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वार्षिक प्रतिवेदन
Annual Report
2013 - 14

INDIAN INSTITUTE OF PULSES RESEARCH
भादअस

भारतीय दलहन अनुसंधान संस्थान
कानपुर 208 024

Indian Institute of Pulses Research
Kanpur 208 024

With best compliments from

Dr. N.P. Singh
Director

Indian Institute of Pulses Research
Kanpur 208 024

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Preface

It gives me immense pleasure to present the Annual Report of IIPR for 2013-14. During this year, pulses production in the country is expected around 20 mt against 18.34 million tonnes in the previous year (2012-13) with a record growth rate of more than 3%. This production was achieved despite prevailing unusual weather conditions with long cold spell with rains and hailstorms. This quantum jump in pulses production to the tune of about 4-5 million tonnes since 2011 had been a remarkable achievement, ensuring food security and towards self-sufficiency in pulses in the country. This could be indeed possible through consistent efforts of pulse researchers throughout the country, strong support of ICAR and Government policies to declare almost all Indian states as pulse states.

The present Annual Report highlights significant achievements made under different research programmes. Concerted efforts of scientists have resulted in identification of three high yielding varieties of chickpea *viz*., GJG 0809 for NHZ, CSJ 515 and GLK 28127 for NWPZ along with three other state released varieties *viz*., IPC 2004-98 (*desi* large seeded), IPC 2004-1 (medium large seeded) and IPC 2005-62 for UP, one variety of summer mungbean MH 421 for Punjab, Haryana, Delhi and western UP, two high yielding varieties of fieldpea *viz*., IPFD 10-12 a dwarf variety for MP, Chhattisgarh, Bundelkhand region of U.P., Gujarat and South Rajasthan and HFP 715, dwarf variety for HP, J & K, hills of Uttarakhand and NEH states, one lentil variety IPL 526 for Uttar Pradesh and one rajmash variety SRJ 1 for eastern U.P., Bihar, Jharkhand and Assam states.

Total 10,452 q breeder seed of chickpea (92 varieties), 673.8 q of pigeonpea (41 varieties), 936.69 q of mungbean (61 varieties), 941.11 q of urdbean (41 varieties), 916.0 q of lentil (30 varieties) and 863.33 q of fieldpea (23 varieties) was produced. The Institute is maintaining >10,000 germplasm accessions of major pulse crops including chickpea (4,000 acc.), lentil (3,000 acc.), mungbean (570 acc.), urdbean (340 acc.), pigeonpea (1,000 acc.), lathyrus (450 acc.), rajmash (65 acc.) and fieldpea (870 acc.) along with large number of accessions of wild species of major pulses which are being utilized in broadening the genetic base. A wild hybridization garden of *Vigna*, lentil, pigeonpea and chickpea has been created and maintained. Online Database and Information System for pulses germplasm has been developed.

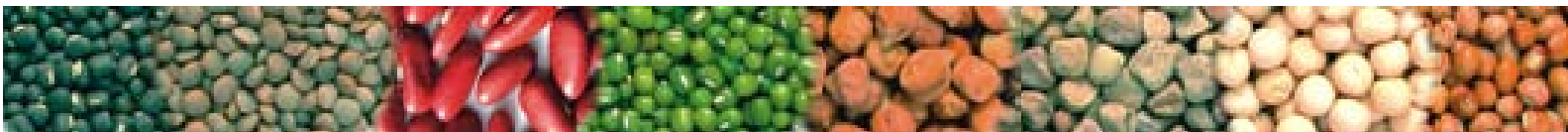
Significant progress in genetic transformation with *cry1Ac* gene in chickpea and pigeonpea against pod borer has been made. For imparting drought tolerance, chickpea *cv*. DCP 92-3 was transformed with the transcription factor (AtDREB1a) gene driven by stress inducible promoter rd29A. To improve drought tolerance and to enrich the superior alleles in single cultivar of chickpea, two different approaches, *viz*., marker assisted backcrossing (MABC) and marker assisted recurrent selection (MARS) were used.

To mitigate the adverse impact of climate changes, genotypes possessing tolerance to heat and drought in chickpea and lentil have been identified and are being utilized widely in breeding programmes to transfer the genes conferring heat tolerance. The on-going long term project on National Initiative on Climate Resilient Agriculture enabled to establish effective phenomix facilities to identify genotypes of urdbean, mungbean and pigeonpea for tolerance to drought and heat. In addition to large number of genotypes identified for combined tolerance to drought and heat, strong phenotyping methodologies have been developed.

In long term trials, inclusion of pulses in cereal based cropping systems and incorporation of crop residue has significantly improved the soil quality and crop productivity. Water and nutrients through drip-fertigation in pigeonpea based intercropping with urdbean and sorghum realized higher system productivity. Pigeonpea equivalent yield was highest with drip-fertigated sorghum based intercropping system. Total yield was significantly higher with irrigation at critical stages over rainfed cultivation. Economizing of water through precision irrigation using laser levelling and micro-sprinkler under dry and hot summer was made successful to reduce number of irrigations (1-2) in summer mungbean and urdbean as catch crops. Successful demonstration of IIPR technologies was carried out at farmers' fields which included post-emergence application of Imazethapyr for *kharif* pulses, ridge planting in pigeonpea, chickpea+ mustard (6:2 ratio) during *rabi* season, popularization of summer mungbean and IPM for pest control.

The soil physical constraints and moisture dynamics under rice fallows across different agro-ecosystem were worked out for higher pulse productivity. A number of innovative moisture conservation technologies were developed, which enabled more productive pulse cultivation under conservation tillage and this venture opens new avenues for horizontal expansion of pulses in non-traditional areas of the country.

A large number of genotypes were screened against *Fusarium oxysporum f*.sp. *ciceri* (race 2) in wilt-sick plot. Effective formulation of *Trichoderma harzianum*



isolate 31 (IPT 31) was successfully demonstrated to reduce plant mortality by 45% and increase yield by 25%. Seed treatment with imidaclorpid 17.8SL @ 5 g/kg seed, followed by foliar spray of Nurelle D505 @ 0.1% was found effective in reducing the incidence of viral diseases (yellow mosaic and leaf curl/necrosis) in mungbean.

Promising chickpea genotypes with combined tolerance to heat and drought have been identified with specific physiological markers. Temperature induction response (TIR) technique was successfully demonstrated to screen pigeonpea lines with high temperature tolerance. A rapid non-destructive technique Near Infrared (NIR) spectroscopy was standardized to assess the protein content of seeds, which has great promise to initiate quality breeding where large sampling is needed. Formulation of unique commercial bioinoculants involving ACC deaminase producing bacteria is in the process of development which is proven to enhance root biomass, higher nodulation and 50% higher grain yield over uninoculated control.

For upliftment of socio-economic condition and upgradation of skill on different aspects of management and protection of crops, selected tribal districts of M.P. and Chhattisgarh were adopted and total 212 participatory demonstrations were laid out in these areas and 1,040 technology demonstrations of chickpea, lentil and fieldpea and off-campus training, field days, diagnostic field visits, farmers' meeting and 12 exposure visits were organized.

The Institute is successfully implementing several externally funded projects of National Fund of ICAR, ICRISAT, ICARDA, DAC, DBT and developed strong linkages with these organizations. Institute is also collaborating in large number of network projects on various aspects including biodiversity, pre-breeding in pigeonpea, lentil and chickpea. For boosting up pulses production and productivity, good linkages were established with states and training courses organized. To develop human resources, the Institute has widened its activities by providing opportunities to students and research fellows for pursuing their Ph.D. in frontier areas and short and long term attachment trainings for post-graduate students. Institute scientists were also deputed to visit advance research centres and laboratories within the country and abroad.

The recent trend of pulse production has clearly demonstrated the potential of high yielding varieties, effective production and protection technologies and pulse researchers available in the country. I am confident that with technologies emanating from research projects under broad themes of national interest and priorities, the Institute will go a long way in augmenting pulse production in the country and is capable to accept new challenges ahead. The Institute has identified major R&D issues as per the recommendations of the RAC which are being tackled through integration of conventional approaches with cutting edge technologies such as genomics, transgenics, molecular assisted breeding, stress management using molecular approaches, high input use efficiency, quality improvement, forcasting and forewarning and resource conservation technologies in the recently formulated research projects.

This all round growth and development of the Institute has been possible with the able guidance, encouragement and continuous support received from Dr. S. Ayyappan, Secretary DARE and Director General, ICAR and Dr. Swapan K. Datta, Deputy Director General (Crop Science), ICAR which I acknowledge with deep gratitude and respect. I am extremely thankful to Dr. B.B. Singh, ADG (O&P) for his involvement, active support and inspiration in carrying out various activities.

I would like to appreciate to Drs. Sanjeev Gupta, I.P. Singh, S.K. Chaturvedi, Jagdish Singh, S.S. Singh, Hem Saxena, S.K. Singh and S. Datta for their valuable inputs and sincere efforts in compiling the report of their respective divisions and section. I am also grateful to members of the Publication Committee Drs. P.S. Basu, G.P. Dixit, Hemant Kumar, G.K. Sujayanand and Chief Editor Mr. Diwakar Upadhyaya for their sincere efforts in bringing out the report in time.

(N.P. Singh)
Director

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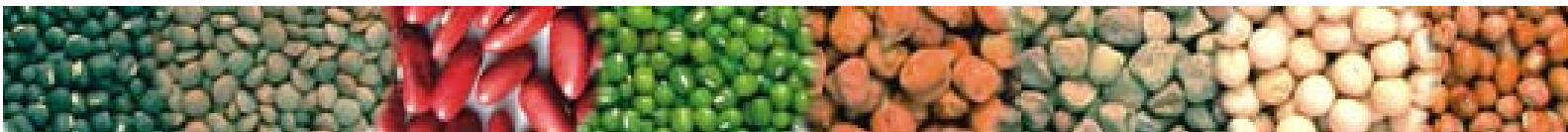
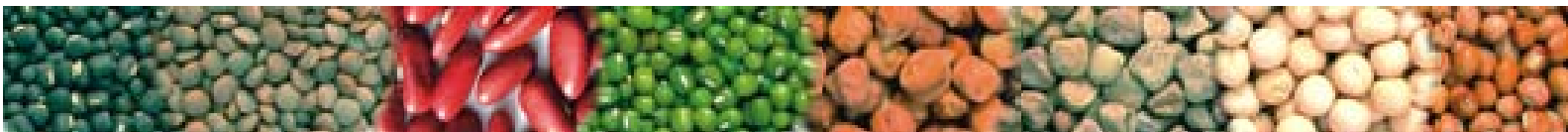


Executive Summary

Crop Improvement

- Three chickpea (*desi*) varieties *viz*., IPC 2004-98 (large seeded), IPC 2004-1 (medium large seeded) and IPC 2005-62 and one lentil variety IPL 526 were identified for cultivation in Uttar Pradesh.
- Green seeded fieldpea variety IPFD 10-12 resistant to powdery mildew disease was identified for cultivation in Madhya Pradesh, Chhattisgarh, Bundelkhand region of Uttar Pradesh, Gujarat and South Rajasthan.
- In AICRP trials, a number of genotypes performed well. These genotypes are IPC 2006-126, IPC 2008-69, IPC 2007-13, IPC 2006-77, IPCK 2009-164, IPCK 2008-109 in chickpea, IPL 220, IPL 325, IPL 327, IPL 534, IPL 580 in lentil, IPM 410-3, IPM 2K15-4, IPM 5-17, IPM 312-394 and IPM 205-7 in mungbean.
- Chickpea genotypes *viz*., IPC 2006-11, IPC 2008-83, IPC 2001-28, IPC 2001-85 and IPC 2011-113 having height >70 cm with $>60^0$ branch angle and tolerant to lodging were identified for mechanical harvesting.
- Screening for resistance/tolerance to biotic stresses resulted in identification of 9 lines each of *kabuli* and *desi* chickpea resistant to wilt for race 2. Multilocation evaluation under AICRP resulted in identification of 7, 1, 2, 4 and 2 genotypes resistance to fusarium wilt, collar rot, dry root rot, ascochyta blight and stunt, 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.
- Eight genotypes of chickpea (ICC 1164, ICC 1205, ICC 1205, ICC 1161, ICC 1381, ICC 1710, IPC 2010-81 and IPC 2008-59) and one genotype of lentil (IG 3031) showed tolerance to post-emergence herbicide at initial stage when Imazethapyr was applied after 30 days of sowing.
- Two accessions of *C. scarabaeoides viz*., ICP 15685 and ICP 15761 have shown consistent resistance against *Fusarium* wilt. In addition, IPAC 66 and IPAC 68 showed resistant to *Fusarium* wilt for 3 consecutive years in wilt sick plot. One newly collected germplasm line, IPAC 494 exhibited resistance against *Fusarium* wilt.
- IPAC 79 exhibited highest survival (50%), followed by ICPL 5028 (29%), MAL 9 and IPAPB 7-2-1-7 (27%) and LRG 30 (24%) under water logging conditions in pigeonpea.
- Interspecific crosses between cultivated and wild species involving *C. reticulum* and *C. echinospermum* in chickpea, *Lens orientalis* in lentil and *C. scarabaeoides* in pigeonpea showed variability for 50% flowering, 100 seed weight, resistance/tolerance to biotic and abiotic stresses.
- Complete sterility (100%) was noted in the backcross progenies, and an additional backcross (BC_6) was performed [(ICPL 88039 × GT 288A) × ICPL 88039] for the newly converted A-line (ICPL 88039A) of pigeonpea.
- ILWLS 118-1, IPLS 09-17, IPLS 09-22, IC560150, IPLS 09-10 and IPLS 09-34 were characterized as early in lentil and flowered between 39 to 43 days. Three breeding lines of lentil including IPL 220 (small seeded), IPL 328 (large seeded), IPL 534 (extra early) were identified as rich for macro- and micro-nutrients.
- Lentil genotypes such as IG 2507, IG 4258, FLIP 2009-55L, ILL 5519, ILL 3517, ILL 4345 and ILL 2150 were identified tolerant to heat under field condition.
- Mungbean genotypes IPM 2K14-7 (1063 kg/ha), IPM 205-9 (888 kg/ha) and IPM 9901-8 (878 kg/ha) were found promising during spring season, while IPM 104-3 (1031 kg/ha) and IPM 545-1 (1031 kg/ha) were promising during summer season.
- Two mungbean genotypes IPM 9901-6 and IPM 02-14 performed consistently better in UP State Adaptive Trials.
- Mapping populations for wilt, earliness and seed size, early seedling vigour and root traits in lentil and pigeonpea were maintained and advanced to next generation.
- Sixty genotypes of mungbean were characterized at molecular level with 59 SSR markers. Molecular marker assisted selection in chickpea resulted in development of BC_3F_3 lines having highest background genome recovery of superior cultivars.
- Total 304 accessions of chickpea and 594



accessions of lentil were evaluated for various qualitative and quantitative traits, while 704 accessions of chickpea, 834 accessions of lentil and 1,130 accessions of pigeonpea were rejuvenated. A mini core of 134 accessions developed by ICARDA was multiplied for seeds. Besides, 120 accessions of fieldpea, 160 active germplasm lines of mungbean, 65 accessions of rajmash, 120 lines of pigeonpea and 296 elite breeding lines/germplasm accessions of chickpea were maintained/ multiplied.

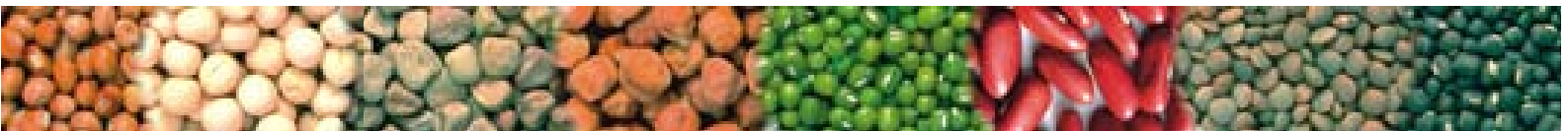
- Total 120 accessions of 6 wild *Cicer* species, 97 accessions of 23 *Vigna* species, 364 accessions of 6 *Lens* species, 50 accessions of 12 wild relatives of pigeonpea and 118 Mediterranean land races of lentil were maintained and characterized for morphological traits.
- More than 10,000 accessions of pulse crops including chickpea (4000 acc.), lentil (3000 acc.), mungbean (570 acc.), urdbean (340 acc.), pigeonpea (1000 acc.), lathyrus (450 acc.), rajmash (65 acc.) and fieldpea (870 acc.) are maintained in medium term cold module (at 4^0C temperature and 40% RH).
- Total 429.48 q breeder seed of three varieties of chickpea (DCP 92-3, Shubhra and Ujjawal), four varieties of fieldpea (Adarsh, Vikash, Prakash and Aman), four varieties of lentil (DPL 15, DPL 62, IPL 81, IPL 406), three varieties of pigeonpea (Bahar, UPAS 120, NDA 1), four varieties of mungbean (Samrat, IPM 2-3, IPM 2-14, Meha) and two varieties of urdbean (Uttara, IPU 2-43) was produced. Nucleus seed of these varieties was also produced for production of breeder seed in next season/year.

Biotechnology

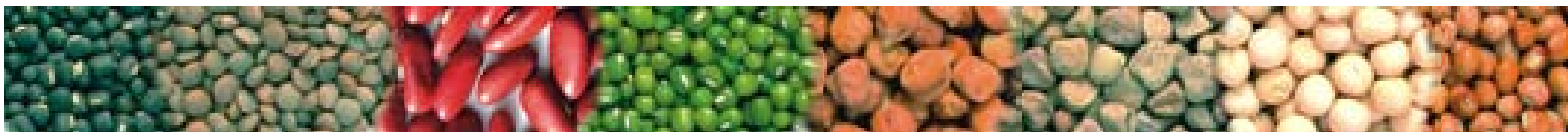
- Genetic transformation in chickpea (17,262 explants) and pigeonpea (3,711 explants) using *Bt* gene (*cry1Aabc*) was done and 63 and 5 independent primary transgenics of chickpea and pigeonpea were established, respectively.
- Genetic transformation with *cry1Ac* gene in chickpea and pigeonpea was done with 40,098 and 16,801 axillary meristem explants, and 94 and 138 independent primary transgenics of chickpea and pigeonpea were established, respectively.
- Detached leaf insect bioassay with 3rd instar *Helicoverpa* larva in T_3 pigeonpea lines was conducted and mortality at 72 hrs ranged from 40-100%. Detached leaf bioassay for 18 T_1 chickpea lines was conducted with 24 hours old neonates of *H. armigera* and upto 67% larval mortality was observed.
- For imparting drought tolerance, chickpea (*cv*. DCP 92-3) was transformed with the transcription factor (AtDREB1a) gene driven by stress inducible promoter rd29A. Three positive independent kanamycin resistant shoots (T_0) indicated presence of gene in the progenies. Seeds from all the 23 plant progenies were harvested.
- To improve the drought tolerance and to enrich the superior alleles in single cultivar of chickpea, two different approaches *viz*., marker assisted backcrossing (MABC) and marker assisted recurrent selection (MARS) were used. For introgressing the QTLs imparting drought tolerance and other yield attributing traits, ICC 4958 was used as donor in background of DCP 92-3 and KWR 108.
- To identify molecular markers linked to *Fusarium* wilt resistance genes against race-2, two different mapping populations (JG 62 x WR 315 and K 850 x IPC 2004-52) were developed and genotyped. F_2 mapping population of JG 62 x WR 315 comprise 178 individuals. A linkage map was constructed with 42 loci covering 158.1cM.
- Three candidate homologs (CAP2, DREB2 and DRO1) were identified in the draft genome based on Pfam Data set utilizing Hidden Markov Model (HMM). Four sets of oligos were designed based on drought responsive transcription factors.

Crop Production

- Inclusion of pulses in cereal based system increased the system productivity and yield of component crops. Inclusion of summer mungbean in cereal based rotation (rice-wheat and maize-wheat) also improved soil organic C and soil available nutrients. In upland system, the base crop (wheat) productivity was maximum under maize-wheat-mungbean (4639 kg/ha) and lowest in pigeonpea-wheat (3631 kg/ha). Similarly, after ten years of crop rotation, inclusion of summer mungbean in rice-wheat system increased rice yield by 10% under recommended inorganic fertilization (NPKSZnB).



- Early sowing (last week of March to first week of April) of summer mungbean was optimum in terms of crop performance and seed yield over late sown with an additional yield of 1.5-2.5 q/ha through second harvest. High density planting (20 and 25 cm) out yielded the wider spacing (30 cm).
- Water and nutrients through drip-fertigation in pigeonpea based intercropping realized mean seed yields to the tune of 490 and 1920 kg/ha with urdbean and sorghum intercropping (50% area basis), respectively in addition to normal seed yield of pigeonpea (2548 kg/ha).
- PEY (Pigeonpea equivalent yield) was highest with drip-fertigated sorghum based intercropping system (at par with urdbean based system). Total yield (PEY of 3075-3322 kg/ha) was significantly higher with irrigation at critical stages over rainfed cultivation.
- Different irrigation schedules (0.4/0.6/0.8 IW/CPE ratio based) with varied irrigations (1-4 number) could not influence productivity levels in the existing rainfall situation during the cropping season (2013-14). Therefore, a couple of supplementary irrigations at branching and pod development were sufficient to realize optimum yields especially in absence of adequate rainfalls during these critical stages of pigeonpea.
- Economizing of water through precision irrigation (through laser levelling and micro-sprinkler) under dry and hot summer was made successful to reduce number of irrigations (1-2 numbers) by growing summer mungbean and urdbean as the catch crops.
- Demonstration of IIPR technologies was carried out at farmers' fields, which included post-emergence application of Imazethapyr for *kharif* pulses, ridge planting in pigeonpea, chickpea+ mustard (6:2 ratio) during *rabi* season, popularization of summer mungbean and IPM for pest control.
- Application of 30 kg S/ha to chickpea recorded highest grain yield (16.81 q/ha), followed by application of 15 kg S/ha to each maize and chickpea (16.44 q/ha). Application of P to maize at 60 kg P_2O_5/ha improved grain yield of chickpea by 1.02 q/ha over 30 kg P_2O_5/ha.
- Application of 30 S kg/ha recorded highest rajmash grain yield (20.3 g/plant) under cultivated soil in pot culture. Further, application of Zn and FYM also improved grain yield of rajmash by 7 and 17%, respectively under cultivated soil.
- Foliar application of Zn, Fe and urea increased chickpea grain yield under irrigation. Water use efficiency improved due to application of Zn, Fe and urea. Protein content of grains increased with N and Zn fertilization.
- Foliar spray of zinc enhanced its concentration in leaves, stem and grain from 15 to 35% both in lentil and fieldpea. Different concentrations of Zn also improved its content in the root, shoot and leaves by 7-22%.
- Yield of mungbean was higher in case of residue incorporation and zero tillage than no-residue and conventional tillage. Improvement in system productivity (9%) was recorded due to residue incorporation. Performance of cropping systems in terms of chickpea equivalent yield (CEY), highest CEY was obtained in rice-wheat-mungbean (5893 kg/ha) followed by rice-wheat (4067 kg/ha) and lowest in rice-chickpea (3712 kg/ha).
- Maximum pearlmillet equivalent yield (4154 kg/ha) was recorded when intercropped with green gram, followed by pearlmillet + cowpea (3722 kg/ha) as compared with pearlmillet sole (2742 kg/ha). Highest SMBC was observed in pearlmillet + cowpea, followed by pearlmillet + greengram and least under pearlmillet sole.
- In early pigeonpea, maximum grain yield was recorded in UPAS 120, followed by Pusa 992 and least by ICP 67B. Higher grain yield was realized under raised bed planting technique over ridge planting.
- Post-emergence herbicides, Fenoxaprop and Clodinafop showed promising results in controlling grassy weeds in both rainy as well as *rabi* season pulses. Quizalofop-ethyl, Fenoxaprop and Clodinafop were also found effective in controlling of *Asphodelus tenuifolius*.
- During rainy season, significantly higher mungbean yield was recorded in raised bed + manual dibbling, followed by IIPR Zero-till seed drill and lowest in Zero-till planter. IIPR Zero-till seed drill gave at par yield of

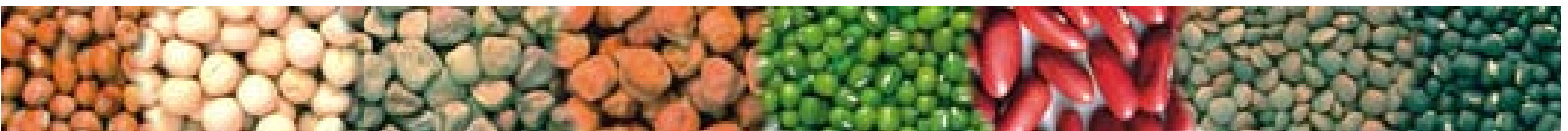


mungbean with conventional plough (803 kg/ha). Significantly higher yield of chickpea was recorded in IIPR Zero-till seed drill and lowest in raised bed planter.

