Member Secretary

13. HRD Cell

Dr. P.S. Basu, Chairman
Dr. Rajesh Kumar
Dr. P.G. Patil
Dr. Md. Akram, Member Secretary

14. Consultancy Processing Cell

Dr. C.S. Praharaj, Chairman
Dr. Rajesh Kumar
Dr. Md. Akram
Dr. M.K. Singh, Member Secretary

15. Institute Joint Staff Council

Dr. N. Nadarajan, Director, Chairman
Dr. S.K. Chaturvedi
Dr. S.K. Singh (Extn.)
Finance & Accounts Officer
Mr. Yashwant Singh (Secretary IJSC)
Mr. Rakesh Kumar (Member, CJSC)
Mr. Rajesh Kumar
Mr. K.A. Chaturvedi
Mr. Sanjay Kumar
Mr. Bachoo Singh
Administrative Officer (Member Secretary)

16. Grievance Cell

Dr. R.G. Chaudhary, Chairman
Dr. Jitendra Kumar
Mr. Kanhaiya Lal
Mrs. Rita Mishra
Mr. Satish Chandra
Administrative Officer, Member Secretary

17. Vehicle Maintenance Committee

Dr. Bansa Singh, Chairman
Dr. M.K. Singh
Finance & Accounts Officer
Administrative Officer
Mr. D.K. Sharma, Member Secretary

18. Computer/ARIS Cell & Instrumentation Committee

Dr. Bansa Singh, Chairman
Dr. M.S. Venkatesh
Dr. Muraleedhar S. Aski
Dr. Devraj, Member Secretary (Computer)
Mr. G.S. Pandey, Member Secretary (Instrumentation)

19. Guest House Management Committee

Dr. Bansa Singh, Chairman
Dr. K.R. Soren
Dr. (Mrs.) Uma Sah
Dr. R. Jagdeeswaran
Administrative Officer, Member Secretary

20. Sports Committee

Dr. Rajesh Kumar, Chairman

Dr. R. Jagdeeswaran

Dr. M.P. Singh

Mr. Yashwant Singh, Secretary, IJSC

Dr. K.R. Soren, Member Secretary

21. *Rajbhasha* Implementation Committee

Dr. N. Nadarajan, Director, Chairman

All HoDs

Dr. R.K. Srivastava

Mr. Diwakar Upadhyaya, Member Secretary

22. Women's Cell & Sexual Harassment Committee

Dr. (Mrs.) Hem Saxena, Chairperson

Dr. (Mrs.) Vijay Laxmi

Dr. Naimuddin

Dr. (Mrs.) Uma Sah, Member Secretary

23. Technical and Proprietary Item Committee

Dr. I.P. Singh, Chairman

Dr. Md. Akram

Dr. Lalit Kumar

Dr. M.K. Singh

24. Incharges

Dr. Aditya Pratap, Convener, Seminars

Dr. S.K. Singh, I/c Photography

Dr. K.K. Singh, I/c Farms (Main Farm)

Dr. Dibendu Datta, I/c Farms (New Research Farm)

Dr. I.P. Singh, I/c Cold Module

Dr. M.K. Singh, I/c Farm Machinery & 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

Dr. M.P. Singh, I/c Gardening

Mr. Alok Kumar Saxena, I/c Sanitation

Mr. D.K. Sharma, I/c Vehicles

Mr. Omkar Nath, I/c Security

Mr. R.K.P. Sinha, Care Taker, Guest House

Mr. R.K. Singh, Asstt. Farm Manager, Main Farm

Panorama

Institute Foundation Day Celebrated

Indian Institute of Pulses Research celebrated its 20th Foundation Day on Wednesday, September 5, 2012. Director, Indian Institute of Technology-Kanpur, Prof. Sanjay Govind Dhande was the Chief Guest for the occasion and Dr. Probir Kumar Ghosh, Director, Indian Grassland and Fodder Research Institute, Jhansi, was Guest of Honour.

Speaking on the occasion, Prof. Dhande said that in comparison to the year 1950, the production of crops has increased by five times but still people are suffering from malnutrition. He expressed his concern over the declining availability of pulses for each individual. Prof. Dhande added that if quality hybrid seeds and appropriate production techniques are made available to farmers, the production of the crops are likely to go up by 30%. He urged the scientists to work in the direction of benefitting the farmers.

Dr. P.K. Ghosh emphasized upon the need to make farmers a part of the various research programmes so that the same research results are applied on their fields. This will surely help the farmers in getting benefits from the research programmes.