- On an average, soil moisture content was recorded higher in chickpea grown after improved rice cultivar Pant Dhan 12 over local rice. Mulch conserved more soil moisture than no-mulch.
- Soil microbial activities like soil dehydrogenase and SMBC were found higher in case of mulch over no-mulch.
- Higher nodules per plant were recorded in mulch over no-mulch. Chickpea yield was higher in mulch, followed by stubbles and lowest in no-mulch.

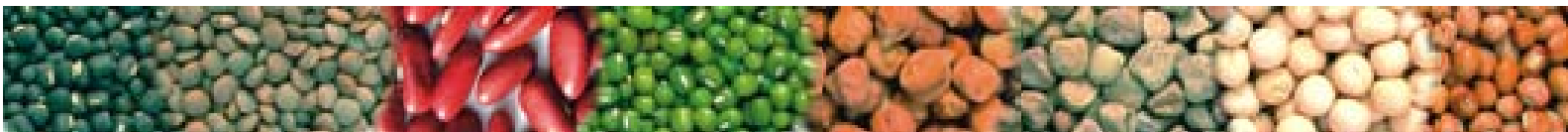
Crop Protection

- Total 784 chickpea genotypes were screened against *Fusarium oxysporum* f.sp. *ciceri* (race 2) in wilt-sick plot, wherein wilt susceptible chickpea genotype JG 62 showed 100% mortality.
- Eight *kabuli* chickpea breeding lines *viz*., IPCK 13-192, IPCK 13-194, IPCK 13-204, IPCK 13-205, IPCK 13-209, IPCK 13-211, IPCK 13-212 and IPCK 13-203 showed resistant reaction to wilt.
- Ten breeding lines of *desi* chickpea *viz*., IPC 2013-01, -03, -12, -21, -23, -25, -83, -84, -97 and IPC 2013-128 were found resistant to wilt.
- Among chickpea genotypes from AICRP trials, 30 entries were found resistant to wilt.
- Among wilt resistance donors, JG 315, JG 74, DCP 92-3, KWR 108 were found resistant, whereas GPF 2 showed susceptible reaction.
- Among 96 promising chickpea lines screened against wilt, eight (IPCK 12-310, IPC 2009 – 43, IPC 07–50, IPC 10–152, IPCK 12–258, IPC 2008– 10, IPC 2010–185, IPCK 12–306) showed resistance.
- Seed treatment with talc based formulation of *Trichoderma harzianum* isolate 31 (IPT 31) reduced plant mortality by 45% and increased yield by 25%. Seed treatment with culture filtrate of IPT31 was equally effective in reducing plant mortality.
- Isolates of *F. oxysporum* f.sp. *lentis* showed diversity in conidial characters. Number of septa in macroconidia varied between 1-5 and majority of the isolates had 1-3 septa in their macroconidia. Length of the macroconidia ranged between 5 - 9.43 µm and in majority of isolates, size of macroconidia varied between 5 - 8 µm.
- Among 100 genotypes of lentil screened against wilt under field conditions, seven (IG 3558, IG 4175, IG 4073, IG 4702, IG 4303, IG 3673, IG 4162) were resistant with less than 10% wilting.
- Isolates of *R. bataticola* varied in their morphological characters such as diameter of sclerotia, colony growth rate, type of growth, time taken for sclerotia formation and in pathogenicity. Largest sclerotia (102.3µm) were observed in isolate Rb48 and the smallest sclerotia (58.90µm) were recorded in isolate Rb29. Among all the isolates, 15 isolates produced scanty growth of mycelium and 10 isolates produced fluffy type of growth.
- Twenty land races and 24 wilt resistance lines of chickpea were screened against *R. bataticola* in lab by paper towel method. Among 24 wilt resistant lines only 6 (IPC 2005-30, IPC 2005-27, IPC 2005-64, IPC 2005-44, IPC 2005-46 and IPC 2005-34) were found promising. None of the 20 land races was however found resistant.
- Of the 22 *Trichoderma* isolates evaluated *in vitro* against *R. Bataticola,* isolates IPT 7, IPT 14 and IPT 3 appeared to be highly antagonistic with 70-80% inhibition of colony growth of *R. Bataticola*.
- Among 120 lines of pigeonpea screened against Phytophthora stem blight (*Phytophthora drechsleri* f.sp. *cajani*) under natural infestation, only six lines (IPA 2013-1, IPA 2013-2, ICP 15761, WDN 2-275, ICP 15685-1,WD-5-2) showed resistance with disease incidence up to 10%. Twenty-six lines showed disease incidence between 10.1-30%.
- Among the eight treatments used for management of viral diseases in mungbean, seed treatment with imidaclorpid 17.8SL @ 5g/kg seed and foliar sprays of Nurelle D505 @ 0.1% at 15 and 45 days of sowing enhanced the grain yield with significantly reducing the incidence of viral diseases (yellow mosaic and leaf curl/necrosis).
- Ethyl acetate fractions of *Tulsi* (*Ocimum sanctum*) leaves were tested against 2nd instar larvae of *Spilosoma obliqua* and found that larval dip method resulted in highest



mortality, followed by leaf contamination method. Result indicated that ethyl acetate fraction of *Tulsi* has some metabolites which has both contact and stomach poison activity.

- In summer season, population of thrips was more (8.8 to 22.5/5 plants) in mungbean than in urdbean (3.7 to 10.9/5 plants). Highest incidence of thrips was observed on 16th SMW in mungbean, whereas in urdbean it was in 18th SMW.
- In *kharif* season, population of thrips ranged from 10.7 to 16.2/5 plants in mungbean and 2.2 to 5.4/5 plants in urdbean.
- *Brumoides suturalis, Coccinella transversalis, Cheilomenes sexmaculata, Micraspis discolour, Coccinella septempunctata, Phrynocaria perrotteti* were recorded as predominant predators of thrips in mungbean ecosystems.
- Thrips species *viz*., *Megalurothrips distalis* (Karny) and *Caliothrips indicus* Bagnall were recorded in summer and *kharif* mungbean and urdbean.
- Spraying of thiomethoxam 25WG at 35 DAS was effective in controlling thrips in mungbean and registered lowest number of thrips (5.6/5 plants) as compared to 29.4 thrips/5 plants in control. This treatment also resulted in highest grain yield (1556.8 kg/ha).
- Among 30 short duration pigeonpea lines screened against *M. vitrata* under field condition, two genotypes *viz*., Pusa 2002-2 and JA 4 with pod evaluation index (Ipe) >50 appeared promising.
- In long duration pigeonpea, podfly (*Melanagromyza obtusa*), *Helicoverpa armigera, Lampides boeticus*, plume moth (*Exelastis atomosa*) were the potential pests at reproductive stage.
- The data on intrinsic rate of increase of *E. atomosa* indicated the innate capacity for increase as 0.1135 females/female/day with a finite rate of increase (l) of 1.121 females/female/day. Thus, the population would be able to multiply weekly @ 2.236 females/female/day. The doubling time (6.027) with a potential fecundity of 377.18 eggs was estimated.
- *Gryon* sp., an egg parasitoid of *Clavigralla gibbosa* was recorded. Parasitization as high as 75% was observed in 25 to 26 hours old eggs.
- The podfly stages survived from 12 to 32°C.
- Of the 162 genotypes of pigeonpea, 17 had pod damage below 5%.
- Flubendiamide @ 0.75 ml/l reduced *H. armigera* larval population by 95.6 and 94.3 percent respectively at 7 and 14 days after treatment. The treated plots registered estimated yield of 14.7 q/ha as against 7.9q/ha in untreated control.
- Three pigeonpea lines *viz*., BRG 11-1, BRG 10-2 and RVKT 260 and seven mungbean lines GM 04-02, VGG 04-011, Pusa-1271, MH 2-15, DGG 5-4, ML-1907 and MH-805 were observed resistant against *Meloidogyne javanica* in the preliminary screening.
- One line of urdbean KKB-05011 was observed resistant and one genotype of chickpea ICC 15626 was observed moderately resistant to root knot nematode, *M. javanica*.
- Nine lines of lentil *viz*., IPL 224, RLG 157, DPL 62, IPL 406, IPL 215, PL 135, RKL 604-01, VL 145 and RKL 607-01 were observed resistant against *M. javanica*.
- Root lesion nematode @ 1000 per pot significantly reduced plant height, fresh and dry shoot weight and pod numbers in chickpea.
- Two kits named as "LYMVs PCR Diagnostic Kit" and "LYMVs Direct PCR Kit" have been developed for detection of legume yellow mosaic viruses (MYMIV, MYMV, HgYMV, DoYMV).
- A Multiplex-PCR Kit for the detection of four viruses (MYMIV, MYMV, HgYMV and DoYMV) was developed.
- *Tomato leaf curl Gujarat virus* was characterized for the first time from the leaf curl affected rajmash.
- Colony diameter in 14 isolates of *Cercospora canescens* ranged between 16.3-30.3mm at 30^{0}C, between 15.1-26 mm at 25^{0}C and between 12.1-27mm at 20 ^{0}C. Data indicates temperature between 25-30^{0}C to be best for the optimum growth in most of the isolates.
- Most of the isolates of *Cercospora canescens* had fluffy growth pattern with grayish white mycelium. In some isolates, pinkish pigmentation was observed in the substrate. Sporulation could not be observed in any of the isolates at any of the temperature.
- Based on number of spots/leaf in spray inoculated plants, the isolates were grouped

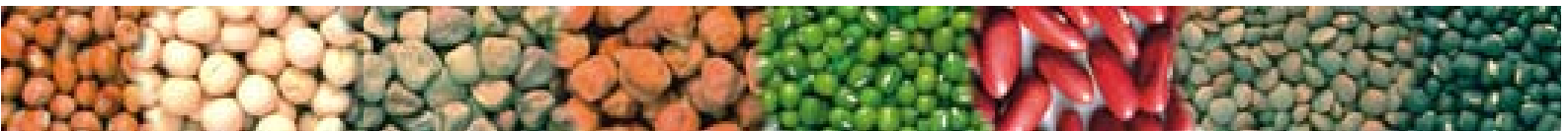


into three categories as weakly pathogenic (0.1 – 4.0), moderately pathogenic (4.1 – 7.0) and highly pathogenic (7.0 – 10.0).

- The best growth (colony diameter 42-43 mm) of the *Cercospora canescens* was observed on PDA media, followed by fungal agar and yeast extract dextrose agar (colony diameter 40-41.5 mm). Oat meal dextrose agar and potato carrot agar media were also good in supporting the growth of both the isolates. Sporulation was however not observed in any of the media used.
- Seed treatment with Trichoderma isolates IPT 10+IPT 21 and 2 foliar sprays of the same in consortium at 30+45 DAS was best in reducing the CLS disease.
- Wild accessions of *Vigna radiata* (TCR 81, 82, 219, JAM/09-29,), *Vigna mungo* (TCR-41, 42, 43, 44, 45), *Vigna mungo* var. *mungo* (TCR-31, 33, 34, 35, 38), *Vigna radiata* var. *radiata* (TCR 78, 73, 74, 0, 75), *Vigna radiata* var. *sublobata* (TCR 218, 64, 238, JAP/10-36), *Vigna mungo* var. *sylvestris* (TCR 265, 256, 254, 260, 390), *Vigna radiata* var. *setulosa* (TCR-71, 67, 8, 110, JAP/10-47), *V. pilosa* (TCR 122, 127), *V. dalzelliara* (TCR 204, 199) showed resistant reaction to CLS disease under field conditions.
- Based on reaction of differential genotypes, 33 of the 50 isolates of *Fusarium udum* were categorised into 7 variants. Most of the isolates (13) resembled variant 1, whereas 8 and 6 isolates resembled variant 2 and 3, respectively. Three isolates resembled variant 4, whereas one isolate each belonged to variant 5, 6, 7 respectively.
- Of the 30 wilt donors of pigeonpea screened, IPA 383B showed highly resistant reaction. Six genotypes (GPS 33, BSMR 853, PI 397430 Sel, ICP 89048, ICP 93012 and AWR 74/15) were recorded as resistant.
- Of the 14 promising pigeonpea lines from IIPR Kanpur screened in wilt sick field, four lines DPPA 85-3, DPPA 85-13, IPA 38 and ICP 7200 showed moderately resistant reaction against wilt.
- Of the eleven pigeonpea wilt differentials, none showed resistant reaction. ICP 9174, ICP 8859, ICP 8858, C11 and ICP 8863 showed moderately resistant reaction with mortality between >10-30%.
- Among 18 multi disease resistant (MDR) pigeonpea genotypes screened for their reaction to wilt, only one line GPS 30 showed resistance, whereas 5 lines *viz*., PH 1063, IPA 16 F, MAL 19, ICP 8859, BSMR 843 showed moderate resistance to wilt.
- Fifty-nine isolates of *F.oxysporum* f.sp. *ciceri* were tested for their pathogenic potential on 14 differential genotypes of chickpea. Disease reaction of differential genotypes indicated presence of 4 races (race 2, 3, 4 and 5). Majority of the isolates (42) resembled race 2 of *F.oxysporum* f.sp. *ciceri*.
- Of the 24 lines of chickpea earlier screened for resistance to wilt were further validated in the wilt sick field. Eighteen (IPC 2005–3, –15, –18, –19, –24, – 30, –34, –35, –37, -41A, – 41B, – 44, –45, –46, –54, –62, –64) maintained resistant reaction, whereas five lines (IPC 2005 – 59, IPC 2004 – 34, IPC 2005 – 27, IPC 2005 – 8, IPC 2005 – 26) turned into moderately resistant.
- Out of thirty-nine RAPD markers screened, ten markers gave thirteen unique bands for the particular race of *F.oxysporum* f.sp. *ciceri*.
- A phylogenetic constructed using part of Internal transcriber spacer (ITS) (680-800bp) sequences of 34 isolates representing *F. udum* and *F. oxysporum* f.sp.*ciceri* indicated that isolates of *F. oxysporum* f.sp.*ciceri* and *F.udum* formed separate clusters.
- Occurrence of *H. armigera* larvae was first noticed in 10th standard meteorological week with intensity of 0.07 larva/plant and reached maximum at 13th standard week with intensity 0.27 larva/plant and 12.06% pod infestation.
- Soil treatment with Trichoderma+seed treatment with Trichoderma @ 5g/kg, imidacloprid and rhizobium in chickpea + coriander intercropping and 2 foliar sprays, one of NSKE at flowering and the second of chlorantraniliprole at podding stage were found best IPM module in chickpea.

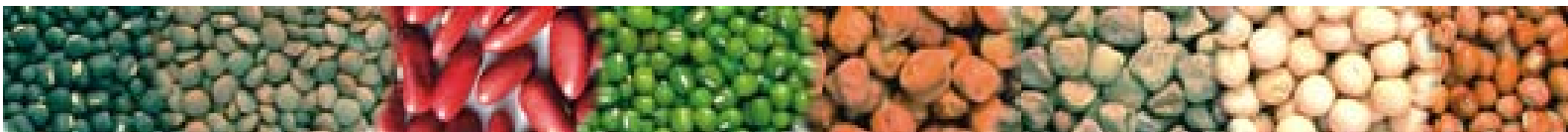
Basic Science

- Chickpea genotypes with higher initial leaf area index (LAI), biomass and higher nodulation coupled with higher branches bearing large number of podding nodes with higher water-use efficiency under late sown non-irrigated condition had better yield and showed combined tolerance to both heat and drought. Genotypes *viz*., Rajas, Vijay, RSG 143-1, Vishal, ICC 1098, RSG 44, RSG 888,



Digvijay, Katila, Annegiri, JG 74, GJG 3, ICC 4958 and Avrodhi showed combined tolerance to drought and heat.

- Thirty-seven pigeonpea genotypes were evaluated for high temperature tolerance employing Temperature Induction Response (TIR) technique. Genotypes like ICP 15761 and ICP 7076 were identified as heat tolerant and IPAC 79, ICP 11477, Amar and IPA 9F as temperature susceptible genotypes.
- Mungbean genotype IPM 99-125 was identified as lodging sensitive, non-shattering pods, synchronous in maturity. Early flowering genotypes PDM 191, PDM 178 and IPM 02-1 were identified as high yielding. Accessions *V. glabrescens* (IC 251372) and *V. umbellata* (IC 251442) were identified as late flowering types.
- Long duration pigeonpea genotypes *viz*., IPAC 78, GRG 2009-3, IPAC 245, IPAC 85, IPA 80, IPAC 78, IPA 16F, NDA 1, IPA 114, IPAC 76, IPA 16F, Amar, IPA 127, IPA 77, ICP 15761, ICP 7076 and IPAC 246 showed less flower and pod drop in peak winter. Osmotic adjustment in leaves increased with the cold stress in tolerant genotypes and reached close to 1.31 MPa. Genotypic variation in OA (ranging from 0.25 to 1.31 MPa) was significant.
- Out of 145 pigeonpea genotypes tested, GRG 2009-3, IPAC 245, IPAC 85, IPA 80, IPAC 78, ICP 15761, ICP 7076, IPA 16F, NDA 1, IPA 114, IPAC 76, IPA 16F and Amar showed the lowest membrane injury index (MII) suggesting higher membrane stability at cold stress condition.
- Moisture and protein content in grains of 280 chickpea genotypes were analyzed using non-destructive technique (Near infrared (NIR) spectroscopy). The protein content ranged from 19.1 to 31.9 %, whereas, the moisture content varied from 8.8 to 14.5%. High correlation (r^2 = 0.92) between Kjeldahl and NIRS protein values were observed.
- Mature seeds of 30 chickpea and 18 lentil genotypes were analysed for the sapogenol A and sapogenol B content. The sapogenol A and B content ranged from 37.49 to 212-.5 mg/100 g and 81.01 to 544.74 mg/100g in chickpea genotypes, whereas in lentil genotypes the values ranged from 73.56 to 282.55 mg/100g and 105.19 to 438.46 mg/100g, respectively.
- Phytic acid and polyphenols limiting the bioavailability of minerals in the grains were analyzed in lentil genotypes, which ranged between 0.130 to 2.00% and 1.17 -6.14 mg/g, respectively.
- The antioxidant activity of lentil grains of 39 genotypes were analyzed using 2,2-diphenyl-1-picryhydrazyl (DPPH) radical scavenging assay. The antioxidant activity ranged between 17.8-108.0mmol TROLOX /100 g. Genotype JL 3 showed maximum antioxidant activity, whereas IPL 313 had minimum antioxidant activity.
- Heating the dehusked grains of lathyrus at 120°C and 150°C for 2 hours removes 45.7 to 46.9% of total BOAA/ODAP, the neurotoxin present in lathyrus seeds. Pressure cooking of dehusked lathyrus grain removes 10.85% phytates, 22.69% phenols and 51.31% of tannins.
- Studies on endophytic bacteria colonizing pigeonpea seeds revealed presence of different bacteria in radical and plumule at the seedling stage. Reactivity towards antibiotics was variable and indicates the differences in the strains of bacteria colonizing the different tissues. Studies indicated that seed soaking in antibiotic solution did not eliminate the endophytic bacteria from the pigeonpea seedlings but seed germination was altered.
- Out of three groups of *Mesorhizobium* based on 16S rDNA restriction pattern, group-C was found to nodulate the chickpea plants grown only under high fertility soil and increased grain yield from 688 kg/ha in un-inoculated control to 925 kg/ha in inoculated with *M. ciceri* strain. It indicates the possible role of plant genotype and soil fertility on selecting symbiotic nitrogen fixing partner with chickpea.
- Chickpea grain yield reduction due to limited P supply in different varieties ranged from 13 to 35 per cent with the exception of no reduction in IPC 2008-92. The reduction in seed yield in JG 16 and BG 256 was however 15 and 22 per cent, respectively.
- Inoculation of ACC deaminase producing bacteria enhanced the root biomass in a range of 66.69-119.46% over uninoculated control. ACC -7, -95, -96, and -16 recorded higher nodule dry weight of >0.1 g/plant over 0.043 g nodule weight of uninoculated control

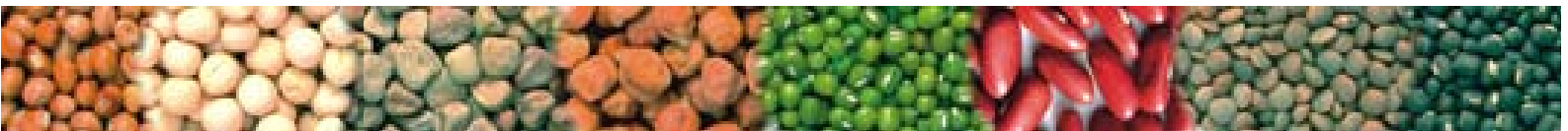


plant. Three ACC deaminase producing isolates *viz*., ACC-10, ACC-16 and ACC-68 that enhanced root, shoot biomass and the grain yield by more than 50% over uninoculated control were selected and recommended for developing commercial bioinoculants.

- Twenty-eight PPFM isolates were isolated from the prominent fieldpea cultivars. Pink Pigmented Facultative Methylotrophs (PPFM) abundance was significantly higher on leaves of *Vigna* than fieldpea.
- For identification of biochemical responsible for borer resistance, chickpea plant extract with polarity index in range of 2-4 having promising biological activities against *Fusarium ciceri* race-2 and *H. armigera* were further purified by fractional crystallization into 14 pure compounds which are being analyzed for their chemical structures.

Social Science

- Total 212 participatory demonstrations were laid out on pigeonpea, urdbean and mungbean during *kharif* and 1040 technology demonstrations of chickpea, lentil and fieldpea were laid out in selected Tribal districts of M.P. and Chhattisgarh. For up-gradation of skill on different aspects of management, protection of crops, 36 off campus trainings were organized, besides 10 field days, 8 diagnostic field visits, 22 farmers' meeting and 12 exposure visits.
- Technologies were percolated to the other farmers of villages through farmers cooperative society. Farmers were actively involved in promotion of formal as well as informal seed procurement and marketing process.
- Entrepreneurship through neem seed kernel collection and marketing can be promoted as neem extract/oil is beneficial to plant protection measures in pulses.
- Training needs of farmers in Kanpur Dehat district under spring/summer pulses included improved varieties, plant population, weed management, insect management, irrigation schedule, seed replacement rate, marketing of produce and value addition.
- Online Database and Information System for pulses germplasm addresses the data management need by producing a user-friendly menu driven system that generates data entry forms, queries and reports and maintains a comprehensive database for statistical analysis and interpretations.
- There is increase in instability in production in 2000-10 as compared to previous decade, but the instability in yield kept on fluctuating with time but come up to constant at 0.04 in the last two decades *i.e.*, 1990-2000 and 2000-10.
- Development of user-friendly analytical modules has been initiated to get the data analyzed in simplified and convenient way from some incomplete block designs.
- *Kharif* fallow lentil/chickpea intercropped or mixed with linseed/mustard is prevalent cropping system under monocropped, rainfed clay/clay loam soils and *Til*-chickpea, urdbean-chickpea cropping pattern are found under partial irrigation facility. Long duration pigeonpea + sorgham as fodder as well as grain is also followed by majority of farmers under rainfed farming situation. Lentil yield varied between 9-13 q/ha during *rabi* in selected villages of Hamirpur.
- Continuous and heavy rains on every week interval during January to mid March, 2014 affected flower initiation, pod formation, plant growth *etc*., in chickpea. Spraying of insecticide (Indoxacarb) at time of 50% podding stage was assessed effective in October sown chickpea for management of pod borer. Farmers perceived that management of pod borer could be done at flowering stage in late sown chickpea and only 5.8% pod damage was noticed, whereas maximum 13.0% pod damage was recorded at full podding stage.
- Demonstrations on use of biorationals were laid in 27 acres of area with participation of 30 farmers in three villages. A total of 9.20 quintal seeds of improved chickpea varieties (Shubhra, Ujjawal and DCP 92-3) were provided to the participating farmers. About 32.5 acres of area was covered under demonstrations on use of pheromone traps in the project villages.
- The yield of demonstration plots where biorational module was utilized with improved chickpea variety gave highest yield in comparison to plots wherein biorational module was used with local variety as well as from the control plots. In addition, pod



damage due to *Helicoverpa* was reported to be lowest in the demonstration plots where biorational module was utilized with improved varieties.

- Month-wise data on arrivals and prices of major pulses in *mandis* have been collected. Crop calendars of the selected pulses have been compiled. Crop profiles for chickpea and lentil have been prepared. Farmers' and trades' survey was carried out for the pre-harvest forecast of the pulses.

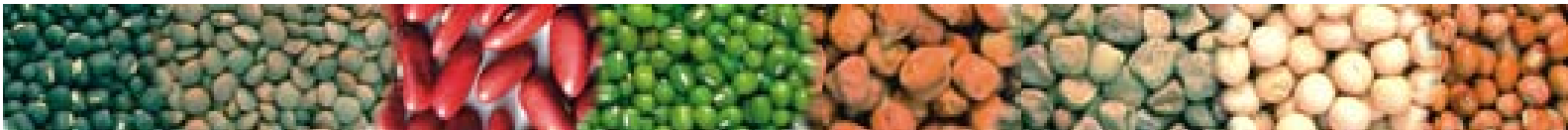
All India Coordinated Research Projects

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

Crop	Variety	States
Chickpea	GJG 0809	Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region
	CSJ 515	North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi
	GLK 28127	North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi
Mungbean	MH 421	Punjab, Haryana, New Delhi and western Uttar Pradesh
Fieldpea	IPFD 10-12	Madhya Pradesh, Chhatisgarh, Bundelkhand region of U.P., Gujarat and South Rajasthan
	HFP 715	Himachal Pradesh, J&K, hills of Uttarakhand and NEH region
Rajmash	SRJ 1	Eastern U.P., Bihar, Jharkhand and Assam

Breeder Seed Production

Total 10,452.06 q of breeder seed of 92 chickpea varieties was produced against DAC indent of 9367.94 q and 673.80 q breeder seed of pigeonpea (41 varieties) was produced against the DAC indent of 390.94 q. Similarly, 936.69 q breeder seed of mungbean (61 varieties), 941.11 q of urdbean (41 varieties), 916.00 q of lentil (30 varieties) and 863.33 q of fieldpea (23 varieties) was produced against the indent of 1033.49 q, 752.11 q, 561.96 q and 691.85 q, respectively.



About The Institute

Pulses continue to be an important ingredient of human diet, specially the large vegetarian population in the country. In the era of Green Revolution with major focus on staple food like rice and wheat, pulses were relegated to the marginal lands with least of inputs. This coupled with the increasing population resulted in reducing *per capita* availability of pulses to the masses. To enhance the productivity of the existing varieties by improved production technologies, besides breeding for high yielding varieties of different pulse crops becomes the prime concern. To take up the cause, All India Coordinated Pulses Improvement Project (AICPIP) was started in 1966 at Indian Agricultural Research Institute (IARI), New Delhi. Later in 1978, its headquarters was shifted to the then Regional Station of IARI at Kanpur under the name of Project Directorate (Pulses). It was further elevated as Directorate of Pulses Research (DPR) in 1984 and became an independent entity under the direct control of ICAR. In 1993 the DPR was upgraded and elevated to the status of Indian Institute of Pulses Research, and simultaneously, AICPIP was trifurcated into three coordinated projects on chickpea, pigeonpea and MULLaRP (mungbean, urdbean, lentil, lathyrus, rajmash and pea) to provide focused attention on each crop. Since then, the Institute is playing a key role in strengthening the nutritional security and sustenance of soil health. Besides generating basic knowledge and material, other activities of the Institute include development of appropriate crop production and protection technologies, production and supply of nucleus and breeder seeds of improved varieties, demonstration and transfer of technologies, and strategic coordination of pulses research through wide network of testing centers across the country.

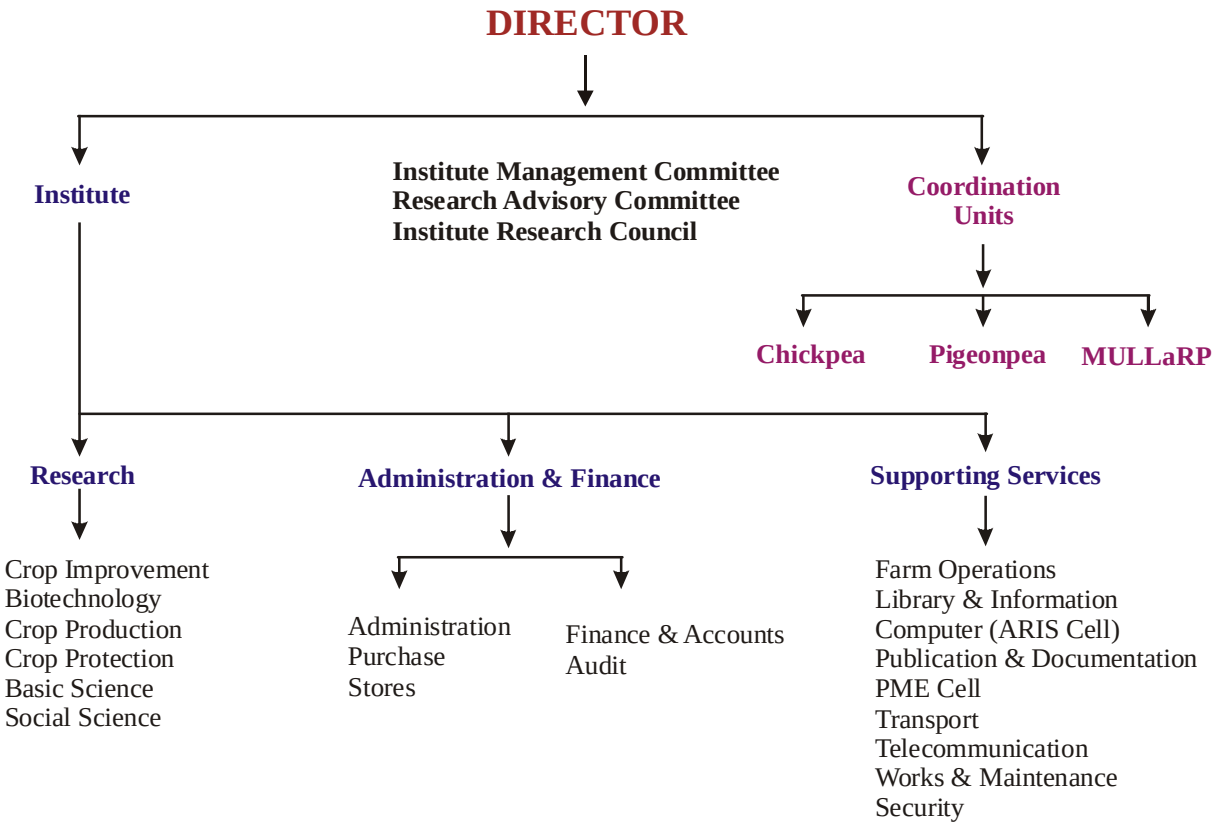
The Institute is located at Kanpur, Uttar Pradesh at $26^0 27'$ N latitude, $80^0 14'$ E longitude and 152.4 metre above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central Railway Station towards New Delhi.

The overall climate varies from semi-arid to sub-arid. The summers are very hot and winters are cool and dry. The monthly weather data for the year 2013-14 revealed that the mean monthly maximum temperature varied from 27.43°C in January to 37.4°C in April and the minimum temperature from 1^0C in January to 23.6°C in July. The relative humidity varied from 36% in May to 99% in August. During the year, total 1318 mm rainfall was received which was above normal. The monsoon rains withdrew by the end of September. During winter season, 140 mm rainfall from November, 2013 to February, 2014 was received. Unusually high temperature was recorded during the month of April which was above 40°C.

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 Section. For 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, 66 technical, 27 administrative and 56 supporting personnel.

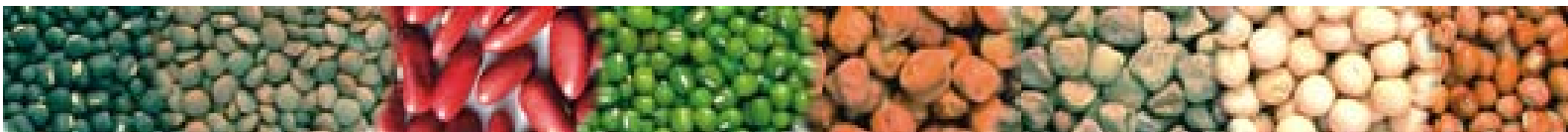
Organizational Set-up



Staff Strength

As on 31.3.2014

Category	Sanctioned	In position	Vacant
RMP	1	1	-
Scientist	88	56	32
Technical	66	61	5
Administrative	27	24	3
Supporting	56	47	9



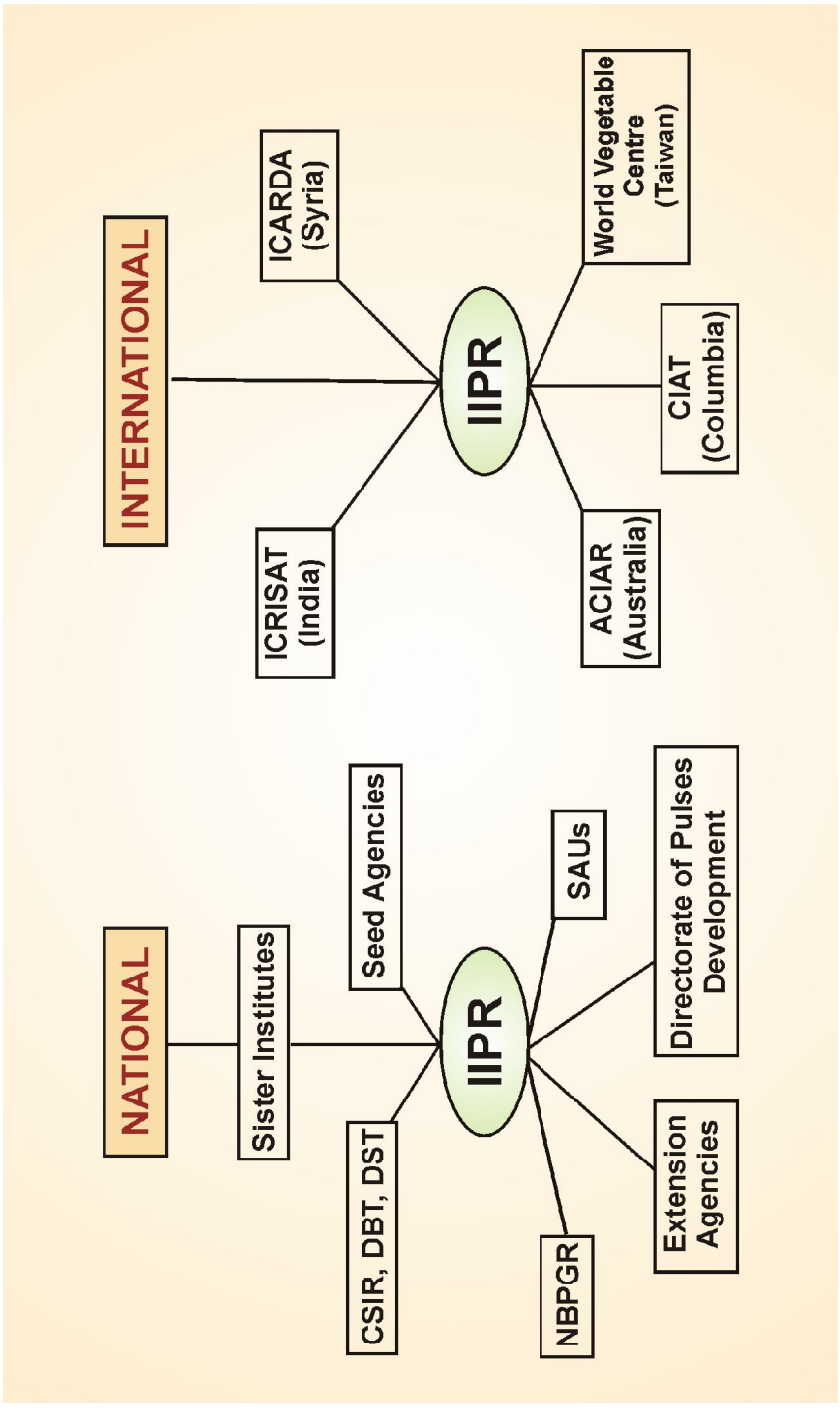
Mandate

- To act as national centre for basic, strategic 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 Diseases & Pests Management
- Physiological Studies
- On-farm Research and Informatics
- Post-harvest Technology.

Linkage and Collaborations



Financial Statement

Statement of Receipt and Expenditure for the Financial Year 2013-14

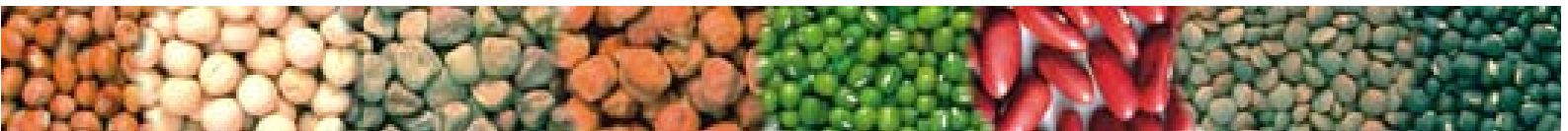
Rs. in lakhs

A.	**Receipt**	179.46
B.	**Expenditure**	
	Non-Plan	1579.49
	Plan	296.87
C.	**Pension and other retirement benefits**	151.20
D.	**AICRP**	
	Chickpea	
	a. Coordination Unit	38.59
	b. Grant-in-aid	1061.12
	Pigeonpea	
	a. Coordination Unit	7.99
	b. Grant-in-aid	1064.01
	MULLaRP	
	a. Coordination Unit	32.03
	b. Grant-in-aid	1117.90

Status of Implementation of XII Five Year Plan (Upto 31.03.2014)

Rs. in lakhs

Head	Approved outlay	Exp. 2013-14
A. Recurring	EFC not approved	
Pay & Allowances/Wages		---
TA		11.23
HRD		6.00
Contingency		209.87
Total		**227.10**
B. Non-Recurring		
Equipment		23.82
Works		0.00
Library		1.12
Total		**24.94**
C. TSP		**44.83**
D. TOTAL (A+B+C)		**296.87**



Crop Improvement

Genetic Enhancement of Chickpea for Improved Plant Type and Multiple Disease Resistance

Varieties developed

Following 3 chickpea (*desi*) varieties have been released for cultivation in different parts of Uttar Pradesh:

IPC 2004-01: This medium size (20 g/100 seed) brownish colour and angular seeded variety suitable for normal sown conditions registered 9.0% yield superiority over best check KWR 108 and gave 1396 kg/ha average grain yield in State Varietal Trials. It gave an yield of 1874 kg/ha in Central and 1362 kg/ha in Bundelkhand regions of U.P.

IPC 2004-98: This large seeded (25.8 g/100 seed) variety registered 11.6% yield superiority over best check KWR 108 under normal sown conditions with average grain yield of 1429 kg/ha. It performed well in Central (1961 kg/ha), Bundelkhand (1359 kg/ha) and western regions of U. P. (1224 kg/ha) as compared to check varieties KGD 1168 and KWR 108.

IPC 2005-62: This wilt resistant, small seeded (15.2 g/100 seeds) and early maturing (120 days) variety registered 7.2% and 3.4% yield superiority over KPG 59 and BG 372, respectively under late sown conditions with average grain yield of 1,018 kg/ha. This variety performed well in western U.P. (8.25% yield superiority over BG 372 : 849 kg/ha) and Bundelkhand (12.96% yield superiority over KPG 59 : 1,307 kg/ha) regions of Uttar Pradesh.

Performance of breeding lines in AICRP trials

Six elite breeding lines of chickpea *viz*., *Desi*: IPC 2006-126, IPC 2008-69, IPC 2007-13 and IPC 2006-77 and *kabuli* : IPCK 2009-164, IPCK 2008-109 performed well under multilocation evaluation in different AICRP trials and promoted/retained for further evaluation.

Generation of breeding material

Seventeen new crosses *viz*., IPC 2009-50 x WR 315, IPC 2004-98 x T 39-1, IPC 2004-98 x IPC 2012-181, JG 130 x IPC 2008-57, IPC 2004-52 x IPC 2008-57, IPC 2008-83 x IPC 2008-57, IPC 2011 x IPC 2008-57, IPC 2006-11 x ICC 1205, HC 5 x ICC 1205, IPCK 2012-304 x IPC 2009-145, IPCK 2002-29 x JG 03-14-16, IPCK 2002-29 x ICC 17196, IPC 2009-45 x IPC 2009-50, Vaibhav x IPC 2009-50, Vaibhav x IPC 2010-116, IPCK 2011-131 x IPCK 2002-29 and IPC 2009-45 x IPC 2010-116 were made using genetically diverse parents (trait specific donors, landraces and acc. of wild *Cicer* sps.) to generate breeding material.

Segregating material/generation advancement

Forty-eight crosses made during 2012-13 were advanced and 306 true F_1 plants were selected. More than 3100 single plant selection (SPS) from segregating generations (62 F_2: 576 sps, 41 F_3: 1,136 sps, 54 F_4: 1,040 sps, 32 F_5: 352 sps) were selected for further advancement. Similarly, 171 progeny bulks (*desi* and *kabuli*) from different generations were selected for further evaluation in different preliminary yield trials.

Seven F_2s, 10 F_3s and 4 F_4s were advanced during off-season at IIPR Regional Station-cum-Off Season Centre, Dharwad and grown at IIPR Main Farm and single plant selections were made from segregating populations.

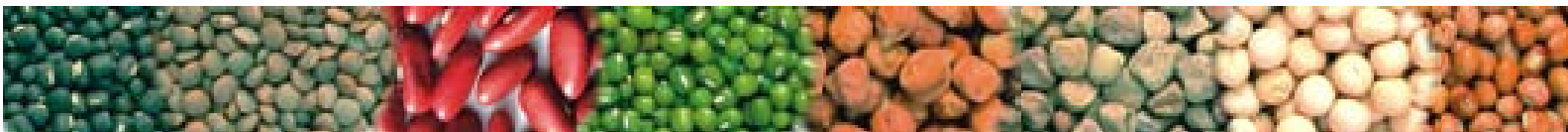
Evaluation of elite breeding lines

More than 240 advanced breeding lines were evaluated under rainfed, irrigated and late sown conditions.

Station Trial 1: Early flowering and podding was observed in several breeding lines under rainfed condition. Genotypes *viz*., IPC 2008-57 and IPC 2012-181 (56 days), IPC 2009-50, IPC 2011-123, IPC 2012-123 and IPC 2011-103 (59 days) attained 50% podding in less than 60 days, whereas earliest maturing check variety JG 11 took 62 days to reach similar stage. Out of 23 genotypes evaluated along with three checks (DCP 92-3, JG 11, JG 16), IPC 2010-9, IPC 2008-11, IPC 2010-25, IPC 2006-11, IPC 2006-127, IPC 2007-28 and IPC 2008-2 were found promising.

Station Trial 2: In trials grown under rainfed condition, 95 elite breeding lines were evaluated. Genotypes *viz*., IPC 2010-107, IPC 2010-134, IPC 2011-85, IPC 2011-112, IPC 2012-99, IPC 2012-98, IPC 2012-108, IPC 2012-181, IPC 2012-208, IPC 2012-3, IPC 2010-72 and IPC 2011-76 performed well as compared to check varieties. However, due to excessive rains yield levels were poor.

Station Trial 3: Under normal sown condition, 24 elite breeding lines were evaluated along with two checks (DCP 92-3 and JG 16). Genotypes *viz*., IPC 2012-49 (2212 kg/ha), IPC 2011-112 (2072 kg/ha), IPC 2011-138 (2067 kg/ha) and IPC 2012-99 (2033 kg/ha) out yielded check varieties, JG 16 (1945 kg/ha) and DCP 92-3 (1380 kg/ha).



Station Trial 4: Under late sown condition, sowing was done on December 3, 2013 to assess performance of 29 genotypes along with four checks *viz*., GCP 105, DCP 92-3, RVG 203 and BGM 547. Genotypes *viz*., IPC 2007-28 (2550 kg/ha), IPC 2006-127 (2342 kg/ha), IPC 2006-126 (2328 kg/ha) and IPC 2008-69 (2306 kg/ha) out yielded the check varieties BGM 547 (2297 kg/ha), DCP 92-3 (1689 kg/ha), GCP 105 (1408 kg/ha) and RVG 203 (1014 kg/ha). There was no significant difference in maturity duration and all high yielding genotypes were at par in maturity with BGM 547 (128 days).

Station Trial 5: In preliminary yield evaluation trial, 20 *kabuli* breeding lines were evaluated along with four checks (HK 1, Shubhra, Pusa 1053, Phule G 0517). Genotypes IPCK 2013-224 (1967 kg/ha), IPCK 2013-207 (1867 kg/ha), IPCK 2013-220 (1838 kg/ha), IPCK 2013-163 (1813 kg/ha) and IPCK 2013-174 (1796 kg/ha) out yielded the best check variety HK 1 (1758 kg/ha).

Besides these trials, ISCN-*Desi*, ICSN-*Kabuli* and two trials (ICEN and CAT) of ICARDA materials were also conducted and 174 SPS were selected from 36 F_2 crosses of ICARDA origin.

Genotypes for mechanical harvesting

Twenty tall and erect genotypes along with two checks (HC 5 and DCP 92-3) were evaluated under normal sown condition for identification of suitable genotypes for mechanical harvesting and with better sunlight interception on crop canopy. Genotypes IPC 2006-11 (2155 kg/ha), IPC 2008-83 (1955 kg/ha), IPC 2001-28 (1955 kg/ha), IPC 20011-85 (1953 kg/ha) and IPC 2011-113 (1933 kg/ha) out yielded the check varieties HC 5 (1780 kg/ha) and DCP 92-3 (1645 kg/ha). All 5 genotypes had more than 70 cm plant height with more than 60^0 branch angle and were lodging resistant. It was also observed that genotypes with more than 80^0 angle had better solar light penetration in North Indian environment at Kanpur and are likely to have advantage due to reduction in humidity inside crop canopy.

Screening against biotic stresses

Wilt resistance

Out of 252 lines (144 *desi* and 108 *kabuli*) of IPC 2013 series screened against fusarium wilt, 18 lines exhibited resistance (*desi*: 9, *kabuli*: 9), whereas 24 lines (*desi*: 14, *kabuli*: 10) showed moderate resistance to fusarium wilt in sick plot. The resistant (<10% plant mortality) genotypes were IPC 2013-1, -3, -12, -21, -23, -25, -83, -84 and IPC 2013-128 in *desi* and IPCK 2013-156, -182, -192 -194, -204, -205, -209, -211 and IPCK 2013-212 in *kabuli* types. Eight genotypes *viz*., IPC 2005-16, -18, -19, -24, -26, -45, -62 and IPC 2005-64 exhibited stable resistance over 5 years (2009-10 to 2013-14) against fusarium wilt at IIPR.

Following chickpea breeding lines exhibited resistance to major biotic stresses under AICRP – Pathology programme (2012-13):

- Fusarium wilt : IPC 2006-56, IPC 2008-69, IPC 2009-21, IPC 2005-74, IPC 2008-103, IPC 2004-68 and IPC 2008-11
- Collar rot: IPC 2006-77
- Dry root rot : IPC 2005-28 and IPCK 2006-78.

Besides above, IPC 79, IPC 92, IPC 104 and IPC 129 showed resistance to ascochyta blight and IPC 2004-52 and IPC 2000-6 showed resistance to stunt.

Abiotic stress tolerance

IPC 98-12 was identified as heat tolerant and found better than the best check ICCV 92944 when screened at 35^0C temperature. Genotype IPC 97-72 also was identified as drought tolerant when screened at several locations under AICRP-Chickpea Physiology programme. Advanced breeding line IPC 2008-57 exhibited cold tolerance as pod formation was observed during December/January when minimum temperature was less than 8^0C, confirming its behaviour against cold stress continuously during third year at Kanpur location. It is also being evaluated in cold nursery.