Dr. N. Nadarajan, Director, in his address highlighted the achievements and on-going activities of the Institute. Further, he added that the research projects on pulses under various national and international programmes are being carried over successfully. The Institute has developed an early duration hybrid pigeonpea variety IPH 09-5, beside IPL 316 and IPL 526 of lentil, IPU 7-3 of urdbean and IPA 203 of pigeonpea during the period. Scientists at the Institute have also identified heat tolerant varieties and donors of chickpea and lentil. Notably, IIPR has developed an online "PulsExpert" system for the benefit of farmers and agriculturists to identify diseases and their remedies in pulse crops. The training and communication centre set up at IIPR will cater the training needs of farmers and extension workers, he said.

On this occasion, four new publications *viz.*, Resource Conservation Technology in Pulse Based Cropping System, Gene Technology for Pulses Improvement, Techniques in Plant Biotechnology and Advances In Pulses Genomics Research were released.

During the function, Dr. Aditya Pratap was awarded Best Scientist Award 2012. Sh. Lallan Yadav was awarded as the Best Worker in Technical Category. Sh. Rajendra Singh and Sh. Samar Singh were awarded the Best Worker award in the Administrative and Supporting Categories, respectively. Later in the evening, a cultural programme was held, where in children of staff members performed dances and songs.

Empowered Committee Reviewed Transgenic Project

To review the progress of the NFBSFARA funded project on "Development of pod borer resistant transgenic pigeonpea and chickpea" the Empowered Committee (EC) of National Fund for Basic, Strategic & Frontier Application Research in Agriculture (NFBSFARA), ICAR, visited the Institute on June 27, 2012. Dr. Mangala Rai, Chairman, EC and former Director General (ICAR), Dr. Swapan K. Datta, Dy. Director General (CS), Prof. S.K. Sen (IIT-Kharagpur), Dr. P. Anand Kumar, Project Director, NRCPB, New Delhi, Dr. A. Bandyopadhyay, National Coordinator, NFBSFARA, New Delhi and project partners from IIPR participated in the meeting.

Dr. Mangala Rai appreciated the efforts being made by different core groups and suggested for more sincere efforts for development of transgenic events and emphasized upon effective interactions between and within groups for streamlining a unified genotype independent transformation protocol for both the pulses. Dr. Swapan Datta exhorted the need for gene pyramiding strategies, containment facility for year round activities in chickpea and pigeonpea and formation of biosafety group for transgenic biosafety evaluation, as component of transgenic development programme.

Dr. N. Nadarajan, Director IIPR, (PI, Core Group 1) presented the detailed progress of the project and narrated the advances made by IIPR towards development of transgenic chickpea and pigeonpea using synthetic *cry* gene. Total 78 and 159 putative primary transgenic plants of chickpea and pigeonpea, respectively have been established successfully in Transgenic Containment Facility at IIPR. Dr. S.K. Sen of IIT-Kharagpur (PI, Core Group 2) and Dr. P. Ananda Kumar, Director, NRCPB (PI, Core Group 3) presented the current status of transgenic development in pulses. The Committee appreciated the work progress and laboratory facilities developed at IIPR, Kanpur.

RAC Meeting Held

The 19th meeting of Research Advisory Committee (RAC) was held on January 30-31, 2013 under the chairmanship of Dr. S.A. Patil, Former Director IARI, New Delhi. The meeting was attended by Dr. D.P. Singh, Former Director Research, GBPUA&T, Pantnagar; Dr. S.V. Sarode, Director Research, PDKV, Akola; Dr. Karabi Datta, Coordinator, Biotechnology Support Programme (DBT), Calcutta University, Kolkata: Dr. Bijay Singh, ICAR National Professor, PAU, Ludhiana, and Dr. N. Nadarajan, Director, IIPR, Kanpur. Project Coordinators and Heads of Divisions also participated in this meeting.

Dr. N. Nadarajan, Director welcomed the chairman and members of the RAC and informed the impressive growth rate of pulses production during 2010-11. Institute has released three high yielding varieties of pulses *viz.*, IPL 316 of lentil for CZ, IPU 07-3 of urdbean for SZ and IPFD 6-3 of fieldpea for U.P. Two varieties of pigeonpea IPH 09-5 (Hybrid) and IPA 203 (Long duration) have been identified for NEPZ. In lentil, IPL 526 has been identified for Uttar Pradesh. Two photo-thermo insensitive lines of wild *Vigna viz.*, IC 251372 and IC 251442 have been identified which can be used extensively in hybridization programme in *Vigna*. Institute has developed low cost traps for management of whitefly in *Vigna* crops and manually operated No-Till drill for rice–fallow conditions.

Dr. Mohan Singh, Member Secretary, RAC presented the action taken report on the recommendations of the last RAC meeting held on February 28-29, 2012. RAC members visited both the main research farm and new research farm and appreciated the upkeep of the experimental fields.