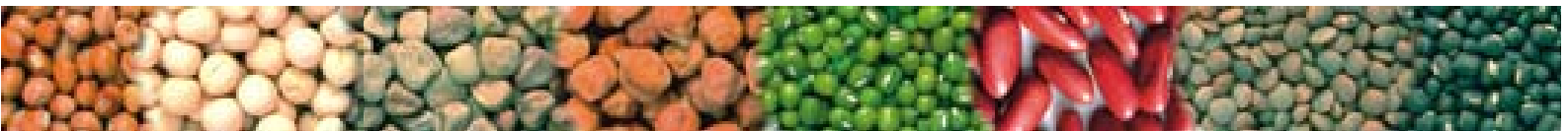
Nucleus seed production

Nucleus seed of DCP 92-3 and IPC 97-67 was produced. At the same time single plants from each variety were also selected to produce nucleus seeds during 2014-15. In addition, test stock seed of three chickpea varieties (IPC 2004-98, IPC 2004-1, IPC 2005-62) was produced.

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

Evaluation in station trials

Out of 34 geno-types evaluated in both irrigated and rainfed conditions along with four checks *viz*., JGK 1, ICCV 4958, ICCV 92944 and RSG 888, genotypes *viz*., FLIP 03-98C, FLIP 05-56C and Pusa 72 (43 days) and C 235 (45 days) were identified as early maturing on the basis of



days to first flowering. Out of 15 genotypes sown under rainout shelter, JG 74 and ICC 8950 (48 days) and RVG 202 (46 days) showed early flowering under early sown and GNG 1581 and Katila showed early flowering under late sown condition. Similarly, 34 lines were screened against heat stress and on the basis of earliness and PG 96006, K 850 and ICCV 10 were selected.

Crosses attempted

Six new crosses *viz*., JG 11 x KWR 108, DCP 92-3 x ICC 92944, DCP 92-3 x ILWC142, ICC 92944 x ILC 3279, JG 11 x ICC 4958 and JGK 1 x ICC 4958 were made to combine desirable traits.

Generation advancement

Eight F_2 crosses (DCP 92-3 x ICC 1205, DCP 92-3 x ICC 4958, DCP 92-3 x ICC 92944, ICC 1205 x ICC 4958, KWR 108 x ICC 1205, JGK 1 x PG 0517, PG 5017 x JGK1 and JG 16 x JGK 1) and one F_3 cross (IPC 09-50 x BPM) were advanced. To develop mapping population, cross IPCK 2002-29 x ILWC 21 was advanced to F_5 following single seed descent (SSD) method.

Multiplication of germplasm lines

Eighty-two germplasm accessions obtained from ICRISAT were multiplied.

Nucleus seed production

Nucleus seed of *kabuli* chickpea varieties (Shubhra, Dhawal and Ujjawal) was produced and single plants were selected for production of nucleus seed in 2014-15.

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

Screening of 68 lines for dry root rot (DDR) tolerance was done by paper towel method. Genotypes *viz*., IPC 2005-46, IPC 2005-34 and IPC 2005-30 were found tolerant for DRR. Nine genotypes (ICC 10803, ICC 11550, ICC 9023, ICC 1003, ICC 2867, ICC 11551, ICC 10384, ICC 9032 and ICC 2644) obtained from ICRISAT were multiplied for screening against combined resistance to wilt and DRR.

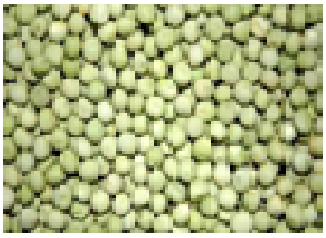
Breeding material generated

Five F_2 populations of different crosses *viz*., WR 315 x JG 03-14-16, BG 212 x JG 03-14-16, IPC 2008-57 x JG 03-14-16, JG 16 x JG 03-14-16 and JG 16 x IPC 2008-57 were generated.

Genetic Improvement for Plant Type and Grain Yield in Lentil

Variety developed

IPL 526: This variety derived from a three way cross [(ILL 7659 × DPL 58) × KL 178] has been identified for cultivation in UP state under late sown conditions. Its average yield is 795 kg/ha which was 13% higher than the best check. It has resistance to wilt and rust diseases.



Performance of breeding lines in AICRP trials

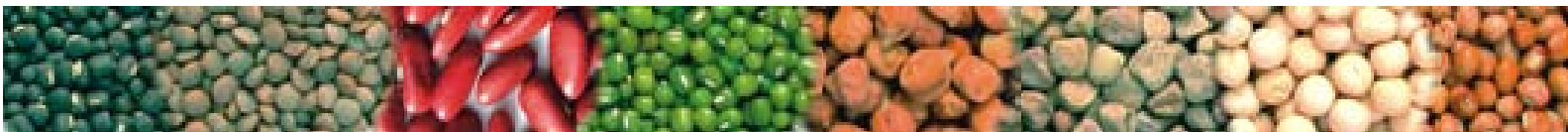
Out of nine entries evaluated in AICRP trials, one small seeded entry IPL 220 [(DPL 44 x DPL 62) x DPL 58)] was retained for further evaluation in AVT 1 for North-East Plain Zone on the basis of richness in micronutrients. One large seeded entry IPL 325 [(ILL 101 x E 362) x DPL 62] was promoted to AVT 2 for hill zone. Another large seeded entry IPL 327 [(ILL 7659 x DPL 58) x KL 178] and one extra early entry IPL 534 (KL 178 x DPL 62) were promoted to AVT 1 for central zone, while IPL 580 was promoted to AVT 1 for NEPZ. Six new entries including two small seeded and four large seeded are being evaluated in IVT.

Evaluation of promising breeding lines

Two station trials with 15 entries each and one preliminary yield trial (PYT) with 60 entries were conducted at main and new research farm for evaluation of their performance for yield. At main farm, three entries *viz*., IPL 11735, IPL 8639 and IPL 8529 in ST-1 yielded 1698 kg/ha, 1698 kg/ha, and 1822 kg/ha, respectively against check variety IPL 406 (1696 kg/ha). In ST-2, four entries *viz*., IPL 8745, IPL 11744, IPL 91213 and IPL 121800 yielded 1900 kg/ha, 1969 kg/ha, 1973 kg/ha and 2095 kg/ha, respectively against best check variety IPL 316 (1677 kg/ha). In PYT, four entries *viz*., IPL 131068, IPL 121832, IPL 131251 and IPL 11695 performed well and yielded 1833 kg/ha, 1882 kg/ha, 2031 kg/ha and 2111 kg/ha, respectively. In another trial, 70 entries alongwith 8 checks were evaluated under late sown conditions (December 1, 2013). Among these, 11 entries *viz*., IPL 10454, –10639, –10679, –11672, –11689, –1732, –11744, –121800, –121905, –121929 and IPL 91227 gave higher yield than the checks.

Generation of breeding material

Ten new crosses were made. Single plant progeny (SPS) were selected from 8 F_2s (90), 27 F_3s (300), 25 F_4s



(86) and 25 F_5s SPS (60). Selection of F_6 lines from 70 progeny bulks (22 F_5/F_6) on the basis of yield are under evaluation. Ten fresh crosses were made involving K 75 using different donors under national crossing programme of AICRP.

Development and maintenance of mapping populations

For maintenance of mapping populations, 135 F_7 RILs for wilt resistance derived from a cross Precoz (S) × PL 02 (R] and 164 F_7 RILs for earliness and seed size derived from cross L 4603 (Early) × Precoz (Late) were grown. 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 advanced to F_4 generation following single pod descent method.

Nucleus seed production

About 680 kg nucleus seed of five released varieties (IPL 81, IPL 406, DPL 15, DPL 62 and IPL 316) were produced. Total 6500 single plants of 5 varieties of lentil *viz.*, IPL 316, IPL 406, IPL 81, DPL 62 and DPL were harvested for next year nucleus seed production.

Genetic Improvement for Plant Type and Grain Yield in Fieldpea

Variety developed

IPFD 10-12: This green seeded dwarf fieldpea variety developed from the cross IPF 99-25 x EC 384275 has been identified for Madhya Pradesh, Chhattisgarh, Bundelkhand region of U.P. and Gujarat. Its average yield is 2176 kg/ha in Central Zone and has shown yield advantage of 17% over the check variety Adarsh. It is resistant to powdery mildew disease and matures in 109 days.

Performance of breeding lines in AICRP trials

One tall entry IPF 11-15 and one dwarf entry IPFD 11-5 both for Central Zone have been promoted to AVT 2. Another dwarf entry IPFD 12-2 was promoted to AVT 1 for CZ, NHZ, NWPZ and NEPZ. Two entries *viz.*, IPF 12-17 (Tall) and IPFD 12-8 (Dwarf) have been promoted to AVT 1 for NEPZ and NHZ, respectively. Four new entries *viz.*, IPF 13-13 and IPF 13-14 (Tall), IPFD 13-2 and IPFD 13-4 (Dwarf) are being evaluated in IVT. In state coordination trial, nine entries were promoted and two new entries submitted this year.

Generation of breeding material

Total 28 crosses were made involving EC1, FC 1, HUDP 16, HFP 4, IPF 99-25, S 143, EC 385246, EC 595959, IPF 5-19, IPFD 2-5, SGS 10, G 10, P 1042, IPFD 99-13, EC 564807, KPMR 522, KVW 10, EC 205228, EC 205228, IPFD 10-12, IPFD 6-3, Ms lognittee and P 6113 as donors possessing large seed size, no. of seeds per pod, pod length, no. of pods/plant, earliness, powdery mildew resistance and rust tolerance.

Evaluation of advance breeding lines

In station trial, amongst 11 dwarf genotypes evaluated, IPFD 2014-2 (2503 kg/ha) and IPFD 14-11 (2470kg/ha) were higher yielder as compared to best check IPFD 99-13 (2464 kg/ha). In another station trial, 11 tall genotypes were evaluated and IPF 2014-16 (2206 kg/ha) and IPF 2014-13 (2006 kg/ha) were found superior as compared to best check IPF 5-19 (1831 kg/ha). In preliminary yield trial, 15 tall and 20 dwarf entries were evaluated along with three checks.

Selection of promising genotypes from segregating generation

Total 40 crosses were raised in F_1 generation. From the segregating generations, single plants were selected on the basis of earliness, seed size, pod length, resistance to powdery mildew, rust and yield/plant. Total 550 single plants from 55 crosses in F_2, 370 single plants from progenies of 37 crosses in F_3 and 490 single plants from 49 F_4 generations were selected. In F_5 and F_6 generations, 300 and 46 single lines were bulked, respectively.

Development of mapping population

F_1 seeds of a cross derived from HFP 4 (S) x FC 1 (R) for rust resistance were harvested for further advancement.

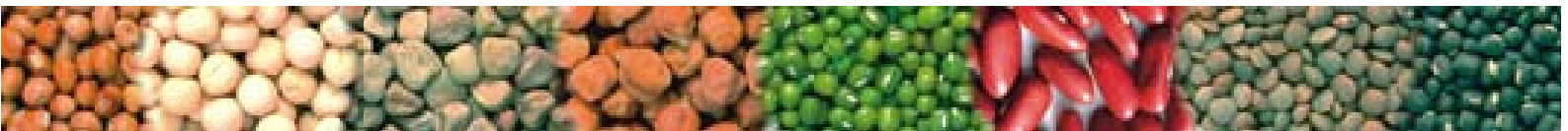
Nucleus seed production

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

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

Evaluation of breeding material and fixed lines

Two station trials were conducted each during spring and summer. Similarly, one trial, 2 ST and 2 PYTs were conducted during *kharif*. Genotypes IPM 2K14-7 (1063 kg/ha), IPM 205-9 (888 kg/ha) and IPM 9901-8 (878 kg/ha) were found promising during spring season, while IPM 104-3 (1031 kg/ha) and IPM 545-1 (1031 kg/ha) were found promising during summer season as these out-yielded the best check



varieties. During *kharif*, genotypes IPM 2K8-1-1 (1951 kg/ha), IPM 9901-13 (1826 kg/ha), IPM 06-LS-1 (1805 kg/ha) and IPM 205-5 (1771 kg/ha) were found promising in PYT I as these out-yielded the best check variety IPM 99-125 (1514 kg/ha). In PYT II, IPM 312-90K (1466 kg/ha) and an F_6 derivative of EC 391178 x V 3518 (1410 kg/ha) were found promising as these out-yielded the check IPM 02-3 (1400 kg/ha). Similarly in ST I, IPM 9901-8 (1210 kg/ha) and IPM 2K14-7 (1115 kg/ha) were better than the best check NM 1 (1071 kg/ha). In ST II, IPM 312-19 (1167 kg/ha) and IPM 312 -90K (1064 kg/ha) were better than best check variety IPM 02-3 (1028 kg/ha).

Evaluation of promising genotypes in AICRP trials

Genotype IPM 410-3 was promoted to AVT 1 in NWPZ and CZ (spring) and IPM 2K 15-4 to AVT 1 in NHZ (summer) and NWPZ and SZ (*kharif*). Genotypes *viz*., IPM 5-17, IPM 312-394 and IPM 205-7 were included in AICRP trials for evaluation during spring/summer season, IPM 410-3 during *kharif* season and 2 extra early lines, IPM 205-7 and IPM 409-4, in extra early mungbean trials. Five genotypes *viz*., IPM 312-09, IPM 312-394, IPM 302-2, IPM 2K14-9 and IPM 205-7 are under evaluation in U.P. state adaptive trials.

Genotype IPM 9901-6 performed consistently better in U.P. State Adaptation Trials for 3 years during summer and spring season as well as in on-farm trials. Similarly, variety IPM 2-14 performed consistently better during summer season in UP State Adaptive Trials.

Off-season trials

Two summer season station trials with 20 entries each were conducted at IIPR Regional Station-cum-Off Season Nursery, Dharwad, (both sown on 31st January). Entries *viz*., IPM 2K14-7, IPM 544-6 and IPM 410-3 performed well in summer season.

Generation and evaluation of breeding material

Six new cross combinations involving 3 mungbean parental lines (IPM 2-3, IPM 2-14 and PDM 139) and 2 urdbean lines (Uttara and IPM 2-43) were made successfully, and good quantity of F_1 seed was obtained.

From the advanced breeding material, 13 fixed superior lines were selected, besides 523 SPS during *kharif*. Total 125 plants were also selected in F_2.

Transferability of SSR markers

To initiate genotyping in mungbean, 384 previously reported SSRs from *Phaseolus*, adzuki bean, urdbean and mungbean were initially screened on 20 diverse genotypes of mungbean. Based upon the preliminary information, 59 markers which showed amplification were shortlisted. These markers are now being screened on a set of another 60 genotypes.

Germplasm resources and wild accessions

Total 160 active germplasm lines of mungbean were evaluated during *kharif*. Reconfirmation of photo-thermo insensitive behaviour of 2 wild accessions of *Vigna* (*V. glabrescens* (IC251372) and *V. umbellata* (IC 251442) was done. Total 97 wild accessions of 23 *Vigna* species including 44 new accessions were maintained in the wide hybridization garden. These were evaluated for 37 morpho-physiological traits. Genomic DNA of the new set of wild accessions subjected to analysis with 88 SSR markers diversity studies has been completed. Population structure analysis was done which revealed that the wild accession belonged to four distinct groups.

Nucleus seed production

Total 512 kg nucleus seed of four mungbean varieties (IPM 99-125 : 90 kg, Samrat : 175 kg, IPM 2-3 : 100 kg and IPM 2-14 : 142 kg) was produced.

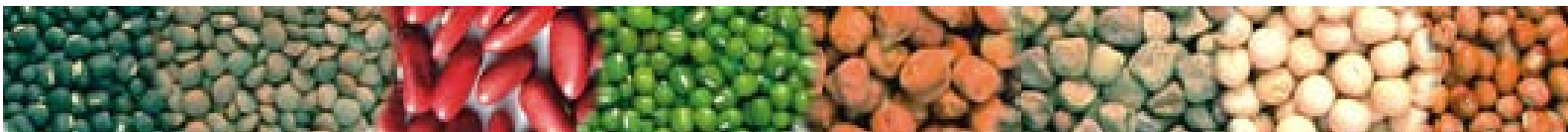
Genetic Improvement for Plant Type and Grain Yield in Urdbean

Evaluation of promising breeding lines

Twenty-seven improved genotypes along with three checks *viz*., IPU 2-43, IPU 94-1 and Shekhar 2 were evaluated during *kharif*. Entries IPU 11-1 (1049 kg/ha), IPU 11-02 (1049 kg/ha), IPU 12-5 (907 kg/ha), IPU 12-19 (1014 kg/ha) and IPU 12-30 (1077 kg/ha) were better than the best check IPU 94-1 (836 kg/ha). Besides, in two station trials, 18 and 35 lines including some advanced lines and diverse germplasm accessions collected from different centres were also evaluated for diversity studies in urdbean.

Generation of breeding material

To incorporate disease resistance specially MYMV/MYMIV, powdery mildew and *Cercospora* leaf spot, 20 new crosses were attempted involving high yielding varieties (IPU 94-1, IPU 2-43), advance breeding lines (IPU 99-123, IPU 06-1, IPU 99-167, IPU 11-6) and donors for resistance to major diseases (VBG 4-008, SPS 5, DPU 88-31, PU 40, CoBG 653, STY 2289, HPU 180, PGRU 95016). Single plant selections were made in 2 F_2 (30 SPS), 6 F_3 (150 SPS), 10 F_5 (255 SPS) and 3 F_6 (135 SPS) on the basis of plant type and reaction to diseases and 9 progeny bulks were identified as promising. Apart from this an active germplasm collection of 264 accessions was also grown.



Breeding lines in AICRP trials

Promising genotypes *viz.*, IPU 10-26 and IPU 10-117 in IVT (*kharif*), IPU 11-2 and IPU 13-1 in IVT (spring) and IPU 02-33 in UP state adaptive trials are being evaluated. These genotypes are high yielding, resistant to YMV with medium maturity and black shining seeds.

Nucleus seed production

Nucleus seed of released varieties IPU 02-43 and IPU 94-1 was produced.

Genetic Enhancement of Long Duration Pigeonpea for Improved Plant Type and Disease Resistance

Evaluation of promising breeding lines

In a station trial comprising of 8 entries *viz.*, IPA 13-1 (IPA 7-4 x IPA 7-5), IPA 13-2 (MAL 13 x Kudrat), IPA 13-3 (selection from IPAPB 7-2-1), IPA 13-4 (Pusa 9 x Ranchi Local), IPA 13-5 (Ranchi Local x UPAS 120), IPA 13-6 (Pusa 9 x Kudrat), IPA 13-7 (Pusa 9 x Ranchi Local), IPA 13-8 (Bahar x Asha) were evaluated against two checks *viz.*, Bahar and NDA 1 at two locations in Main Farm and New Research Farm of IIPR, Kanpur. Three lines *viz.*, IPA 13-3, IPA 13-4, IPA 13-5 and IPA 13-6 were found better than the checks.

Generation of breeding material

Two new crosses *viz.*, IPA 203 x MAL 13 and NDA 1 x MAL 13 were made for combining earliness and wilt resistance along with good agronomic background. To combine resistance against major biotic and abiotic stress with high yield potential, nine new crosses *viz.*, Bahar x KPL 43, Bahar x KPL 44, Bahar x KPBR 80-2-1, NA 1 x KPL 43, NA 1 x KPL 44, NA 1 x KPBR 80-2-1, IPA 203 x KPL 43, IPA 203 x KPL 44 and IPA 203 x KPBR 80-2-1 were advanced to F_2 generation. The derivatives of Bahar x ICPL 87154, (Bahar x ICPL 87154) x Bahar, (Bahar x ICPL 87154) x ICPL 87154, (ICPL 87154 x Bahar) x ICP L87154 (ICPL 87154 x IPA 203) x ICPL 87154 and (IPA 203 x ICPL 87154) x ICPL 87154 were advanced to BC_1F_3 and F_4 generation through backcrossing and selfing. Twenty-three single plant selections (SPS) emanating from crosses *viz.*, ICP 2039 x Pusa 9, Bahar x Pusa 992, ICP 2043 x NDA 1, ICP 2043 x Bahar, KPBR 80-1 x KPL 43 and ICP 2039 x Type 7 were advanced to F_6 generation. Forty-two SPS originating from crosses *viz.*, IPAPB 7-2-1 x KPL 43, Type 7 x Dholi Dwarf, IPA 7-4 x IPA 7-5, IPA 92 x IPA 6-1, Bahar x IPA 6-1, Type 7 x Kudrat and Pusa 9 x Ranchi Local were advanced to F_7 generation for evaluation and preliminary yield trials. Sixty-five advance lines emanating from crosses *viz.*, Kudrat x Dholi Dwarf, IPA 7-1 x IPA 7-3, IPA 6-1 x IPA 92, Bahar x ICPL 66B, Bahar x Maruti, Bahar x BDN 2, Bahar x BDN 1, Bahar x Asha, UPAS 120 x Asha, IPAPB 7-2-1-2, Type 7 x BDN 2, Ranch Local x UPAS 120, Pusa 9 x Ranchi Local, MAL 13 x Kudrat, MAL 13 x NA 1, Pusa 9 x Kudrat, Ajitmal Local x Bahar, Bahar x UPAS 120, PI 397430 x UPAS 120, MAL 13 x UPAS 120 were evaluated and five promising lines were selected for replicated yield trials. Four SPS were made in BC_1F_6 generation of (IPA 6-1 x Type 7) x Type 7, (IPA 6-1 x UPAS 120) x UPAS 120 for yield evaluation.

Mapping population

Two mapping populations (Bahar x 66 B) for earliness and (UPAS 120 x Asha) for *Fusaium* wilt tolerance are at F_6 stage. The mapping populations were selfed for generation advancement. Apart from genetic studies, top ten lines from each mapping population were selected and evaluated for seed yield. None of the derivatives of UPAS 120 x Asha were superior than UPAS 120. Similarly none of the derivatives of Bahar x 66 B were superior than Bahar.

Genetic studies

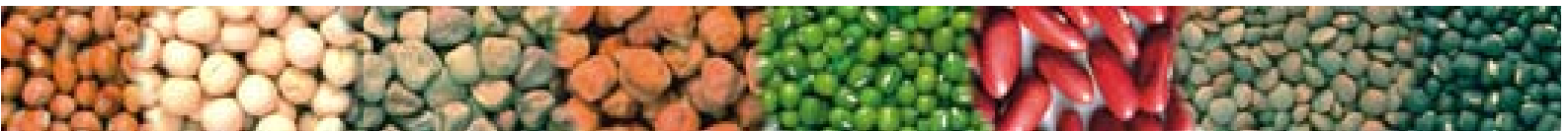
The F_2, F_3 and backcross derivatives of Bahar x ICPL 87154, (Bahar x ICPL 87154) x Bahar, (Bahar xICPL 87154) xICPL 87154, (ICPL 87154 x Bahar) x ICPL 87154 (ICPL 87154 x IPA 203) x ICPL 87154 and (IPA 203 x ICPL 87154) x ICPL 87154 were analysed for floral characteristics for carrying out genetic studies. A leaf mutant derived from the progeny of long duration variety MA 3 was maintained through selfing. The F_2 and F_3 population derived from MA 3 and its leaf mutant was analysed for leaf and floral characteristics and few agronomic traits for genetic studies.

Nucleus seed production

Nucleus seed of IPA 203, Asha and Bahar was maintained through artificial selfing and progeny testing. The nucleus seed of IPA 203 was grown in isolation for mass multiplication of genetically pure seed. Genetic purity was maintained through roughing of off-type plants at flowering and maturity.

Seed multiplication

Crossing block comprised of fifty promising genotypes of long duration pigeonpea and some early and medium duration lines. These lines were maintained through netting of individual plants and selfed seeds were harvested. Genetic purity was monitored throughout flowering to maturity. The seed of Asha, a medium duration variety used in transformation, was also mass multiplied under isolation. The seed of promising entries *viz.*, IPA 206, IPA 7-10 and IPA 11-1 were multiplied through selfing.



Pre-breeding in Pigeonpea for Widening Genetic Base

With an aim to broaden the genetic base of breeding population, pre-breeding in pigeonpea was initiated. New crosses were attempted between *Cajanus cajan* and *Cajanus scarabeoides* and between improved cultivars and different trait specific lines of *C. cajan* for incorporation of specific traits into improved lines as well as to study the inheritance of concerned traits.