Annual Group Meets of AICRPs

❖ The Annual Group Meet of AICRP on Pigeonpea was held at UAS, Bangalore on May 13-15, 2012. In the inaugural session Dr. K. Narayana Gowda, Vice-Chancellor, UAS, Bangalore, Dr. S.K. Datta, DDG (CS), ICAR, Dr. H. Shivanna, Director of Research UAS, Bangalore, Dr. N. Nadarajan, Director, IIPR and other dignitaries were present. Dr. K. Narayana Gowda, in his address said that pigeonpea is becoming important crop in Karnataka as it is gaining popularity over other crops, such as ragi, groundnut, *etc*.

Dr. Swapan K. Datta stressed upon the need to find out good plant types, good pest management practices and post-harvest management techniques and advised to identify germplasm lines for various characters.

Dr. N. Nadarajan, Director, IIPR, Kanpur presented the scenario of pigeonpea in the country along with Project Coordinator's report. He stressed on using the genomic resources developed through whole genome sequencing of pigeonpea, identification of new genetic resistance sources of SMD, development of transgenic for *Helicoverpa* resistance and development of typical plant types for different agro climatic conditions. He also emphasised on refinement of micro irrigation technology, identification of post-emergence herbicides, IPM modules, forecasting system of pests and mechanization of pulses production.

Later in the technical sessions, programmes of various disciplines were discussed and finalized. Three new varieties were identified in the group meet.

❖ The Annual Group Meet on Mungbean and Urdbean (MULLaRP) was held on May 4-6, 2012 at Orissa University of Agriculture and Technology, Bhubaneshwar. The inaugural session was chaired by Prof. D.P. Ray, Vice Chancellor, OUAT, Bhubaneshwar, while Dr. B.B. Singh, ADG (O&P), ICAR, was the Chief Guest and Dr. N. Nadarajan, Director, IIPR was Guest of Honour. The Group Meet was attended by Dr. Sanjeev Gupta, PC, MULLaRP, Prof. J.M.L. Gulati, Dean of Research, OUAT, Bhubaneshwar, Dr. J. S. Sandhu, ADG (Seeds), ICAR and about 100 *Vigna* researchers from different AICRP centres and other organizations of the country. Dr. D.P. Ray in his address appreciated the efforts of *Vigna* researchers and emphasized upon the need to develop improved cultivars in these important crops.

Dr. N. Nadarajan presented an overview of the pulse production scenario in the country and deliberated upon major researchable issues like, widening genetic base through distant hybridization and utilization of wild species, development of genomic tools, development of linkage map in mungbean and urdbean, varieties for specific niches such as rice fallows, tolerance to terminal heat and drought stress and development of photo-thermo-insensitive cultivars. Dr. B.B. Singh appreciated the research efforts of *Vigna* workers towards increasing the productivity and quality of *Vigna* crops and called for using the unique germplasm and wild species for broadening the genetic base of these crops.

Dr. Sanjeev Gupta presented the salient research findings of the last year *kharif* season. Among the significant achievements, he informed that 17 MULLaRP crop varieties were registered with PPV&FR authority. On this occasion the website of AICRP on MULLaRP crops was also launched by the chief guest. Later in the technical sessions, programmes of various disciplines were discussed and finalized.

❖ The Annual Group Meet of AICRP on Chickpea was held on September 1-3, 2012 at G.B. Pant University of Agriculture & Technology, Pantnagar. About 150 delegates from cooperating centres of SAU's, ICAR Institutes, State Department of Agriculture and State Farm Corporation of India attended the group meet. Dr. B.B. Singh, Asstt. Director General (O&P) chaired the inaugural session. Dr. Singh stressed upon restructuring of on-going programmes to increase the production and productivity of pulses and said that new technologies are to be evolved in context of changed scenario of climate in recent years. Dr. N.P. Singh, PC (Chickpea) presented the progress report of the project for the year 2011-12. Later in the technical sessions, programmes of various disciplines were discussed and finalized.

❖ The Annual Group Meet of AICRP on MULLaRP crops was held at IIPR, Kanpur on September 7-8, 2012. About 90 delegates from cooperating centres, SAUs and state departments of agriculture participated in the Meet. Dr. Sanjeev Gupta, Project Coordinator (MULLaRP), while presenting the significant findings of the project, highlighted the progress made in identification of post-emergence herbicides and specific recommendations for *rabi* pulses. Dr. N. Nadarajan, Director, IIPR desired that centres should take innovative programmes and trials on precision agriculture and resource conservation technologies should find the place in programme formulation. Dr. N.P. Singh, Project Coordinator (Chickpea) while chairing the session on presentation of progress report by Principal Investigators strongly focused on need of off-season nurseries of *rabi* pulses flow of breeding material. Later in technical sessions, programme for 2012-13 was disussed and finalized for each discipline.

❖ The Annual Group Meet of AICRP on MULLaRP was held at ARS, Lam on October 18-19, 2012. About 30 delegates from SAU's and cooperating centres participated in the Group Meet. Dr. Sanjeev Gupta, PC, MULLaRP presented the PC report and informed that it is the Ist group meet for rice fallow cultivation and elaborated the importance of rice fallow areas in increasing the pulse production of the country. He stressed upon exploratory trials in rice fallow areas and practicing resource conservation technology.

Dr. N. Nadarajan, Director IIPR applauded the newly launched efforts for improvement of rice fallow pulses. He stressed upon broadening the genetic base of mungbean and urdbean through distant hybridization and alien gene introgression, utilization of wild species and distant relatives, development of genomic tools for *Vigna* improvement, development of linkage map and development of suitable plant types for rice fallows.

Dr. A. Raghvaiah, Director, RARS Lam, emphasized upon the need of developing new cultivars suitable for special niches such as rice fallows, development of short duration genotypes and integration of biotechnological approaches in pulses improvement. Later, the results of previous crop season were discussed and the technical programmes for the next crop season were finalized.

IMC Meeting Held

The meeting of the Institute Management Committee was held on October 31, 2012 under the chairmanship of Dr. N. Nadarajan, Director. The meeting was attended by Dr. B.B. Singh, Assistant Director General (O&P), ICAR, Mr. L.S. Katiyar, Joint Director (Pulses), Directorate of Pulses, Lucknow, Dr. Bhagwan Singh, Director of Research, NDUA&T, Faizabad, Dr. Jyoti Kaul, Principal Scientist, DMR, New Delhi, Dr. Jitendra Kumar, Principal Scientist, IARI, New Delhi, Dr. A.K. Patra, Principal Scientist, IARI, New Delhi and Dr. V.V. Ramamoorthi, Principal Scientist, IARI, New Delhi, along with Project Coordinators (Chickpea and MULLaRP), Heads of Divisions, Administrative Officer and Finance & Accounts Officer.

At the outset, Dr. N. Nadarajan, Chairman extended a warm welcome to all the members and other participants. Dr. Nadarajan briefed the house about the progress made in research and various developmental activities since the last meeting. All the Heads of Divisions and Project Coordinators presented highlights of research achievements made during the period. The Committee reviewed different research and developmental activities and applauded the overall progress made by the Institute.

Farmers-Pulse Millers and Scientists Interface Meeting Organized

Farmers - pulse millers and scientists interface meeting was organised at IIPR on June 23, 2012 on the eve of Industry Day. The main objective of this interface was to ascertain opinion of farmers - pulse millers and scientists on different aspects related to pulses *viz*., varietal development, delivery system, milling recovery, marketing and profit gained by the farmers. Dr. N.P. Singh, Project Coordinator (Chickpea) and acting Director, IIPR emphasized on scenario of state wise pulses production. He urged the pulse millers association for development of collaborative projects, so that good quality as well as required quantity of pulses could be made available to our population. Sri Mithilesh Kumar, President, *Dal* Mill Association, Kanpur and others focused mainly on market trends of pulses and minimum support price (MSP) of pulses, fixation of price of pulses based on the nutritive value and uniform supply of pulses. Scientists of the Insitute highlighted achievements especially in the area of varietal development and pulses availability in different *Mandies* and markets. Farmers also gave their opinion on different aspects related to pulses. Total 136 farmers from Fatehpur, Ramabai Nagar and Kanpur districts and 18 pulse millers took active part in the interface meeting. Dr. S. K. Singh, Principal Scientist (Agril. Extension) was coordinator of the event.

Participation of IIPR in ICAR Sports

IIPR participated in the ICAR Sports Tournament-2013 (North Zone) held during March 19-22, 2013 at Indian Institute of Sugarcane Research, Lucknow. Dr. K.R. Soren, Scientist won the Gold Medal in 100 metre race. A contingent of 37 players participated in table tennis, carom, chess, volley ball shooting and smashing, football, badminton, kabaddi and racing. Dr. Rajesh Kumar accompanied the team as CDM and Mr. Panchoo Lal, AO and Mr. K.N. Gupta, F&AO as Team Managers.

Training on DUS Test – Chickpea

AICRP on Chickpea organized training on DUS Test – Chickpea at IIPR, Kanpur on February 7-8, 2013 to create awareness among breeders about Plant Variety Protection Rights, DUS Test and Registration of Varieties. Total 32 participants from different cooperating centres of AICRP on Chickpea attended the programme. Dr. N. Nadarajan, Director IIPR inaugurated the training and emphasized the importance of registering the precious germplasm material and released varieties in the era of IPR. Dr. N.P. Singh, Project Coordinator (Chickpea) in his welcome address emphasized the importance of Plant Variety Protection Right and registration of varieties. Certificate of registration of chickpea varieties *viz*., RSG 902 (Aruna), RSG 991 (Aparna), RSG 973 (Abha), RSG 895 (Arpita), RSG 807 (Abhar), Virat (Phule G 95311), DCP 92-3 and JG 11 issued by PPV&FR Authority, New Delhi were distributed among the concerned breeders.