Advancing pre-breeding material

The F_2s derived from crosses *viz.*, ICP 12195 x VKS 11/24-2, IPA 9F x ICP 12195, VKS 11/24-2 x Bahar, IPAC 67 x IPAC 68, IPAC 68 x Bahar), IPAC 79 x WRP 1, ICPL 20135 x Bahar, ICPL 20135 x IPAC 72, IPAC 66 x IPA 8F, Maruti x IPAC68, Maruti x IPAC 66, Maruti x IPAC 67, IPAC 79 x IPAAC70, Bahar x IPAC 79, IPAC 24 x IPAC 72, ICP 10958 x IPAC 70, IPA 8F x Bahar, IPA 8F x 56/2010, IPAC 70 x IPA 8F, SEL 14 x IPA 8F, IPA 7F x IPA 8F, UPAS 120 x ICPL 88039, ICP 7366 x ICP 7148, IPAC 24 x IPAC 64, IPAC 66 x IPAC 67 were planted in the field for generating F_3. In addition, the F_2s derived through intercrossing of TTB 7, IPAC 80, IPAC 79, BSMR 853, IPA 8F and JKM 189 were advanced to F_3 generation. The BC_1F_2 and F_3 populations of crosses *viz.*, IPAC 79 x IPAC 80, JAP 10-50 x IPA 203, Maruti x IPA 8F, NA 1 x ICPL 87154, IPAC 80 x ICPL 87154, IPAC 79 x ICPL 87154, Prabhat x IPAC 64, LRG 30 x Dholi Local, ICP 970 x JAP 10-52, Bahar x Maruti, NA 1 x NA 1 mutant for obcordate leaf, NA 1 x IPA 8F and NA 1 x IPAC 68 were sown in the field for generation advancement.

Segregation pattern of flower colour, seed colour, pod colour, branching pattern, plant height, growth habit, stem pigmentation, high selfing trait, flower morphology, leaf morphology, keel modification and filament condition, obcordate leaf shape, *etc.*, are being studied in the F_3 families.

Identification of donors for *Fusarium* wilt resistant

Two *C. scarabaeoides* accessions (ICP 15685 and ICP 15761) showed consistent resistance against *Fusarium* wilt. In addition, IPAC 66 and IPAC 68 showed resistance to *Fusarium* wilt for 3 consecutive years in the wilt sick plot. One newly collected germplasm line IPAC 494 exhibited resistance against *Fusarium* wilt. Derivatives of cultivated x wild pigeonpea (*C. scarabaeoides* - acc. no. ICP 15685 and ICP 15761) bore flowers and set pod at high temperature (40^{0}C) in May at IIPR, Kanpur. Apart from being early in flowering, these accessions were also resistant to *Fusarium* wilt in the wilt sick nursery and tolerant to *Phytopthora* stem blight under field condition.

Multiplication and characterization of new germplasm

The mini-core collection of pigeonpea and new collections from Tripura were multiplied through selfing. Lines collected from Chhattisgarh were characterized for morpho-agronomic traits. In addition, 120 lines procured from ZRS, Khargone, ARS, Badnapur, ARS, Gulbarga and PAU, Ludhiana were maintained through selfing.

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

Evaluation of advance breeding lines

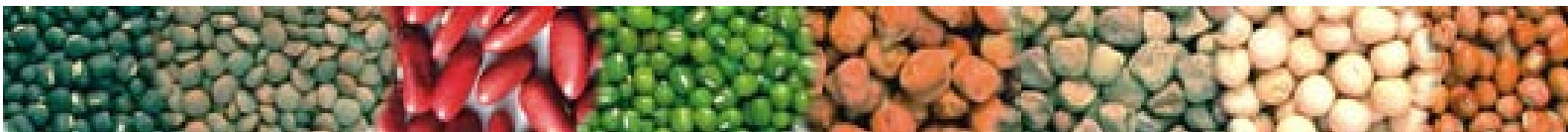
Total 8 entries were evaluated in station trial along with two checks *viz.*, Pusa 992 and UPAS 120. Five entries *viz.*, IPA 2013-4 (1300 kg/ha), IPA 2013-3 (1300 kg/ha), Pusa 992 × UPAS 120 (1157 kg/ha), IPA 2013-2 (657 kg/ha) and IPA 2013-1 (635 kg/ha) out yielded check varieties Pusa 992 (427 kg/ha) and UPAS 120 (350 kg/ha).

Generation of breeding material

Ten fresh crosses were made for earliness, growth habit and higher yield using ICPL 20335/IPA 2013-2/IPA 2013-3 as trait specific donors, respectively. F_2 seeds were harvested from 17 F_1s (Pusa 992 × Co 7), (Pusa 992 × Early Cliesto), (Pusa 992 × ICPL 20335), (UPAS 120 × 67 B), (ICPL 20330 × Pusa 992), (ICPL 20335 × Early cliesto), (Co 7 × Pusa 992), (UPAS 120 × ICPL 20335), (ICPL 20335 × Pusa 992), (UPAS 120 × Early cliesto), (67 B × UPAS 120), (ICPL 20335 × UPAS 120), (ICPL 20335 × Pusa 992), (ICPL 88039 × UPAS 120), (Pusa 992 × UPAS 120), (Early Cliesto × Pusa 992) and (UPAS 120 × Pusa 992). Single plant selections were made in 4 F_2s (13 SPS), 3 F_3s (10 SPS), 2 F_4s (2 SPS) and 14 F_5s (64 SPS).

Identification and Evaluation of Herbicide Resistant/Tolerant Genotypes in Pigeonpea

Total 1,561 germplasm 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 done with a gap of 45 days to identify herbicide tolerant lines. Only 20 genotypes exhibited some degree of tolerance, which are being rescreened to confirm their tolerance against post-emergence herbicides. Glyphosate was used for herbicide screening which affected plant at cell level-irregular cell division was observed. Glyphosate led



affect was observed at tissue level – carbohydrate, protein, DNA and RNA synthesis.

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

Evaluation of early hybrids

Six entries *viz*., IPH 13-1, IPH 13-2, IPH 13-3, IPH 13-4, PHP 86 and PHP 97 along with three checks UPAS 120, Pusa 992 and AL 201 were evaluated in IHT. All the hybrids exhibited more than 95% fertility. However, in terms of yield, no hybrid could out-perform the best check variety (UPAS 120) in early maturity group.

Station trial

Four hybrids derived from crosses *viz*., CoRG 990047A × AK 261322 R, CoRG 990052A × AK 261322 R, ICP 67A × AK 261322 R and ICP 84023 A × AK 261322 R were evaluated in station trial along with two checks (Pusa 992 and UPAS 120). The extent of fertility restoration in hybrids was found in the range of 92-98%, with days to maturity varying from 141 to 160. One hybrid (CoRG 99047 × AK261322) with yield of 1,815 kg/ha exhibited 25% yield superiority over the best check variety UPAS 120 (1452 kg/ha).

Development of new experimental hybrids

Four new hybrids were developed *viz*., PA 163A × AK250189 R, UPAS 120 A × AK 250189 R, ICP 88039 A × AK 261322 R and ICP88039 A × AK 261354. Besides, F_1 seeds were generated for all the hybrids that were examined in IHT and station trial.

Development and utilization of new male sterile line

Complete sterility (100%) was noted in the backcross progenies, and an additional backcross (BC_6) was performed [(ICPL 88039 × GT 288A) × ICPL 88039] for newly converted A-line. In addition, it was crossed with two potential restorers *viz*., AK 261322 R and AK 261354 to generate F_1 seeds, which after evaluation will provide estimates of fertility restoration and more importantly, the extent of heterosis. Besides, additional backcrosses were done for another A-line being converted in the background of Pusa 992.

A-line (ICPL 88039A)

Maintenance of available A, B and R lines

Twelve sterile lines (A-lines) were maintained using A (sterile line), while respective maintainer (B lines) are being maintained *via* selfing. In similar fashion, availability of pure seed of 38 different restorer (R lines) is being ensured through selfing. In addition, eight A-lines (respective B-lines as well) and 23 R-lines belonging to late maturity group were also maintained.

Seed production

Adequate quantity of pure seeds (~35 kg) was generated for recently identified hybrid IPH 09-5. Seed production was carried out in isolation using its parental lines *viz*., PA 163A ('A' line or female parent) and AK 261322 R ('R' line or male parent).

Maintenance of early maturing varieties

Selfing was done to produce genetically pure seeds of some early maturing varieties like UPAS 120, Pusa 992, 67B and AL 201.

Molecular Mapping of Resistance Genes against Variant 1 and Variant 2 of Pigeonpea Wilt [*F. udum*]

Crossing between the parents

To generate mapping population for *Fusarium* wilt, the parental genotypes *viz*., ICP 8863 and Type 7 were crossed to develop F_1s. The resultant F_1 seeds were harvested.

Extraction of genomic DNA

The genomic DNA was isolated from the young leaves of parents (Fig. 1). Subsequently, the extracted DNA was quantified and normalized to perform the PCR analysis.

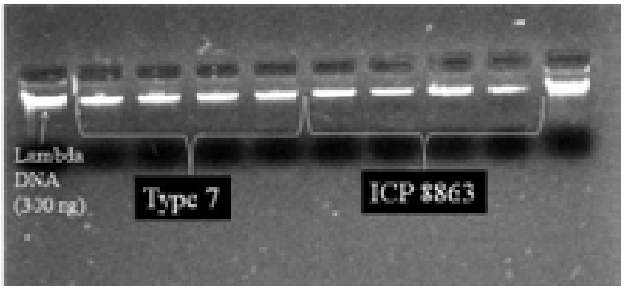
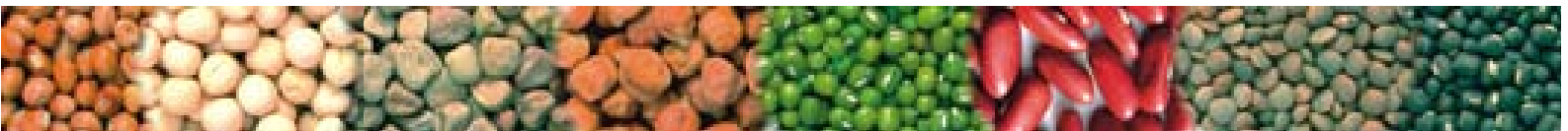


Fig. 1: Genomic DNA extracted from mapping parents

Screening parents with SSR markers and detection of DNA polymorphism

Based on the informativeness and length of SSR tracts, genomic SSR (gSSRs) markers were chosen to investigate the DNA polymorphism between the two



parents. The SSRs were taken from the published reports. As evident from earlier published reports, low level of polymorphism was shown by the SSR analysis conducted using Type 7 and ICP 8863. While screening with 80 SSR markers, only five SSR markers *viz.*, HASSR 5, HASSR 18, HASSR 23, HASSR 29 and HASSR 45 could provide polymorphic fragments (Fig. 2).

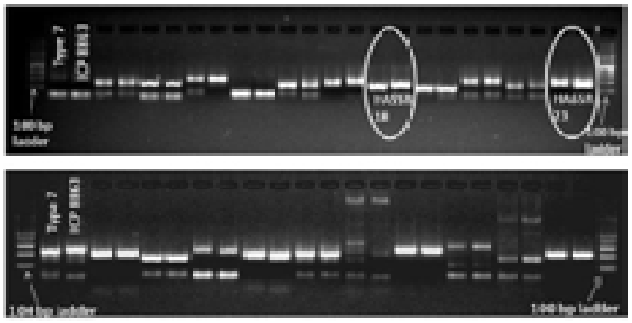


Fig. 2: Screening SSR polymorphism between parental genotypes ICP 8863 and Type 7

A low level of polymorphism in cultivated pool of pigeonpea warrants largescale screening using informative or hyper-variable SSR markers. The polymorphic SSR markers obtained here will be subsequently used to ensure the true hybridity of F_1s derived from cross Type 7 × ICP 8863.

Genetic Resource Management

Chickpea

Total 304 chickpea germplasm accessions were evaluated for various qualitative and quantitative traits along with four checks *viz.*, L 550, DCP 92-3, K 850 and Shubhra at IIPR Regional Station, Phanda (Bhopal). In addition, a set of 704 chickpea germplasm lines was sown for rejuvenation.

Pigeonpea

Genetically pure seed of 30 accessions including lines of early maturity group (Manak, Paras, ICPL 88039, AL 15, AL 201, UPAS 120 and Pusa 992) was produced through selfing for sharing with collaborators. Out of fifty accessions received from NBPGR, Hyderabad, only 20 accessions germinated and were maintained.

Total 750 (Late) and 380 (Early) germplasm lines were rejuvenated. In addition to this, 50 accessions of wild relatives of pigeonpea (*Cajanus scarabeoides* : 27, *C. albicans* : 1, *C. cajanifolius* : 2, *C. lineatus*: 1, *C. platicarpus* : 7, *C. serecious* : 2, *C. viscid* : 1, *C. volublis* : 1, *Rhyncosia bracteafa* : 1, *Fleminga macrophylla*: 1, *R. minima* : 2, *R. rothi* : 4.) and 5 donors (IPA 8F, IPA 9F, IPA 15F, IPA 16F, KPL 43) were maintained under net house for seed multiplication.

Fieldpea

Total >120 accessions of fieldpea were maintained.

Rajmash

Total 65 accessions of rajmash were maintained and evaluated for various traits:

Qualitative attributes

Character	Descriptive state	No. of accessions
Plant habit	Determinate	40
	Indeterminate	25
Flower colour	White	59
	Pink	6
Seed colour	White	23
	Brown	17
	Red	19
	Dark red	4
	Black	2

Quantitative traits

Character	Promising accessions
Days to 50% flowering	IC 541703, EC 565673, IC 14351
Seed size (100 seed) (< 250 g)	EC 564797, ET 8415, ET 8447
(> 450 g)	EC 400414, EC 400445

Lentil

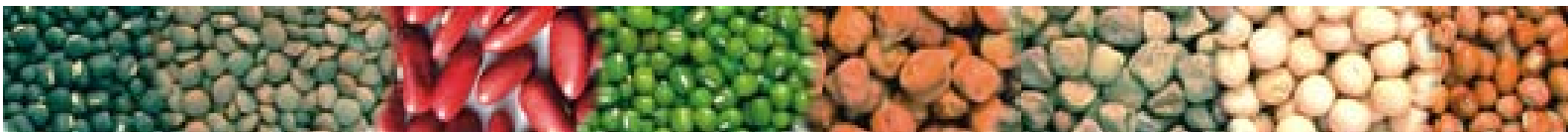
Total 257 accessions of active germplasm and 237 accessions of core collection were grown for maintenance and evaluation of different traits. The data was recorded on plant growth at different stages. Total 834 accessions of base collection of lentil were rejuvenated. A mini core of 134 accessions developed by ICARDA was multiplied for seeds.

National Active Germplasm Site for Pulse Crops

Institute is maintaining more than 10,000 accessions of mandated pulse crops in medium term cold module (4^{0C} with RH 40%). These include chickpea (4000 acc.), lentil (3000 acc.), mungbean (570 acc.), urdbean (340 acc.), pigeonpea (1000 acc.), lathyrus (450 acc.), rajmash (65 acc.) and fieldpea (870 acc.)

Breeder Seed Production

Total 429.48 q breeder seed of three varieties of chickpea (DCP 92-3, Shubhra and Ujjawal), four varieties of fieldpea (Adarsh, Vikash, Prakash and



Aman), four varieties of lentil (DPL 15, DPL 62, IPL 81, IPL 406), three varieties of pigeonpea (Bahar, UPAS 120, NDA 1), four varieties of mungbean (Samrat, IPM 2-3, IPM 2-14, Meha) and two varieties of urdbean (Uttara, IPU 2-43) were produced. Nucleus seed of these varieties was also produced for production of breeder seed during next year/season.

EXTERNALLY FUNDED PROJECTS

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

Total 216 elite breeding lines possessing specific traits and exotic germplasm accessions were maintained. Besides these, 120 accessions of 6 wild *Cicer* species (*C. reticulatum*, *C. judaicum*, *C. echinospermum*, *C. pinnatifidum*, *C. cuneatum*, *C. bijugum*) were maintained in larger pots in wide hybridization garden. Seeds from all 120 accessions were collected leaving few in pots itself. Morphological characterization of all the accessions was done. Wide hybridization garden has been developed for maintenance of wild species of chickpea and *Vigna* pulses.

A view of wide hybridization garden

Generation of breeding material

Nine new crosses *viz*., IPC 2009-50 x ILWC 115, HC 5 x ILWC 292, IPCK 2011-39 x ILWC 115, ILC3297 x ILWC 185, IPC2006-11 x ILWC142, IPCK 2011-39 x ILWC 141, IPC 2004-98 x ILWC 238, IPC 2008-69 x ILWC 252 and IPCK 2009-40 x ILWC 115 were made using genetically diverse parents (landraces and acc. of wild *Cicer* sps.) to generate breeding material.

Segregating material/generation advancement

More than 298 single plant selections were made from interspecific crosses (Shubhra x ILWC 21, GNG 469 x ILWC 21, ILWC 21 x IPC 2008-57). Nine F_4s interspecific crosses were advanced and 213 selections were made.

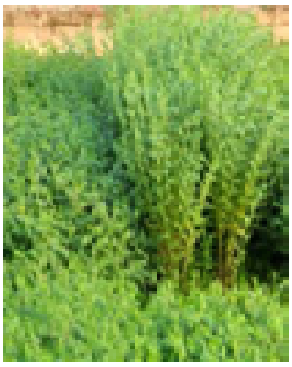
Evaluation of tall and erect *kabuli* types

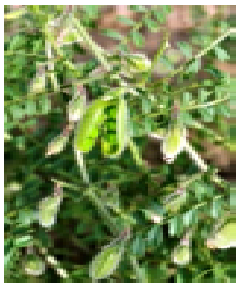
In *kabuli* chickpea trial, 24 tall and erect breeding lines were evaluated along with Shubhra and Ujjawal. Genotype IPCK 2011-48, IPCK 2012-143, FLIP 3-82, IPCK 2011-44 and IPCK 2011-3 performed well and out yielded the check varieties.

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

Evaluation of tall and upright lines

Tall and erect genotypes were evaluated for identification of suitable genotypes for mechanical harvesting and with better sunlight interception on crop canopy. Institute has developed large number of tall and erect elite breeding lines possessing non-lodging behaviour. Genotypes *viz*., IPC 2006-27 , IPC 2006-11, IPC 2006-14, IPC 2008-02 and IPC 2006-142 performed well during 2012-13 with respect to grain yield and non-lodging behaviour. These selected breeding lines along with others were evaluated. In another trial, 30 entries including 28 breeding lines and 2 checks were evaluated under normal sown condition. Tall and erect genotypes *viz*., IPC 2011-28, IPC 2012-47, IPC 2012-57, IPC 2008-83, IPC 2012-104, IPC 2012-228 and IPC 2012-39 showed promise with respect to plant type, plant height, podding behaviour and grain yield. Another trial involving 100 elite breeding lines was also conducted and 13 genotypes have shown promise.





Herbicide tolerance

Total 300 new entries were screened against post-emergence herbicide Imazethapyr. Several genotypes showed promise with respect to herbicide tolerance. In another experiment, genotypes ICC 1164, ICC 1205, ICC 1161, ICC 1381, ICC 1710, IPC 2010-81 and IPC 2008-59 were found promising as these lines were almost not affected and only showed inhibited growth at initial stage when Imazethapyr was applied after 30 days of sowing. At the same time, ICC 5484 was found most sensitive and showed leaf burning within 7 days of herbicide application.

Generation of breeding material

Seven new crosses *viz*., JG 130 x IPC 2008-57, IPC 2004-52 x IPC 2008-57, IPC 2008-83 x IPC 2008-57, IPC

2011 x IPC 2008-57, IPC 2006-11 x ICC 1205, IPC 2008-57 x ICC 1205 and HC 5 x ICC 1205 were made using genetically diverse parents to generate breeding material. Two chickpea varieties (*Desi*: DCP 92-3, *Kabuli*: IPCK 2002-29) were subjected to mutagenic treatment using 3% EMS for inducing herbicide tolerant mutants.

Evaluation of RIL Populations for Heat Tolerance

Total 300 recombinant inbred lines (RILs) from cross ICC 4567 x ICC 15614 segregating for response to heat stress were sown under normal (10 November, 2013) and late sown (27 January, 2014) conditions. Variation amongst RIL population with respect to pod and seed development was observed under late sown condition. Non-stressed crop had normal podding and showed no symptoms of stress. However, there was loss in pods due to heavy rains during crop season under normal sown condition. Variable response against high temperature has been observed under late sown condition.

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

Maintenance of wild species and land races

Total 364 accessions of six wild species (*Lens orientalis, L. odemensis, L. nigricans, L. erevoides, L. tomentosus* and *L. lamottei*) and 118 accessions of Mediterranean land races were grown. The characterization of wild accessions was made on the basis of morphological traits.

Advancement of generation

F_1 seeds were harvested from 5 crosses derived from crosses between wild (*Lens orientalis* and L. *odemensis*) and cultivated species. F_2 seeds were harvested from 2 fresh crosses involving *Lens orientalis* as one of the parents. Out of 17 F_2 populations involving wild species (*Lens orientalis* and *Lens odemensis*) as one of the parents, 13 populations showed segregation and seed of these populations was bulked to assess in next year to identify new plant type segregating populations. Total 80 single plants were selected from 260 F_3 progenies for different plant types having earliness, leaf size, seed size and biomass from crosses made between cultivated and *Lens orientalis* species. F_3 population comprising of 230 individuals was advanced to F_4 for developing mapping population from wild and cultivated cross following the SSD method.

Characterization of genotypes for earliness

Thirty-eight genotypes were evaluated for earliness. Among these, 6 genotypes (ILWLS 118-1, IPLS 09-17, IPLS 09-22, IC 560150, IPLS 09-10 and IPLS 09-34) exhibited flower initiation between 39 and 43 days. Genotype ILWLS 118-1, a selection from accession ILWL 118 of wild species (*Lens orientalis*) was observed earliest flowering (39 days). During the past three years, this genotype tested at different sowing dates showed stability in days to 50% flowering over the environments. In addition, this genotype also had high biomass. Therefore, it can be a useful donor in developing the early maturing cultivars with high biomass for rice-fallow areas.

Development of Lentil Cultivars with High Concentration of Iron and Zinc

Total 96 accessions including breeding lines, release cultivars and ICARDA entries were screened for macro- and micro-nutrients in their seeds. Among these, three breeding lines including IPL 220 (small seeded), IPL 328 (large seeded), IPL 534 (extra early) were identified rich for macro- and micro-nutrients. Seeds were harvested and grown for analysis of their micro- and macro-nutrients concentration to validate the results. F_1 seeds were harvested from crosses involving IPL 220 as donor for Fe and Zn.

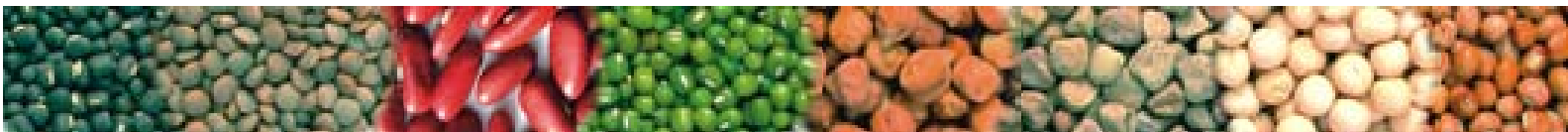
Evaluation of Lentil Germplasm for Heat and Herbicide Tolerance

Evaluation of germplasm for heat tolerance

Total 134 germplasm lines were sown in field under late condition (January) to expose the genotypes to higher temperature (>35^{0}C) at flowering and podding stages for identification of heat tolerant genotypes. Based on flowering and podding, genotypes IG 2507, IG 4258, FLIP 2009-55L, ILL 5519, ILL 3517, ILL 4345 and ILL 2150 were identified as tolerant to heat. Pollen germination and viability test is under progress.

Evaluation against post-emergence herbicide

Total 400 germplasm lines were sown for evaluating against the post-emergence herbicide Imazethapyr. The herbicide was applied at recommended dose (2%) on the plants after 35 days of sowing. Only one line IG 3031 showed no damage after



the application of herbicide. Eighty lines were found highly sensitive to herbicide (100% damage). However, remaining lines showed damage up to 10%. Further validation is required to confirm the results.