Director and other scientists of the Institute delivered lectures on various aspects of DUS Test. A visit was also organized to DUS chickpea plots where reference and example varieties were grown.

Special Secretary DAC Visited IIPR

Md. Siraj Hussain, Special Secretary, Department of Agriculture and Cooperation, GoI visited IIPR on February 15, 2013. Dr. N. Nadarajan, Director briefed about Institute activities and achievements. The Special Secretary interacted with Head of Divisions and visited the Institute museum, Biotechnology labs, experimental plots and seed production plots along with a team of officials of Directorate of Agriculture, Lucknow (U.P.). He appreciated the efforts of the Institute for developing various technological options for different agro-ecological situations of the country. He also urged the scientists to develop varieties, management and protection technologies to suit climate resilient agriculture.

New Regional Station of IIPR established at Bhopal

New Regional Station of Indian Institute of Pulses Research, Kanpur has been established at Bhopal, Madhya Pradesh. The station is located at Fanda village at Bhopal-Indore highway, about 15 km from Bhopal city. The land for this station has been provided by the Government of Madhya Pradesh. Dr. N. Nadarajan, Director, IIPR on behalf of Secretary, DARE & Director General, ICAR and the District Collector, Bhopal on behalf of Government of Madhya Pradesh signed the lease deed on 01.02.2013, which was followed by physical possession of land on March 13, 2013.

The station will prove to be a milestone in expansion of research and extension activities of IIPR. It will cater the needs of pulse growing farmers of central India, large scale quality seed production and generation of breeding material of pulses for the states of central India. The station will also develop location specific technologies and varieties for enhanced pulses production and will contribute to capacity building of officials of state department of agriculture and impart need based training to pulse growing farmers in association with state agricultural universities.

हिन्दी दिवस का आयोजन

भारतीय दलहन अनुसंधान संस्थान में दिनांक 29 सितम्बर, 2012 को हिन्दी दिवस समारोह पूर्वक मनाया गया। समारोह में ब्रह्मानन्द डिग्री कालेज, कानपुर के प्राचार्य डा. विवेक द्विवेदी मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक डा. ना. नडराजन ने की। अपने उद्‌बोधन में डा. द्विवेदी ने कहा कि हिन्दी इस समय पूरे देश में समझी और बोली जाती है और राष्ट्रीय सम्पर्क सूत्र की महती भूमिका निभा रही है। उन्होंने कहा कि हिन्दी अपनी सरलता और सहज बोधगम्यता के कारण ही जीवन के हर क्षेत्र में व्यापक स्तर पर उपयोग की जा रही है। सभी क्षेत्रों में हिन्दी की सफलता का परचम लहरा रहा है। अध्यक्षीय उद्‌बोधन में निदेशक डा. नडराजन ने कहा कि हिन्दी दिवस के आयोजन से हम हिन्दी के प्रति अपना सम्मान और निष्ठा व्यक्त करते हैं और हिन्दी के उत्थान के लिए संकल्प लेते हैं। उन्होंने वैज्ञानिकों का आवाहन किया कि नई तकनीकी जानकारी किसानों तक उन्हीं की भाषा में पहुँचाने के लिए सतत प्रयास करें और हिन्दी के नये प्रकाशनों पर बल दिया। अतिथियों का स्वागत संस्थान की राजभाषा समिति के सचिव श्री दिवाकर उपाध्याय ने किया और संस्थान में राजभाषा की प्रगति आख्या प्रस्तुत की। इस अवसर पर मुख्य अतिथि ने संस्थान की राजभाषा पत्रिका दलहन आलोक तथा हिन्दी के चार अन्य नये प्रकाशनों यथा, संस्थान का वार्षिक प्रतिवेदन, काबुली चना की उन्नत खेती, दलहन फसलों के प्रमुख कीट एव व्याधियों का समेकित प्रबंन्धन और कृषक भागीदारी द्वारा मसूर का बीज उत्पादन का विमोचन किया।

हिन्दी पखवाड़े में आयोजित विभिन्न प्रतियोगिताओं के विजयी प्रतिभागियों कु. कीर्ति त्रिपाठी, श्री कन्हैया लाल, श्रीमती रश्मि यादव, सर्वश्री प्रोमित डायस, हरगोविन्द राठौर, रामबाबू, आलोक कुमार सक्सेना, श्रीमती रीता मिश्रा, सर्वश्री आर. के. पी. सिन्हा, मो. शब्बीर, राजेन्द्र कुमार, गोविन्द राम, श्रीमती मीनाक्षी वार्ष्णेय तथा कार्यालयीन कामकाज में हिन्दी का उत्कृष्ट प्रयोग करने के लिए सर्वश्री शुकदेव महतो, शिवशरण सिंह, श्रीमती रीता मिश्रा, श्रीमती मीनाक्षी वार्ष्णेय, सर्वश्री गुलाब चन्द्र शर्मा, आलोक कुमार सक्सेना, राजेन्द्र कुमार, अनिल कुमार सोनकर, हरगोविन्द राठौर और श्री जियालाल को मुख्य अतिथि ने पुरस्कार और प्रमाण पत्र प्रदान किए। कार्यक्रम के अन्त में डा. संजीव गुप्ता ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन डा. (श्रीमती) उमा साह ने किया।