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

Seventy-eight BC_3F_1 seeds of the cross Pusa 256 x Vijay were sown during off-season (May-August) at Regional Station-cum-Off-season Nursery, Dharwad. Foreground selection was conducted on 66 germinated seedlings using TA 110 and TA 37 markers. As a result, 26 plants were found common heterozygotes. These 26 plants were subjected to background selection using 45 SSR markers and background recovery percentage ranged between 61-89%. Among all plants, top 13 plants were selfed and 462 BC_3F_2 seeds were obtained. These were raised during the main season (October-November) at IIPR Farm. DNA was extracted from all the individual plants of the progeny and all plants were subjected to foreground selection using TA 110 and TA 37 markers (Fig. 3). On the basis of foreground selection, 47 plants were found true heterozygotes, among which 20 plants recorded >90% background recovery with the highest recovery percentage of 95%. Similarly in BC_2F_2 generation, 16 plants recorded background recovery of >85 % out of 39 heterozygous plants. This completes the backcrossing and selfing cycle and the plants will now be subjected to phenotypic screening for resistance to *F. oxysporum* race 2.

Evaluation of Waterlogging Tolerance in Pigeonpea

Five pigeonpea lines *viz*., NA 1, IPAC 79, IPAC 42, IPAC 76 and LRG 30 showed relative tolerance against water logging in the initial growth stage in an experiment conducted in 2011-2012. In another trial in 2012-13, six lines *viz*., ICP 5028, LRG 30, MAL 9, IPAPB 7-2-1-7, SGBS 3 and SIPS 2 showed high survival rate. Based on previous results, a trial consisting of 11 entries was conducted. The test entries were sown under water logged and normal conditions. Water logging situation was created at 40 days seedling stage by flooding the plot with 6-8 inches of water for 6 days and at least 2 inches of water was maintained all the time during the entire period of water logging. Survival rate was calculated as per cent of surviving plants at 24 hours after withdrawal of water logging condition. Lowest survival under water logging was observed in ICPL 7035 (1.6%), followed by IPAC 3 (7.8 %) and JBP 110B (9%), whereas IPAC 79 exhibited highest survival (50%), followed by ICPL 5028 (29%), MAL 9 and IPAPB 7-2-1-7 (27%) and LRG 30 (24%). Though IPAC 79 showed highest survival rate but it was prone to lodging as compared to ICPL 5028, MAL 9 and IPAPB 7-2-1-7.

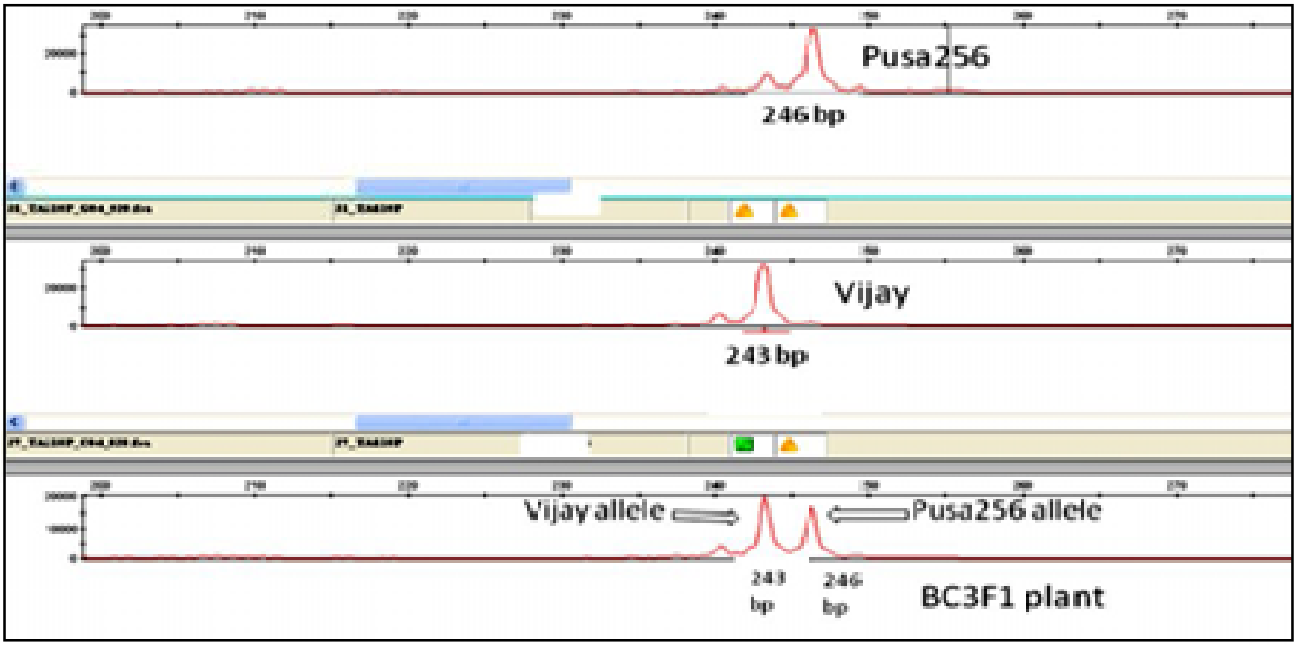


Fig. 3: TA110 foreground marker showing heterozygous condition in BC_3F_1 positive plant

Biotechnology

TRANSGENIC DEVELOPMENT

Transgenic in Chickpea and Pigeonpea for Pod Borer Resistance

Transformation and molecular analysis

Genetic transformation (*Agrobacterium tumefaciens* mediated) in chickpea and pigeonpea using *Bt* gene (*cry1Aabc*) was done with 17,262 and 3,711 axillary meristem explants, respectively. This resulted in establishment of 63 and 5 independent primary transgenics of chickpea and pigeonpea, respectively.

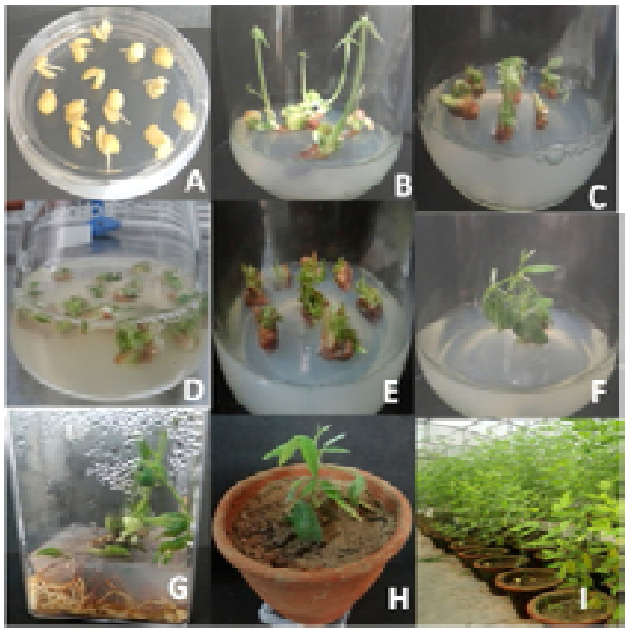
In chickpea, 63 independent primary transgenic lines were screened using quantitative ELISA and 4 positive lines were obtained (Expression range: 20.33-31.59 ng/mg TSP). Total 590 T_3 chickpea progenies (derived from 4 T_0) were analysed using strip test and qualitative ELISA, of which 22 plants (derived from 3 T_0) and 33 plants (derived from 3 T_0) were positive, respectively. Quantitative ELISA and PCR were performed using positive plants found in qualitative ELISA and strip test (39 T_3 plants derived from 3 T_0) of which 28 T_3 (derived from 3 T_0) were found positive (Expression range: 8.572-39.44 ng/mg TSP) and 39 T_3 plants (derived from 3 T_0) were positive, respectively. Southern blot analysis of 11 T_3 plants derived from 3 T_0 events, indicated presence of gene in the progenies. To detect the expression of 66 KDa *Cry* protein in T_3 chickpea, total17 ELISA positive plants derived from 3 T_0 were analysed in western hybridization using chemiluminescence substrate of which 15 plants derived from 3 T_0 were found positive.

In pigeonpea, 213 T_4 progenies (derived from 2 T_0) were analysed using PCR and qualitative ELISA and 54 plants (derived from 2 T_0) and 27 plants (derived from 2 T_0) were found positive, respectively. Quantitative ELISA was performed using positive plants found in qualitative ELISA and PCR (76 T_4 plants derived from 2 T_0) of which 31 T_4 plants (derived from 2 T_0) were found positive (Expression range: 8.76- 96.45 ng/mg TSP). Southern hybridization analysis of 6 T_4 plants derived from 2 T_0 events, indicated presence of gene in the progenies.

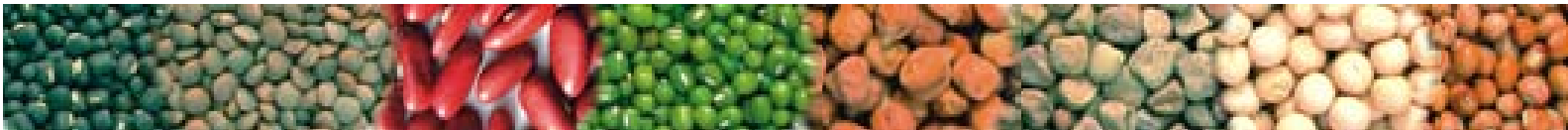
Insect bioassay

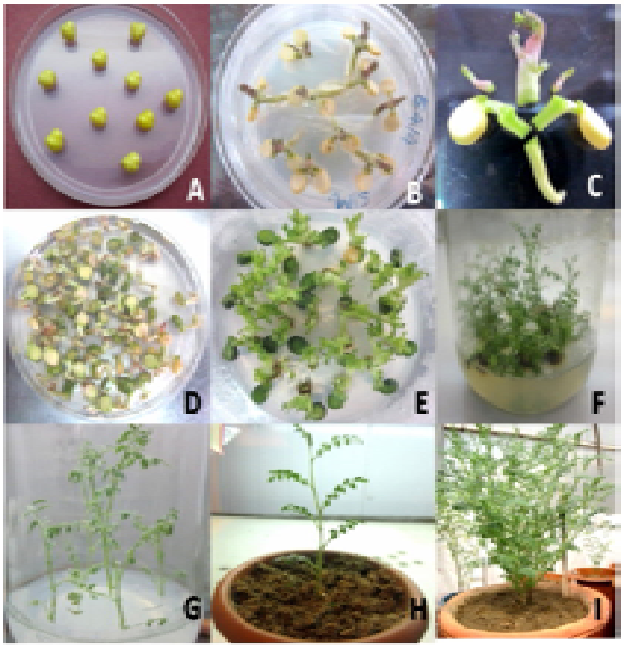
Cup bioassay for 10 T_3 pigeonpea lines was conducted with 2nd instar larva and at 24 hrs after release, the mortality ranged from 0 to 50%. For the same lines detach leaf assay with 3rd instar larva was conducted and mortality at 72 hrs ranged from 40-100%. Detached leaf assay was conducted in 10 T_3 pigeonpea lines with 10 days old larva and the larval mortality varied from 0 to 100%. Similarly in 42 T_4 pigeonpea lines detached leaf bioassay was done with 5 days old larva and the larval mortality varied from 16.66 to 100%. Detached leaf and pod assay was conducted in 3 T_4 pigeonpea lines with 5 and 7 days old larva, respectively and the larval mortality varied from 0 to 100 and 0 to 50 per cent, respectively. Detached pod assay was conducted in 5 T_4 pigeonpea lines (213 DAS) with 7 days old larva the mortality varied from 40 to 90% at 7 days after release.

Similarly, detached leaf bioassay for 16 T_3 chickpea lines (82 DAS and 94 DAS) was conducted (7 days old larva and 24 hrs old neonates) and the larval mortality at 7 days after release varied from 0 to 50 and 0 to 22.22 per cent, respectively.

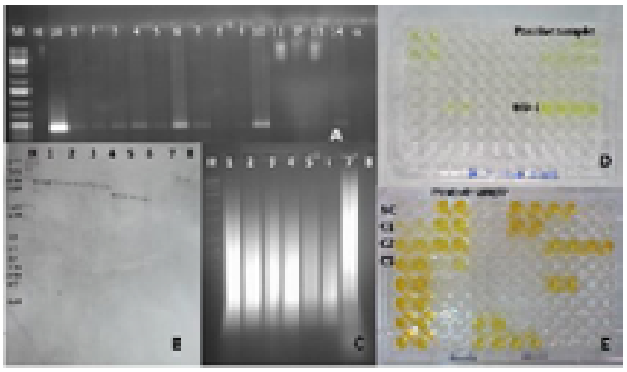


Different stages of transgenic pigeonpea plants: A. Inoculated seeds in SIM, B. Germinated seedlings, C. AMEs preparation, D. AMEs in *Agrobacterium* suspension, E. AMEs containing multiple shoots, F. AMEs in Kanamycin selection, G. Elongated shoots in Kanamycin selection, H. Micro-grafting of Kanamycin resistant Shoot, I. Mature fertile transgenic plant



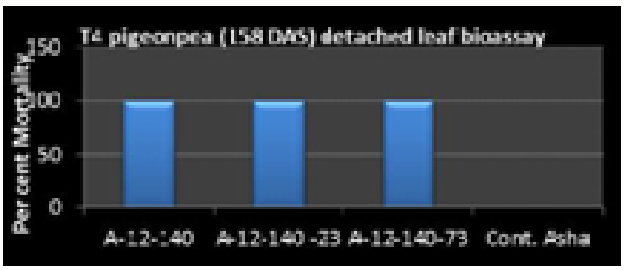


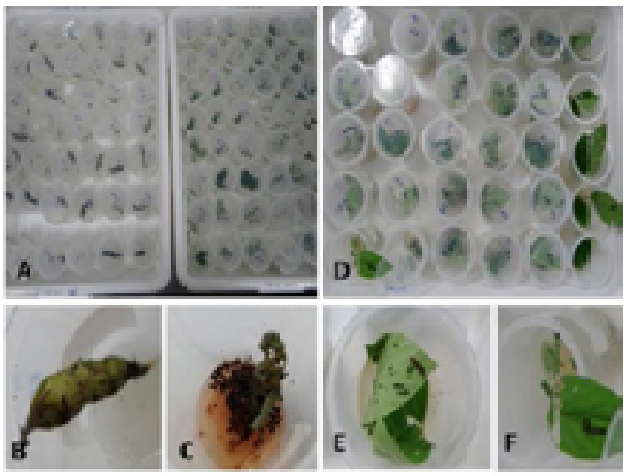
Different stages of transgenic chickpea plants: A. Inoculated seeds in SIM, B. Germinated seedlings, C. AMEs preparation, D. AMEs in *Agrobacterium* suspension, E. AMEs containing multiple shoots, F. AMEs in Kanamycin selection, G. Elongated shoots in Kanamycin selection, H. Micro-grafting of Kanamycin resistant shoot, I. Mature fertile transgenic plant



A. PCR based screening of transgenic pigeonpea plants; B. Southern hybridization performed on independent T_4 transgenic events showed integration pattern in different events, C. Agarose gel electrophoresis of Hind III digested genomic DNA, D. Expression analysis by qualitative ELISA, E. *Bt* protein estimation in transgenic T_4 pigeonpea by quantitative ELISA.

Western hybridization of T_3 chickpea: 1-7 Plant samples, NC- Negative control (DCP 92-3), PC-Positive control (purified *Cry*)





Insect bioassay in pigeonpea

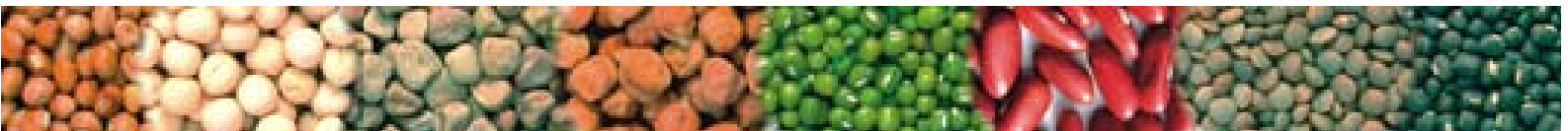
A.Detached pod and detached leaf assay; B. Mortality in 5 days after release of 7 days old larva due to transgenic pod feeding; C. Healthy larvae in non transgenic control; D. Detached leaf assay; E. Mortality in 4 days after release of 5 days old larva; F. Healthy larva in non transgenic control.

Development of Pod Borer Resistant Transgenics in Pigeonpea and Chickpea

Transformation and molecular analysis

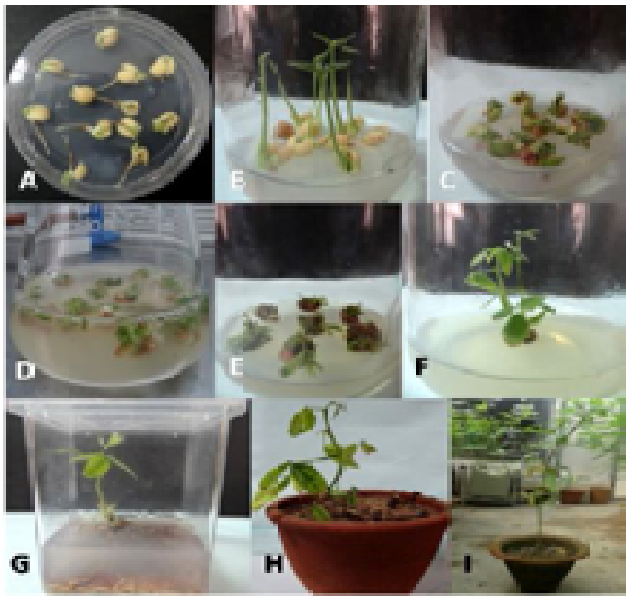
Genetic transformation (*Agrobacterium tumefaciens* mediated) in chickpea and pigeonpea using *Bt* gene (*cry1Ac*) was done with 40,098 and 16,801 axillary meristem explants, respectively. This resulted in establishment of 94 and 138 independent primary transgenics of chickpea and pigeonpea, respectively.

In chickpea, 94 independent primary transgenic lines were screened using quantitative ELISA and 2 positive lines were obtained (Expression level: 23.14 and 23.43 ng/mg TSP). Total 227 T_1 chickpea progenies (derived from 30 T_0) were analysed using strip test and qualitative ELISA and 14 plants (derived from 11 T_0) and 18 plants (derived from 11 T_0) were found positive, respectively. Quantitative ELISA was performed using positive plants found in qualitative ELISA and strip test (27 T_1 plants derived from 16 T_0) of which 22 T_1 plants (derived from 14 T_0) were found positive (Expression range: 9.70 – 65.04 ng/mg TSP). PCR analyses of 27 T_1 (derived from 16 T_0) with gene specific primer, 25 T_1 plants from 15 T_0 were found positive. Total 600 T_2 chickpea progenies (derived from 20 T_0) were analysed using strip test and qualitative ELISA,



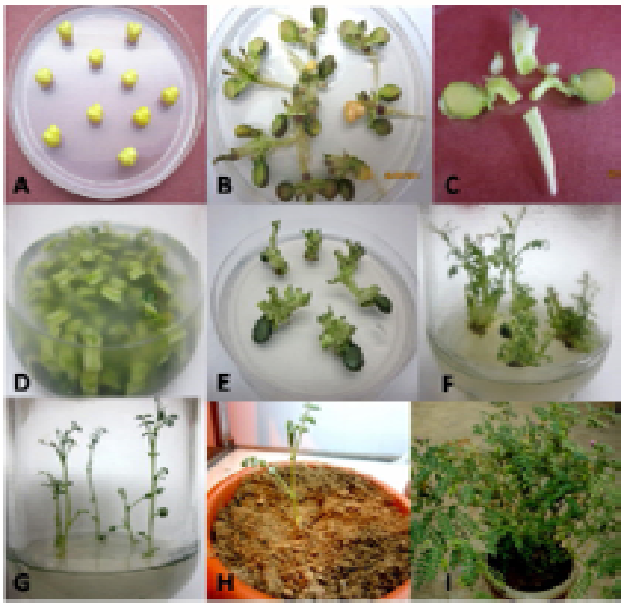
of which 30 plants (derived from 14 T_0) and 36 plants (derived from 15 T_0) were positive, respectively. Quantitative ELISA was performed using positive plants found in qualitative ELISA and strip test (50 T_2 plants derived from 17 T_0) of which 36 T_2 plants (derived from 12 T_0) were found positive (Expression range: 6.16 – 38.11 ng/mg TSP). PCR analyses of 50 T_2 (derived from 17 T_0) with gene specific primer was done and all plants were found positive. To detect the expression of 66 KDa *Cry* protein in T_1 chickpea, total 4 ELISA positive plants derived from 2 T_0 were analysed in western hybridization using chemiluminescence substrate, of which 3 plants derived from 2 T_0 were found positive.

In pigeonpea, 234 T_1 progenies (derived from 78 T_0) were analysed using PCR and qualitative ELISA, of which 58 plants (derived from 28 T_0) and 14 plants (derived from 12 T_0) were found positive, respectively. Quantitative ELISA was performed using positive plants, 66 T_1 plants (derived from 34 T_0) and 6 T_1 (derived from 6 T_0) were found positive (Expression range: 1.45 – 68.30 ng/mg TSP). Further, 198 T_2 progenies (derived from 11 T_0) were analysed using PCR and qualitative ELISA, resulting in 56 plants (derived from 5 T_0) and 7 plants (derived from 2 T_0) were found positive, respectively. Quantitative ELISA was performed using positive 61 T_2 plants (derived from 6 T_0) of which 10 T_2 (derived from 4 T_0) were found positive (Expression range: 2.37 – 80.80 ng/mg TSP). Southern blot analyses of 6 T_2 plants derived from 4 T_0 events, indicated presence of gene in the progenies.



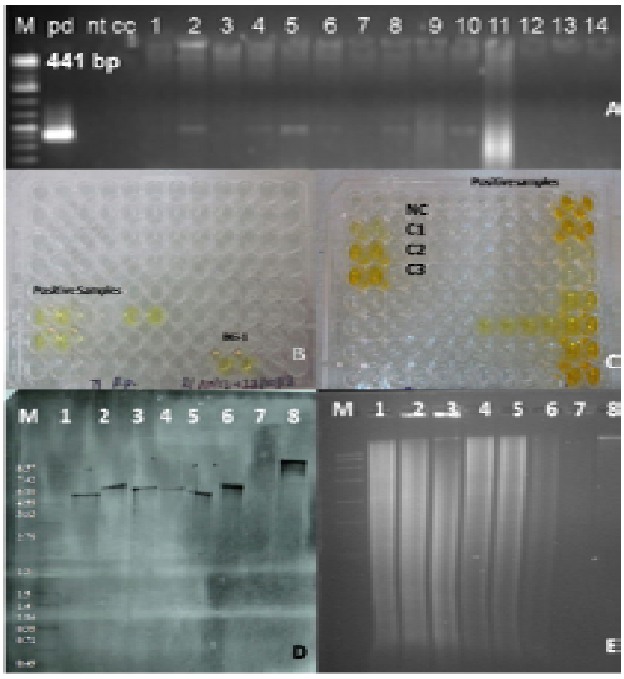
***In vitro* regeneration and establishment of transgenic pigeonpea**

A. **Inoculated seeds**, B. **Germinated seedlings**, C. **Axillary meristem explants (AMEs) ready for co-cultivation**, D. **Explants in *Agrobacterium* suspension**, E. **Explants in Kanamycin selection**, F. **Kanamycin resistant shoot**, G. ***In-vitro* grafting of shoot**, H. **Acclimatization of plant**, I. **Mature fertile transgenic plant.**

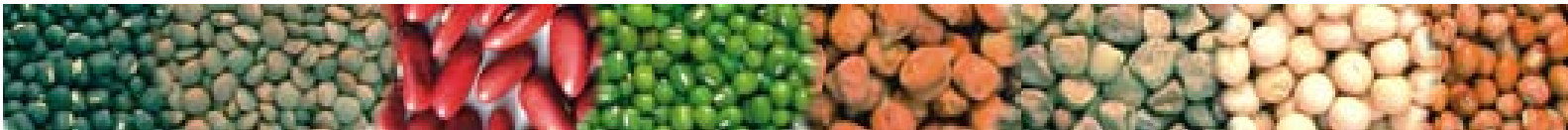


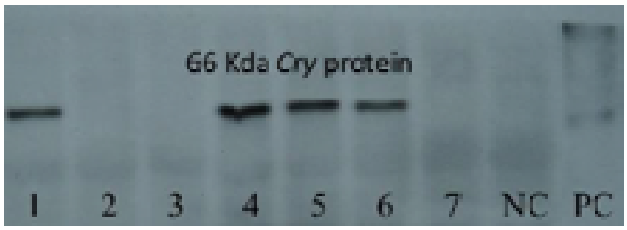
***In vitro* regeneration and establishment of transgenic chickpea**

A. **Inoculated seeds** B. **Germinated seedlings**, C. **Axillary meristem explants (AMEs)**, D. **AMEs in *Agrobacterium* suspension**, E. **Explants in ACCM+C medium**, F&G. **Explants in Kanamycin 100 mg/l**, H. **Micro-grafting of Kanamycin resistant shoots.** I. **Established fertile plant.**



Molecular analysis of T_1 pigeonpea: A. PCR based screening of transgenic plants, B. Expression analysis by qualitative ELISA, C. *Bt* protein estimation by quantitative ELISA in transgenic plants, D. Southern hybridization performed on independent T_1 transgenic events showed different integration pattern in different events, E. Agarose gel electrophoresis of Hind III digested genomic DNA

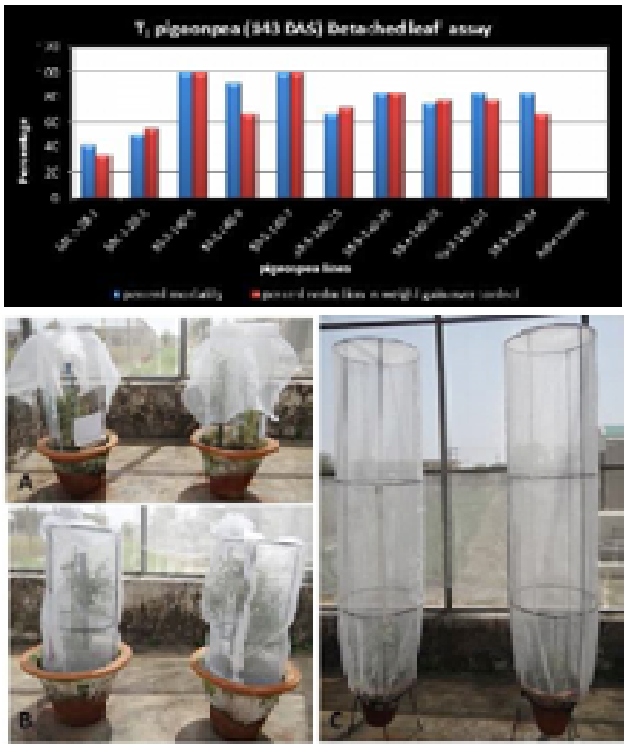




Western hybridization of T_1 chickpea
1-3 T_3 chickpea Plant samples, 4-7 T_1 chickpea plant samples NC- Negative control (DCP 92-3), PC-Positive control (purified *Cry*)

Insect bioassay

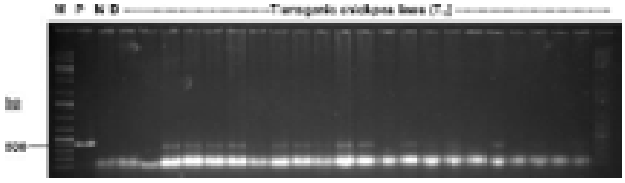
Detached leaf bioassay on 10 T_2 pigeonpea plants was done with 5 days old larva and the larval mortality varied from 41.66 to 83.33 per cent at 7 days after release. Detached leaf bioassay on 15 T_2 pigeonpea plants was done with 5 days old larva and the larval mortality varied from 25 to 100% at 7 days after release. Detached pod assay for 12 T_1 pigeonpea was conducted with 7 days old larva and the larval mortality varied from 10 to 60% at 7 days after release. Detached leaf bioassay for 18 T_1 chickpea lines was conducted with 24 hours old neonates of *H. armigera* and upto 67% larval mortality was observed.



Standardisation of whole plant bioassay in chickpea
A- Acrylic cage, B- Small iron cage with insect net, C- Large iron cage with insect net

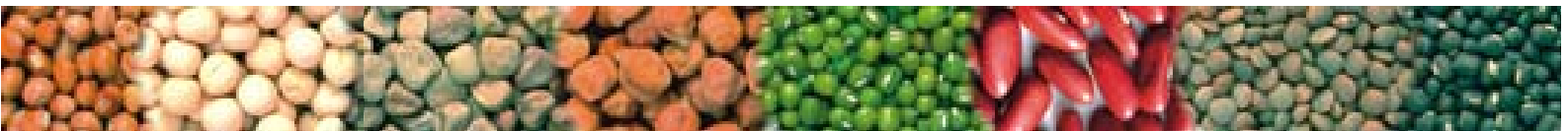
Development of Transgenic Chickpea (*Cicer arietinum* L.) for Drought Tolerance

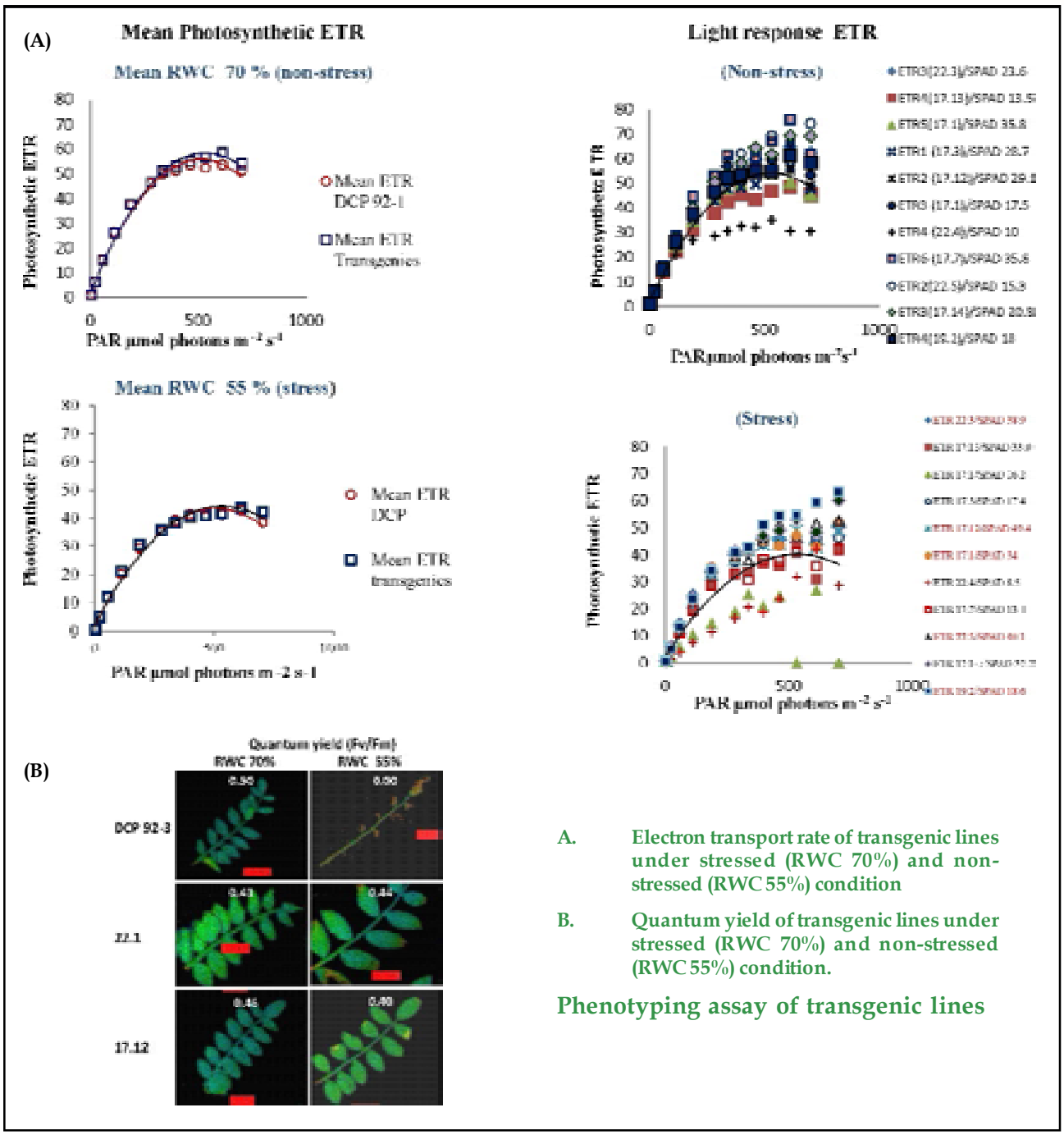
For imparting drought tolerance, chickpea (*cv.* DCP 92-3) was transformed with transcription factor (AtDREB1a) gene driven by stress inducible promoter 29 A. Four kanamycin resistant chickpea shoots (T_0) were established and 23 progenies (T_1) generated from 3 positive independent kanamycin resistant shoots (T_0) indicated presence of gene in the progenies. Seeds from all the 23 plant progenies were harvested.



[M: 1 kb DNA Ladder; P: positive control; N: negative control; D: negative control (DCP 92-3)]
PCR analyses of transgenic chickpea lines with gene specific primer

Progenies were subjected to phenotyping utilizing "dry-down" experiments. The level of water stress was monitored through periodical measurements of relative water content (RWC) and soil moisture at 10 cm depth. With progressive development of drought and corresponding variation in stress response to photosynthesis among transgenics, events and checks were assessed using Fluorescence Imaging System (Mess & Regeltechnik, Walz, Germany). The dark-adapted leaves were exposed to weak modulated light with a frequency of 4 KHz / PAR 0.15 µmol, followed by super imposition of saturation pulse of blue-enriched photon flux of 4000 µmol for 0.4 seconds to obtain fluorescence images. Subsequently light response of electron transport rate representing the photosynthetic activity of leaves without any external influence such as stomatal factors, temperature, *etc.*, was worked out. The images of quantum yield as depicted in the pictures indicated a large variation and deviation from mean values between stressed and non-stressed leaves. Few lines showing least deviation of quantum yield (Fv/Fm, ratio of variable fluorescence over maximum fluorescence under optimum irradiance) were superior performer under drought which were also supported by least distortion of fluorescence images when compared between non-stressed (RWC 70%) and stressed (RWC 55%) leaves. The transgenic events showing light response of ETR at high level of irradiances revealed a large difference among the test lines. The high values of ETR exceeding over mean values of checks and total transgenic events (averaging over) have been tentatively identified as superior lines having improved tolerance to drought. The initial evaluation suggests that differences in the maturity of lines tested as indicated by the SPAD values of chlorophyll may also influence the imaging pattern as well as ETR values besides the observed effects of drought.





A. Electron transport rate of transgenic lines under stressed (RWC 70%) and non-stressed (RWC 55%) condition

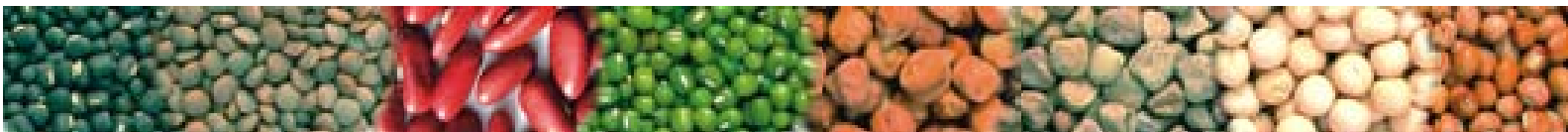
B. Quantum yield of transgenic lines under stressed (RWC 70%) and non-stressed (RWC 55%) condition.

Phenotyping assay of transgenic lines

GENOMICS AND MOLECULAR BREEDING

Center of Excellence for High Throughput Allele Determination for Molecular Breeding

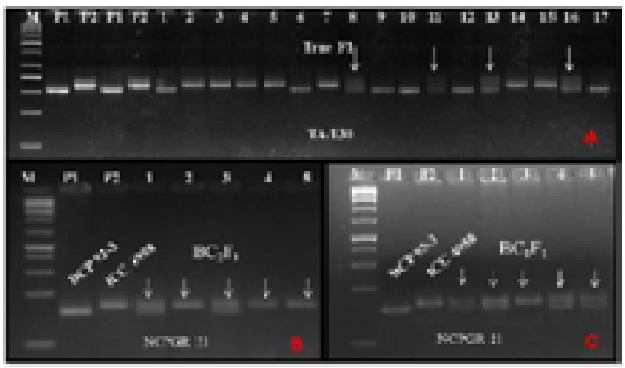
To improve the drought tolerance and to enrich the superior alleles in single cultivar of chickpea, two different approaches *viz.*, marker assisted backcrossing (MABC) and marker assisted recurrent selection (MARS) were used. For introgressing the QTLs imparting drought tolerance and other yield attributing traits, ICC 4958 was used as donor in background of DCP 92-3 and KWR 108. In last main cropping season, 72 BC_1F_1 seeds derived from DCP 92-3 x ICC 4958 were analyzed using linked marker, NCPGR 21 and advanced to BC_2F_1 and BC_3F_1 at IIPR Regional Station-cum-Off Season Nursery, Dharwad and IIPR main farm, respectively. Based on the foreground marker analysis, presently there are three positive BC_2F_1 and 17 BC_1F_1 plants, in which backcross



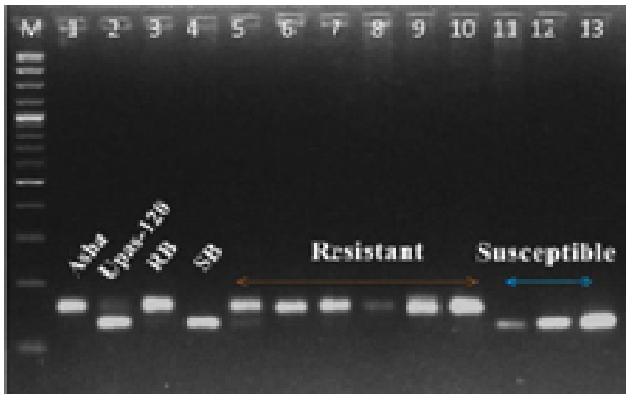
was attempted and seeds were harvested. Simultaneously, genome recovery of recurrent plant in positive BC_2F_1 plants was analyzed using background marker and ~65-70% genome recovery was observed in BC_2F_1 progenies. Similarly, 59 BC_2F_1 and 102 BC_1F_1 seeds were harvested after backcrossing with recurrent parent (KWR 108) in main cropping session in 2013. Of these, 15BC_2F_1, 44 BC_2F_1 and 102 BC_1F_1 seeds were advanced at IIPR Regional Station-cum-Off Season Nursery, Dharwad and IIPR, Kanpur during 2013-14. Based on the foreground analysis with TAA 170 linked marker, 4 plants of BC_2F_1 and 3 BC_1F_1 plants were found positive.

In marker assisted recurrent selection (MARS), total 200 F_2 seeds derived from DCP 92-3 x ICCV 10 were advanced at IIPR Regional Station-cum-Off-Season Nursery, Dharwad and IIPR Main Farm, Kanpur to get F_3 seeds. The parental polymorphism survey between parents was also done with markers. Out of screened SSR markers, 71 markers were found polymorphic between parents.

In pigeonpea, mapping populations (191 plants) derived from Asha x UPAS 120, segregating for *fusarium* wilt disease were advanced to F_6 generation using single pod descend methods. Bulked segregant analysis (BSA) was performed in F_5 progeny using resistant and susceptible bulks with hyper variable HASSR markers and one marker was found differentiating both parents as well as bulks. This observation was further validated in six resistant donor and three susceptible genotypes. For the study of parental polymorphism, ~ 250 pigeonpea specific SSR markers were screened and of these, 50 markers were found to be polymorphic between parental lines.



Molecular analysis of markers for true hybrid (A) identifications and foreground analysis of BC_2F_1 (B) and BC_1F_1 chickpea(C) plants using NCPGR 21.



Amplification pattern of HASSR in parents (Asha and UPAS 120), resistant (RB) and susceptible bulk (SB) in pigeonpea samples resolved on 3 % agarose gel.

Functional Genomics in Chickpea

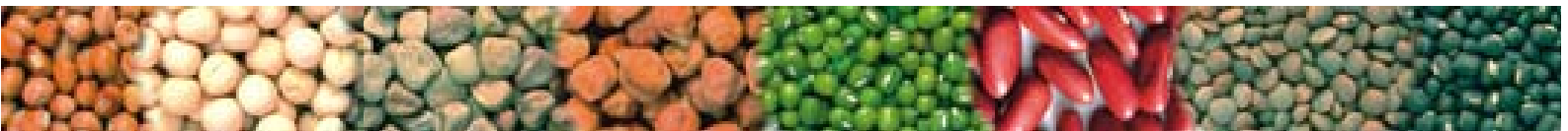
The RIL derived from the cross BG 256 x WR 315 was advanced to F_{10} generation (195 individuals). The population is being used for tagging gene(s) for yield attributing traits *viz.*, 100 seed weight. Thus, phenotyping was carried out for different characters *viz.*, germination, days to flowering, leaflet size, pod type, plant height, primary branch, secondary branch, no. of pods/plant, no. of seeds/plant and 100 seed weight. In addition to previously identified polymorphic markers, 60 new polymorphic markers (SSRs) were identified between BG 256 and WR 315 on 6% PAGE. These markers will be further used for mapping QTL/genes for yield trait and linkage map construction.

Segregation pattern for pod and seed sizes in the F_9 population.

Validation of molecular markers linked to wilt resistance was carried on sixteen chickpea genotypes and one genotype WR 315 was completely resistant to race 1, 2, 3 and 4, in contrast to genotype JG 62 which was completely susceptible for all the four race. Marker TA 96 and TA 59 can be effectively used for screening of *Fusarium* wilt for race 2 and marker TA 110 can be used to screen *Fusarium* wilt for race 1 in local genotypes.

Identification of Molecular Markers Linked to *Fusarium* wilt Race 2 Resistance Genes in Chickpea (*Cicer arietinum* L.)

The basic objective of this project was to develop mapping population of two contrasting chickpea

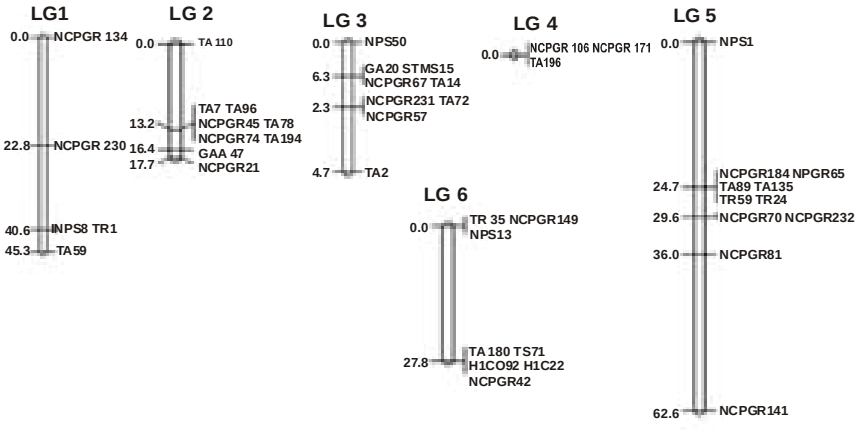


parents for *Fusarium* wilt to tag the resistant gene(s)/QTLs. To identify molecular markers linked to *Fusarium* wilt resistance genes against race 2, two different mapping populations (JG 62 x WR 315 and K 850 x IPC 2004-52) were developed and genotyped F_2 mapping population of JG 62 x WR 315 comprising 178 individuals. ~600 markers (RAPD, ISSRs and SSRs) were screened between parents for polymorphism and 84 polymorphic markers were found polymorphic and used for genotyping the population. The preliminary linkage map using Mapmaker /GMENDEL (iMAS) software was constructed, which mapped 42 loci covering 158.1cM. It indicates that the markers positioned in linkage group 2 namely TA 96, TA 194 and TA 110 are reported to be linked to race 1, 2 and 3, respectively. Both the mapping populations were advanced to F_5 generation.

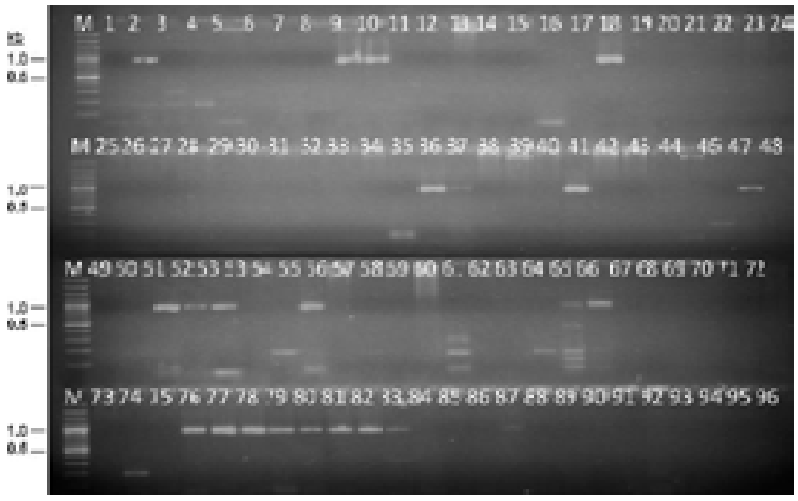
Prospecting Alleles for Enhanced Drought Tolerance in Chickpea and Pigeonpea

Utilizing the draft genome sequence information of chickpea and pigeonpea, allelic variants of drought responsive family proteins were studied. Bioinformatics analysis was conducted for genome level homology search in the draft genome of chickpea, to identify genes encoding drought responsive factor (DRF), followed by gene ontology analysis. Three candidate homologs (CAP 2, DREB 2 and DRO 1) were identified in the draft genome based on Pfam Data set utilizing Hidden Markov Model (HMM). Four sets of oligos were designed based on drought responsive transcription factors.

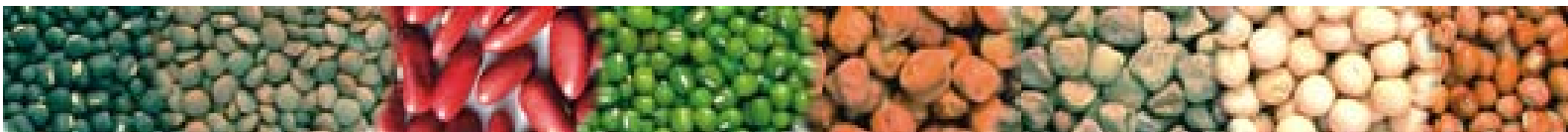
The chickpea, *CAP2* (GenBank ID: DQ3217191) is an *APETELLA2 (AP2)* transcription factor that plays an important role in growth, development and stress response. *CAP2* appeared to be a single/low copy intronless gene (1071 bp), and the protein product localized in the nucleus. Genomic DNA was isolated from chickpea genotypes (wild and cultivated) and screening for presence of the transcription factor (CAP2) is in progress.



Linkage map of chickpea with 42 loci covering 158.1 cm



[M: 100 bp DNA Ladder Plus; Lane 1-96: Chickpea genotypes]
PCR amplification of CAP2 homologs from chickpea genotypes



Crop Production

Long-term Fertility and Cropping System Studies

A trial was 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 variable nutrient management. The data reported pertains to a decadal effect of inclusion of pulses and nutrient management in maize (upland) and rice (lowland) cropping systems in eastern Indo-Gangetic plain zone of India.

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 nutrient management- INM (crop residues+biofertilizers *viz*., *Rhizobium* for pulses and phosphate solubilising bacteria for cereals, +farm yard manure @ 5 t/ha+50% NPK) and inorganic fertilizers (recommended dose of N,P,K,S,Zn & B). Inclusion of pulses in the cereal based system increased the system productivity and yield of component crops (Fig. 4). Wheat was the common crop in all the rotation in this experiment and under recommended nutrient management. The yield of spring wheat was maximum under MWMb (4639 kg/ha) and lowest in PW (3631 kg/ha) system. Among different nutrient management practices, recommended fertilization resulted in higher wheat yield, followed by integrated nutrient management. The productivity of pulses *viz*., pigeonpea, chickpea and mungbean under INM was enhanced by 11.0, 10.7 and 8.5 % over recommended inorganic fertilization.