IIPR Organizes International Training Course

International Training Course for officials of Afghanistan on "Improvement of pulses production in dry land farming" is being organized at IIPR from March 29 to April 18, 2013. This training course is funded by Ministry of External Affairs, GoI, New Delhi and supported by ICAR, ICARDA and ACIAR. Total 29 participants of different states of Afghanistan from Ministry of Agriculture, Livestock, Irrigation *etc.*, are taking part in this training.

Dr. N. Nadarajan, Director, IIPR highlighted the importance of pulses in improving soil health, maintaining ecological sustainability and in providing nutritional security to the huge vegetarian population. He also briefed the participants about the scenario of pulse production and prospects of increasing the pulses production. In the inaugural session, Dr. Javed Rizvi, Country Manager, ICARDA for Afghanistan stressed about the potential role, the pulses can play in agricultural growth and in nutritional security.

A visit to Barhapur village of Kanpur Dehat was also organized on March 29, 2013. Dr. S.K. Singh, Course Coordinator briefed about impact of out-reach project and involvement of farmers' associations in quality seed production of pulse crops. Participants visited the farmers' fields and interacted with the farmers.

Personnel

A. Research Management

1.	Dr. N. Nadarajan	Director	

B. Scientific

Crop Improvement

2.	Dr. S.K. Chaturvedi	Plant Breeding	Head of the Division
3.	Dr. N.D. Majumder	Plant Breeding	Principal Scientist
4.	Dr. I.P. Singh	Plant Breeding	Principal Scientist
5.	Dr. Dibendu Datta	Plant Breeding	Principal Scientist
6.	Dr. Aditya Pratap	Plant Breeding	Senior Scientist
7.	Dr. Jitendra Kumar	Plant Breeding	Senior Scientist
8.	Dr. Basudeb Sarkar	Plant Breeding	Senior Scientist
9.	Mr. Udai Chand Jha	Plant Breeding	Scientist
10.	Mr. Debjyoti Sen Gupta	Plant Breeding	Scientist
11.	Dr. Muraleedhar S. Aski	Plant Breeding	Scientist
12.	Dr. Ashok Kumar Parihar	Plant Breeding	Scientist
13.	Mr. Abhishek Bohra	Plant Breeding	Scientist
14.	Mr. D.N. Gawande	Plant Breeding	Scientist
15.	Dr. Revanappa	Plant Breeding	Scientist

Crop Production

16.	Dr. P.K. Ghosh	Agronomy	Head of the Division (Upto 14.8.2012)
17.	Dr. C.S. Praharaj	Agronomy	Principal Scientist
18.	Dr. K.K. Singh	Agronomy	Principal Scientist
19.	Dr. M.S. Venkatesh	Soil Science	Principal Scientist
20.	Dr. Narendra Kumar	Agronomy	Senior Scientist
21.	Dr. Ummed Singh	Agronomy	Senior Scientist
22.	Mr. Kali Krishna Hazra	Agronomy	Scientist
23.	Mr. Prasoon Verma	Agril. Engineering	Scientist (SG) (Upto 14.12.2012)
24.	Dr. M.K. Singh	Agril. Engineering	Scientist (Sr. Scale)

Crop Protection

25.	Dr. C. Chattopadhyay	Plant Pathology	Head of the Division (Upto 30.11.2012)
26.	Dr. R.G. Chaudhary	Plant Pathology	Principal Scientist
27.	Dr. (Mrs.) Hem Saxena	Entomology	Principal Scientist
28.	Dr. Bansa Singh	Nematology	Principal Scientist
29.	Dr. Shiva Kant Singh	Entomology	Principal Scientist
30.	Dr. S.D. Mohapatra	Entomology	Senior Scientist (Upto 19.11.2012)
31.	Dr. Mohd. Akram	Plant Pathology	Senior Scientist
32.	Dr. Naimuddin	Plant Pathology	Scientist (SG)
33.	Dr. R. Jagdeeswaran	Nematology	Scientist
34.	Mr. P.R. Saabale	Plant Pathology	Scientist
35.	Dr. G.K. Sujayanand	Entomology	Scientist

Basic Science

36.	Dr. Jagdish Singh	Plant Physiology	Head of the Division
37.	Dr. Mohan Singh	Microbiology	Principal Scientist
38.	Dr. R.P. Srivastava	Biochemistry	Principal Scientist
39.	Dr. P.S. Basu	Plant Physiology	Principal Scientist
40.	Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
41.	Dr. Lalit Kumar	Agril. Chemistry	Senior Scientist
42.	Dr. M. Senthil Kumar	Microbiology	Senior Scientist
43.	Mr. S. Paul Raj	Microbiology	Scientist
44.	Mr. Alagupalamuthir Solai	Plant Physiology	Scientist

Social Science

45.	Dr. S.K. Singh	Agril. Extension	Principal Scientist & Acting Head
46.	Dr. Rajesh Kumar	Agril. Extension	Principal Scientist
47.	Dr. (Mrs.) Uma Sah	Agril. Extension	Senior Scientist
48.	Dr. Purushottam	Agril. Extension	Senior Scientist
49.	Dr. Devraj	Computer Application	Scientist (SG)
50.	Mr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)
51.	Mr. Deepak Singh	Agril. Statistics	Scientist
52.	Mr. Shripad Bhat	Agril. Economics	Scientist

Biotechnology Unit

53.	Dr. S. Datta	Biotechnology	Senior Scientist & In-charge
54.	Mr. P. Nandeesha	Biotechnology	Scientist
55.	Mr. Prakash G. Patil	Biotechnology	Scientist
56.	Dr. Khela Ram Soren	Biotechnology	Scientist
57.	Dr. Alok Das	Biotechnology	Scientist

C. AICRP on Pigeonpea

58.	Dr. N. Nadarajan	Acting Project Coordinator
59.	Dr. Farindra Singh	Principal Scientist

D. AICRP on Chickpea

60.	Dr. N.P. Singh	Project Coordinator
61.	Dr. Shiv Sewak	Principal Scientist

E. AICRP on MULLaRP

62.	Dr. Sanjeev Gupta	Project Coordinator
63.	Dr. G.P. Dixit	Principal Scientist
64.	Dr. P.K. Katiyar	Principal Scientist

F. Technical

65.	Mr. Diwakar Upadhyaya	Editor (T-9)
66.	Mr. D.N. Awasthi	Architect (T-9)
67.	Dr. T.N. Tiwari	Technical Officer (T-9)
68.	Mr. Lallan Yadav	Technical Officer (T-9) (Upto 31.1.2013)
69.	Mr. D.K. Sharma	Technical Officer (T-9)
70.	Mr. M.R. Tripathi	Technical Officer (T-7/8) (Upto 30.4.2012)
71.	Mr. Desh Raj	Technical Officer (T-7/8)

72.	Dr. M.P. Singh	Technical Officer (T-7/8)	
73.	Mr. Vijendra Singh	Technical Officer (T-7/8)	
74.	Mr. S.P.S. Chauhan	Technical Officer (T-7/8)	
75.	Mr. R.S. Mathur	Technical Officer (T-7/8)	
76.	Dr. G.K. Srivastava	Technical Officer (T-7/8)	
77.	Mr. Omkar Nath	Technical Officer (T-7/8)	
78.	Mr. Radha Krishan	Technical Officer (T-7/8)	
79.	Dr. Ved Ram	Technical Officer (T-7/8)	
80.	Mr. A.B. Singh	Technical Officer (T-7/8)	
81.	Mr. Jokhu Ram	Technical Officer (T-6) (Upto 31.1.2013)	
82.	Dr. Aditya Prakash	Technical Officer (T-6)	
83.	Mr. S.K. Garg	Technical Officer (T-6)	
84.	Mr. Ramesh Chandra	Technical Officer (T-6)	
85.	Mr. Ved Prakash	Technical Officer (T-6)	
86.	Mr. A.P. Singh	Technical Officer (T-6)	
87.	Mr. Rajendra Prasad	Technical Officer (T-5)	
88.	Mr. V.B. Choube	Technical Officer (T-5)	
89.	Mr. R.P. Singh	Technical Officer (T-5)	
90.	Mr. R.K.S. Yadav	Technical Officer (T-5)	
91.	Mr. S.P. Kushwaha	Technical Officer (T-5) (Upto 31.5.2012)	
92.	Mr. Krishna Autar	Technical Officer (T-5)	
93.	Mrs. Rashmi Yadav	Technical Officer (T-5)	
94.	Mr. G. S. Pandey	Technical Officer (T-5)	
95.	Mr. Kailash Chandra	Technical Officer (T-5)	
96.	Mr. S.K. Dwivedi	Technical Officer (T-5)	
97.	Mr. Lakhan	Technical Officer (T-5)	
98.	Mr. R.K. Singh	Technical Officer (T-5)	
99.	Mr. Rakesh	Technical Officer (T-5)	
100.	Mr. Malkhan Singh	Technical Officer (T-5)	
101.	Mr. Ashraf Khan	Technical Officer (T-5)	
102.	Mr. Arvind Singh Yadav	Technical Officer (T-5)	
103.	Mr. R.M. Pal	Technical Officer (T-5)	
G.	**Administrative**		
104.	Mr. K.N. Gupta	Finance & Accounts Officer	
105.	Mr. Rajendra Singh	Administrative Officer (Upto 30.11.2012)	
106.	Mr. Panchoo Lal	Administrative Officer (From 31.12.2012)	
107.	Mr. A.K. Saxena	Assistant Administrative Officer	
108.	Mrs. A. Abraham	Assistant Administrative Officer	
109.	Mr. B.K.Verma	P.S. to Director	
H.	**Regional Station cum Off-Season Nursery, Dharwad**		
110.	Dr. A.K. Choudhary	Plant Breeding	Principal Scientist & Station In-charge
111.	Dr. Pramod Kumar	Agronomy	Scientist (Upto 7.3.2013)
112.	Mr. Anand Kumar	-	Technical Assistant (T-3)

Appointments, Promotions, Transfers, *etc.*

Appointments

Name	Designation	Date of joining
Dr. Ummed Singh	Senior Scientist (Agronomy)	21.4.2012
Dr. Pramod Kumar	Scientist (Agronomy)	2.5.2012
Dr. Revanappa	Scientist (Plant Breeding)	2.5.2012
Dr. G.K. Sujayanand	Scientist (Entomology)	8.10.2012
Km. Kirti Tripathi	Assistant	7.8.2012
Mr. Anand Kumar	T-3	20.10.2012
Mr. Ravi Ranjan Singh	T-1	10.12.2012

Promotions

Name	Promoted to	w.e.f.
Dr. Farindra Singh	Principal Scientist	1.1.2009
Dr. P.K. Katiyar	Principal Scientist	13.2.2010
Dr. A.K. Choudhary	Principal Scientist	14.6.2011
Dr. M.S. Venkatesh	Principal Scientist	22.9.2011
Dr. T.N. Tiwari	T-9	3.2.2012
Mr. Lallan Yadav	T-9	3.2.2012
Mr. D.K. Sharma	T-9	3.2.2012
Mr. Omkar Nath	T-7/8	12.8.2011
Mr. Radha Krishan	T-7/8	1.1.2011
Mr. G.K. Srivastava	T-7/8	1.7.2009
Mr. Lakhan	T-5	1.1.2012
Mr. R.K. Singh	T-5	4.1.2012
Mr. Rakesh	T-5	4.1.2012
Mr. Malkhan Singh	T-5	6.1.2012
Mr. Ashraf Khan	T-5	7.1.2012
Mr. Arvind Singh Yadav	T-5	10.1.2012
Mr. R.M. Pal	T-5	28.2.2012
Mr. Kanhaiya Lal	T-4	13.10.2011
Mr. Balram Singh	T-4	10.1.2012
Mr. Krishan Pal	T-3	31.1.2012

Transfers

Name	Designation	From	To	Date
Mr. Panchoo Lal	Admin. Officer	NBFGR, Lucknow	IIPR, Kanpur	31.12.2012
Dr. S.D. Mohapatra	Sr. Scientist	IIPR, Kanpur	CRRI, Cuttack	19.11.2012
Dr. Basudeb Sarkar	Sr. Scientist	DWR, Karnal	IIPR, Kanpur	10.9.2012
Mr. Prasoon Verma	Scientist (SG)	IIPR, Kanpur	CIPHET, Ludhiana	14.12.2012
Mr. Sanjay Kumar	T-3	IIPR, Kanpur	IIVR, Varanasi	30.11.2012

- Dr. P.K. Ghosh, Head, Division of Crop Production was relieved from the Institute on 14.8.2012, to join as Director, Indian Grassland and Fodder Research Institute, Jhansi.
- Dr. C. Chattopadhyay, Head, Division of Crop Protection was relieved from the Institute on 30.11.2012, to join as Director, National Centre for Integrated Pest Management, New Delhi.

Retirements

Name	Post held	Date of retirement
Mr. Rajendra Singh	Administrative Officer	30.11.2012
Mr. Lallan Yadav	Technical Officer (T-9)	31.1.2013
Mr. Jokhu Ram	Technical Officer (T-6)	31.1.2013
Mr. M.R. Tripathi	Technical Officer (T-7-8)	30.4.2012
Mr. S.P. Kushwaha	Technical Officer (T-5)	31.5.2012

Resignation

Dr. Promod Kumar, Scientist (Agronomy) has resigned from his services on 7.3.2013, consequent upon his selection in UP PCS.

Obitury

Mr. Rama Kant Patel, Supporting Staff, left for heavenly abode on 26.7.2012. May his soul rest in Peace.

Indian Institute of Pulses Research, Kanpur-208 024

Phone: 0512-2570264, 2572011, 2572464 Fax: 0512-2572582

Email: director@iipr.ernet.in

Website: http://iipr.res.in

army printing press
www.armyprintingpress.com
Lucknow (0522) 2481164