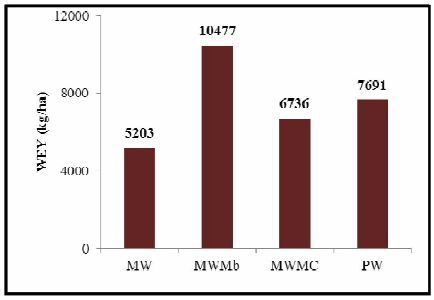


Fig. 4: Long-term effect of crop rotation on system productivity after 10 years cropping cycles (WEY- Wheat equivalent yield)

Rice based cropping system

Four rice based cropping systems *viz*., rice-wheat (RW), rice-chickpea (RC), rice-wheat-mungbean (RWMb) and rice-wheat-rice-chickpea (RWRC) were evaluated at three nutrient management systems as described in case of maize based system above. The RWMb system had higher system productivity (REY of 14595 kg/ha) (Fig. 5). Inclusion of summer mungbean in RW system increased rice yield by 10% under recommended inorganic fertilization (NPKSZnB), while inclusion of chickpea in alternate and every year have relatively marginal effect on rice productivity. After ten years of continuous cropping, RWMb system with higher annual nutrient input resulted in higher soil available nutrients, whereas continuous application of inorganic fertilizers increased available N, P, DTPA-extractable Zn and B among the nutrient management.

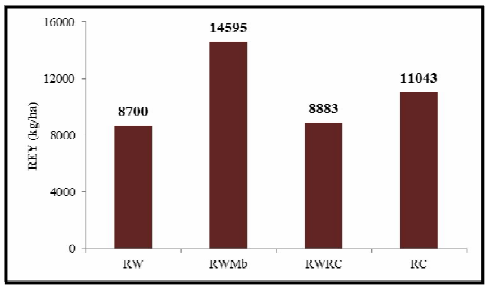


Fig. 5: Long-term effect of crop rotation on system productivity after 10 years cropping cycles (RYE-rice equivalent yield)

Nutrient Management

Phosphorus and sulphur management in maize-chickpea cropping sequence

A field experiment was conducted to evaluate the effect of FYM, phosphorus and sulphur management in maize-chickpea sequence on crop productivity and soil fertility. The treatment comprised of 3 levels of P (0, 30, 60 kg P_2O_5/ha) and 2 levels of FYM (0 and 5 t/ha) applied to maize and four levels of S applied to chickpea (No S to maize and chickpea, 30 kg S/ha to maize and no S to chickpea, no S to maize and 30 kg S/ha to chickpea, 15 kg S/ha to maize and 15 kg S/ha to chickpea). Results revealed that application of 30 kg S/ha to chickpea recorded highest grain yield (16.81 q/ha), followed by application of 15 kg S/ha to each maize and chickpea (16.44 q/ha) and least under no application of S to both maize and chickpea. The residual effect of P applied to maize also significantly enhanced grain yield of chickpea. Application of P to maize at 60 kg P_2O_5/ha improved grain yield of chickpea by 1.02 q/ha over 30 kg P_2O_5/ha.

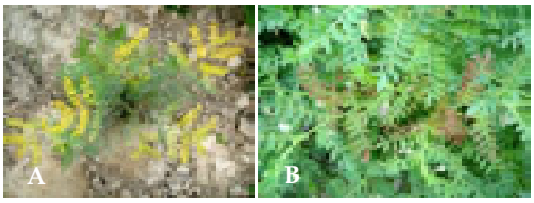
Effect of S, Zn and FYM on rajmash

A pot experiment was conducted to evaluate the effect of S, Zn and FYM on rajmash under virgin and

cultivated soil. Plant height, dry matter, pods/plant and seeds/pod were markedly increased upon application of above nutrients. The effect was more under cultivated soil than virgin soil. Application of 30 S kg/ha recorded highest grain yield (20.3 g/plant), while Zn and FYM improved grain yield by 7 and 17%, respectively under cultivated soil.

Foliar fertilization of chickpea

A field experiment was conducted to investigate the effect of foliar application of Zn, Fe and urea or combination thereof on chickpea. Foliar application of Zn, Fe and urea increased grain yields under irrigation. Water use efficiency improved due to application of Zn, Fe and urea. At maturity, Zn, Fe and N accumulation in plant organs generally increased with application of Zn, Fe and N, but the largest proportion of Zn, Fe and N was found in the seeds. Protein content of grains increased with N and Zn fertilization. Combined spray had marked influence on the content of Zn, Fe and protein in decorticated chickpea (*dal*) and whole grain over single or no foliar fertilization.



Fe (A) and Zn (B) deficient chickpea

Micronutrient fortification of lentil and fieldpea

Under pot experiment, it was observed that foliar spray of zinc @ 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4% at pre-flowering stage enhanced its concentration in leaves, stem and grain from 15 to 35% both in lentil and fieldpea. Soil applied zink (No Zn, 0.5, 1.0, 1.5, 2.5, 3.0, 3.5 mg Zn/kg soil) improved its concentration from 7 to 22% in the root, shoot and leaves. Zinc nutrient application through seed coating (control, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 g Zn/kg seed) had positive effect on fieldpea and lentil under lower levels. Seed coating beyond 4.0 g Zn/kg seed showed toxicity symptom both in lentil and fieldpea at germination stage. Seed priming of fieldpea and lentil with zinc (control, 0.025, 0.05, 0.075, 0.10, 0.125, 0.150 and 0.175%) improved seed germination, stand establishment and zinc concentration in root, stem and leaves.

Overview of pot experiment

Resource Conservation Technology

Conservation tillage and residue management in pulse based system

Under resource conservation technology in pulse based cropping system, two tillage practices (zero tillage, ZT and conventional tillage, CT), three cropping systems (rice-wheat, rice-chickpea, rice-chickpea-mungbean) and two residue management practices (residue retention and residue removal) were evaluated. Summer mungbean performed better under zero tillage and residue incorporation. Yield of mungbean was higher in case of residue incorporation (11.3%) and zero tillage (25.4%) in comparison to no-residue (1510 kg/ha) and conventional tillage (1415 kg/ha), respectively. System productivity in terms of chickpea equivalent yield during 4th crop cycle was 4% higher in case of zero-tillage than conventional tillage (4467 kg/ha). Improvement in system productivity (9%) was also recorded due to residue incorporation. In cropping systems, highest system productivity in terms of chickpea equivalent yield was obtained in rice-wheat-mungbean (5893 kg/ha), followed by rice-wheat (4067 kg/ha) and lowest in rice-chickpea (3712 kg/ha).

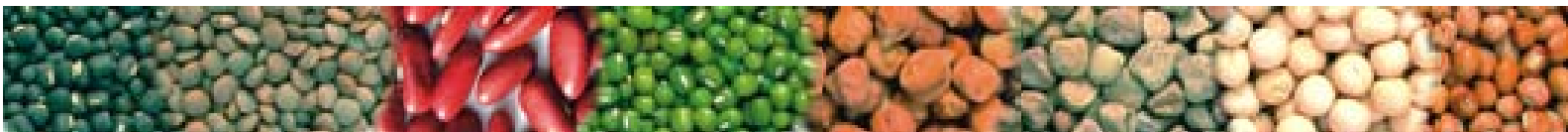
Enhancing productivity of maize-chickpea cropping system under permanent raised bed

A raised bed of 75 cm width was prepared with tractor drawn raised bed maker and maize-chickpea cropping system was followed. To sustain the system productivity of component crops, integrated nutrient management practices (sunhemp green manure, FYM @ 5 t/ha, sunhemp + FYM @ 5 t/ha and control in maize crop) were imposed. After maize harvest, 2 rows of chickpea were grown on each bed after reshaping with tractor drawn raised bed maker. Intercrop of spinach in combination with maize stalk mulch was taken. Maize grain yields varied between 4800-5500 kg/ha and spinach between 1600–2600 kg/ha.

In-situ green manuring of sunhemp in maize crop

Moisture and nutrient conservation in pearlmillet–chickpea sequence

An experiment was initiated during *kharif* to assess the effect of pulse intercrop, soil moisture



conservation practices and nutrient management options on chickpea productivity. Pearl millet (Proagro 9444) was intercropped with greengram and cowpea during rainy season and chickpea (JG 16) was grown in winter season. The treatment comprised of pearl millet sole, pearl millet+cowpea, pearl millet + green/gram, mulching, mulching+one irrigation, mulching + two irrigation and 75% RFD and 100% RDF. Highest pearl millet equivalent yield (4154 kg/ha) was recorded in pearl millet intercropped with green gram, followed by pearl millet+cowpea (3722 kg/ha) and least under pearl millet sole (2742 kg/ha). Significant variation in soil microbial biomass carbon in chickpea was observed due to pulse intercrop on succeeding chickpea. Among intercropping system, highest SMBC was observed in pearlmillet intercropped with cowpea, followed by pearlmillet + greengram and least under pearlmillet sole.

Yield maximization and resource use efficiency enhancement in pigeonpea-wheat system

A field experiment was conducted on a *Typic Ustochrept* soil of Kanpur to evaluate suitable crop establishment practice and system productivity in pigeonpea-wheat system using UPAS 120, Pusa 992 and ICP 67B pigeonpea cultivars under both raised bed and ridge planting. UPAS 120 yielded highest (1381 kg/ha), followed by Pusa 992 (1214 kg/ha) and the least was in ICP 67B (912 kg/ha). Plant survival, crop growth, yield attributes and yield also varied with pigeonpea cultivars (UPAS 120>Pusa-992>ICP-67B) due to their earliness and vigour in growth. Among crop establishment practices higher grain yield was realized under raised bed planting (1234 kg/ha) over ridge planting (11.04 kg/ha). Among wheat cultivars Unnat Halna matured earlier (105 days) than Shatabdi (113 days).

Effect of variable row spacing and sowing date on summer mungbean

Evaluation of effect of sowing dates and row spacing on growth and productivity of summer mungbean revealed that early sowing (last week of March to first week of April) can produce higher yield over late sown crops. Highest productivity of mungbean was recorded in 27th March sown crop (1363 kg/ha), followed by 3rd April (1238 kg/ha). Early sowing of summer mungbean allows second harvest that can provide additional yield of 1.5-2.5 q/ha. Among the different row spacing (20, 22.5, 25, 30, paired row 22/30), high density planting (20 and 25 cm) out yielded the crop with wider spacing (30 cm).

Water Management

Efficient management of water for higher productivity in pulses

With an objective to study the efficient utilization of water and nutrients (N & K) through drip-fertigation in long duration pigeonpea, a field experiment was carried out with three irrigation scheduling (0.4/0.6/0.8 IW/CPE ratio) and five pigeonpea (raised bed) based intercropping along with irrigation *viz*., pigeonpea sole as rainfed control with NPK at planting (S1), pigeonpea+urdbean with drip-fertigation of ½ NK during branching and pod development (S2), pigeonpea+urdbean with furrow irrigation during above critical stages with NPK at planting (S3), pigeonpea+grain sorghum with drip-fertigation with ½ NK during branching and pod development (S4) and pigeonpea+grain sorghum with furrow irrigation during both the above stages with NPK at planting (S5). Sorghum (MSH 51), urdbean (IPU 2-43) and pigeonpea (NA 1) were *kharif* crops grown in inter-rows of paired row planted pigeonpea on raised beds (Fig. 6), while during *rabi*, pigeonpea only was continued as urdbean/sorghum were harvested by then. Two rows of each of urdbean and sorghum were adjusted in the inter-row space (120 cm raised bed) of pigeonpea as per the treatments (urdbean or sorghum). Pigeonpea was given optimum dose of fertilizers, while both the intercrops were applied with 50% NPK as per area coverage by these.

Mean seed yield of 490 and 1920 kg/ha (50% area basis) were realized with urdbean and sorghum intercropping, respectively (Table 1) in addition to a mean seed yield of 2548 kg/ha for the main crop of

Fig. 6: Performance of pigeonpea based intercropping (sorghum and urdbean) on raised bed

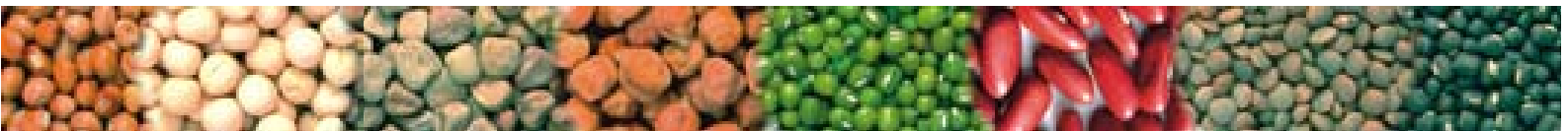


Table 1: Effect of pigeonpea based irrigation schedules on seed yields and PEY (kg/ha)

Irrigation schedules	Pigeonpea		Urdbean		Sorghum		PEY (Seed yield)	PEY#
	Seed	Stalk*	Seed	Stalk	Grain	Straw		
0.4 IW/CPE	2485	7.13	474	1105	1903	4069	2994	3233
0.6	2618	7.27	483	1124	2089	3860	3159	3400
0.8	2541	6.53	513	1149	1767	3997	3045	3268
C.D. (0.05)	NS							
Intercropping								
Pigeonpea (sole)	2431	6.33	-	-	-	-	2431	2595
Pigeonpea +urdbean (drip)	2760	8.49	472	1105	-	-	3287	3537
Pigeonpea +urdbean (furrow)	2648	6.81	506	1147	-	-	3214	3421
Pigeonpea +sorghum (drip)	2535	6.88	-	-	2020	3922	3322	3603
Pigeonpea +sorghum (furrow)	2367	6.37	-	-	1819	4030	3075	3346
CD(P=0.05)	176.0	0.99	NS	NS	NS	NS	201	207

*Stalk yield of pigeonpea in t/ha # Both seed and straw yield taken

pigeonpea. The intercrop(s) were harvested before the onset of winter. The main crop of pigeonpea was harvested during April, 2014. Drip-fertigation in pigeonpea+urdbean produced significantly higher pigeonpea seed yields (2760 kg/ha) over the sole crop (2431 kg/ha). Similar higher values on WUE, WP and economics with low water use were also obtained. Interestingly, irrigation at critical stages either through drip in both the intercrops or through only furrow in pigeonpea+urdbean produced significantly higher yield over sole crop of pigeonpea. Total yield *i.e.*, pigeonpea equivalent yield (PEY) was highest with drip-fertigated sorghum based intercropping system (at par with urdbean based system). Due to late winter rains during podding stage (mid February and beyond), the need for irrigation did not arise that resulted in producing similar effects of all the irrigation schedules, yet the effect was significantly higher over the control. Different irrigation schedules (0.4/0.6/0.8 IW/CPE ratio based) with varied irrigations (1-4 no.) could not influence productivity levels in the existing rainfall situation during the cropping season.

Influence of precision tillage and sprinkler irrigation in summer pulses

A study was undertaken on the role of precision tillage through application of laser land levelling in combination with normal preparatory (sowing) tillage and precision irrigation (through micro-sprinkler) on water savings and productivity in summer pulses *e.g.*, mungbean and urdbean as catch crops during spring/summer. Studies showed the pertinent role of timely, frequent and shallow irrigation through micro-sprinklers in comparison to normal flood irrigation at different critical stages of urdbean and mungbean (Fig. 7).

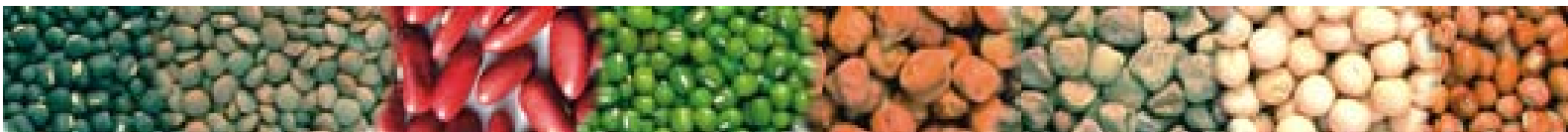
Fig. 7: Effect of laser leveller cum micro-sprinkler in urdbean (centre) *versus* control (right)

Weed Management

Screening of post-emergence herbicides in pulses

Total seven post-emergence herbicides *viz.*, Carfentrazone, Oxyfluorfen, Oxadiazone, Mesosulfuron, Propaquizafolp, Fenoxaprop and Clodinafop were evaluated in mungbean during rainy season and chickpea during *rabi* season. Fenoxaprop and Clodinafop did not show any toxicity on mungbean and chickpea and controlled grassy weeds more effectively during both seasons. Some broad leaved weeds were also controlled by these herbicides. Carfentrazone, Oxyfluorfen, Oxadiazone and Mesosulfuron showed toxicity to both mungbean as well as chickpea crops. Propaquizafop was non-toxic to both mungbean as well as weeds. Therefore, Fenoxaprop and Clodinafop can be further evaluated for optimum doses and time of application.

Fenoxaprop effect in mungbean



Above post-emergence herbicides along with Quizalofop-ethyl were also evaluated to control *Asphodelus tenuifolius*, an emerging weed in *rabi* season pulses in light soils of Bundelkhand. Quizalofop-ethyl, Fenoxaprop and Clodinafop effectively controlled *Asphodelus tenuifolius*.

Mechanization for Pulses

Evaluation of sowing equipments for pulses

Sowing equipments *viz*., raised bed planter, IIPR zero till seed drill (manual) and zero till planter were evaluated with conventional plough and bed planter+manual dibbling for sowing of rainy season mungbean and *rabi* chickpea. During rainy season, significantly higher mungbean yield (1024 kg/ha) was recorded in raised bed+manual dibbling, followed by IIPR zero-till seed drill (847 kg/ha) and lowest in zero-till planter (695 kg/ha). IIPR zero-till seed drill gave at par yield of mungbean with conventional plough (803 kg/ha). In case of chickpea, significantly higher yield was recorded in IIPR zero-till seed drill (1119 kg/ha), while lowest in raised bed planter (980 kg/ha). Raised bed+manual dibbling (1039 kg/ha) and conventional plough (1102 kg/ha) gave at par yield with IIPR zero-till seed drill. Thus, IIPR zero-till seed drill (manual) performed well in both rainy as well as in *rabi* season pulses.

Demonstration of IIPR Technologies at Farmers' Fields

The technoloy demonstration at farmers' fields in adopted villages *viz*., Barhapur, Saryiapur and Kueitkheda in Kanpur Dehat, included post-emergence application of Imazethapyr for *kharif* pulses (mungbean, urdbean and pigeanpea), ridge planting in pigeonpea, chickpea+mustard (6:2 ratio) during *rabi* season, popularization of summer mungbean at farmers' fields and IPM for pest control. The major interventions applied to the farmers and their effect include the following:

Post-emergence application of Imazethapyr for mungbean, urdbean and pigeonpea

Application of Imazethapyr as post-emrgence (20-25 DAS) @ 100 g/ha (POE) was effective against diverse weed flora in *kharif* pulses (area sown 2000 m^2 each crop) under farmers' conditions. Combined application of pendimethalin @ 1-1.25 kg/ha (pre-emergence)+Imazethapyr @100 g/ha (post-emergence 20-25 DAS) gave adequate control of weeds especially in *kharif* mungbean, urdbean and pigeonpea.

Application of Imazethapyr (POE) in pigeonpea for efficient weed control

Crop performance of ridge planting *vis-à-vis* flat planting in pigeonpea

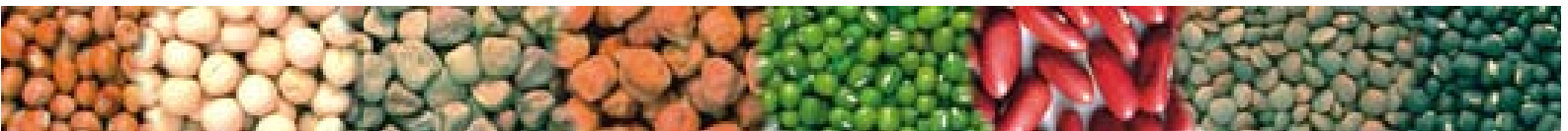
Ridge planted pigeonpea variety NA 1 performed better in comparison to flat planted. Besides improvement in growth and biomass, there was yield superiority to the extent of 20% in ridge planting of long duration pigeonpea.

Ridge sowing of pigeonpea with manifold advantages

Remunerative chickpea + mustard inter-cropping *versus* chickpea sole cropping

Chickpea+mustard intercropping (6:2 row ratio in replacement series) produced similar chickpea yield with additional mustard yield to the tune of 2-4 q/ha over chickpea sole system. Chickpea equivalent yield was superior over chickpea sole cropping. Besides this, there was also low incidence of pests and diseases in the above intercropping situations.

Popularization of chickpea+mustard intercropping (6:2) as a remunerative enterprise



Popularization of summer mungbean at farmers' fields

Studies on summer mungbean (Samrat) revealed that it was more remunerative and was adopted by farmers where irrigation facility is available. With 2-3 irrigations and little management, they could profitably grow the crop both for seed and table purpose. Since the previous field was garlic or potato (or in some cases wheat), the farmers could raise good summer mungbean crop with very little fertilizer or other inputs.

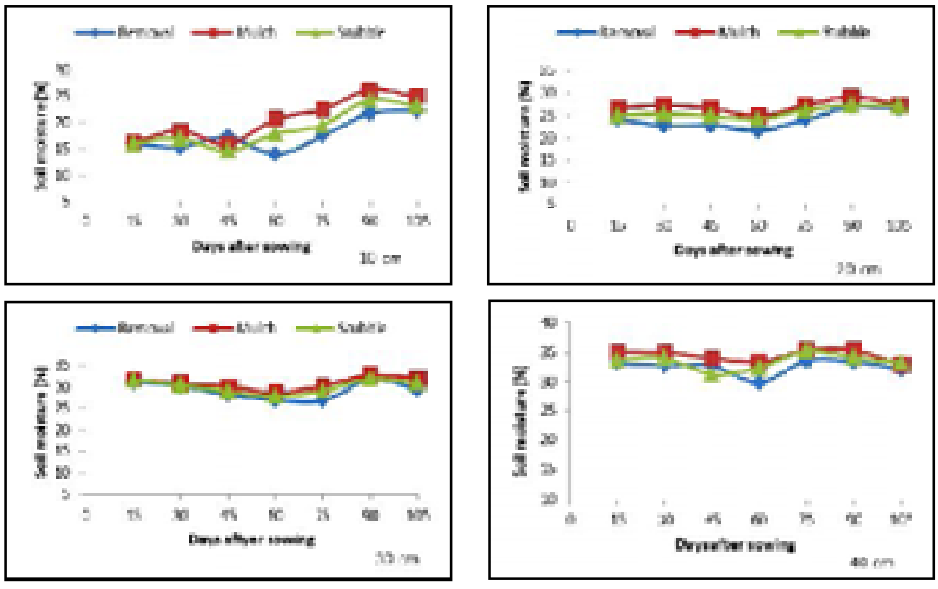
Summer mungbean as a profitable alternative cash crop

EXTERNALLY FUNDED PROJECT

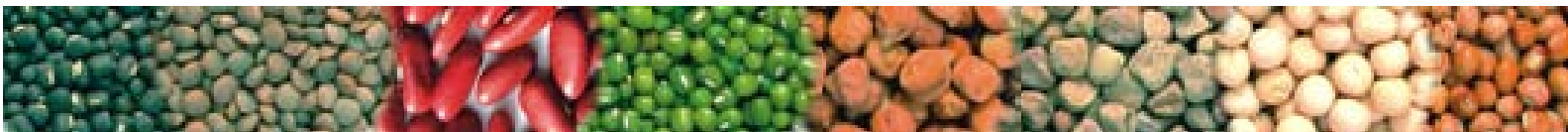
Mitigating Abiotic Stresses and Enhancing Resource-use Efficiency in Pulses in Rice Fallows through Innovative Resource Conservation Practices

The project has the objective of basic understanding of rice-fallows ecology and development of resource conservation technology for pulses to mitigate abiotic stress in rice fallows. The major achievements of the project are as under:

- The cumulative infiltration rate after chickpea harvest was significantly higher (21.1%) in improved early rice variety Pant Dhan-12 over local rice cultivar. Cumulative infiltration rate was 21.4 and 14.7% higher in mulch and stubble, respectively over no mulch.
- Soil moisture varied between 18.4 to 20.0% during chickpea sowing. After 15 days of sowing soil moisture depleted faster in local rice (7.5 %). Higher soil moisture was found at upto 16 cm soil depth in improved variety Pant Dhan-12 over local rice cultivar. In residue management practices at same soil depth, mulch and stubble conserved more soil moisture than no-mulch.
- Soil moisture dynamics was recorded with soil moisture probe at 15 day intervals during *rabi* season. On an average, soil moisture content was recorded higher (15.7% at 10 cm, 10.8% at 20 cm, 9.4% at 30 cm and 5.2% at 40 cm soil depth) in chickpea grown after improved rice cultivar Pant Dhan-12 over local rice and mulch conserved more soil moisture than no-mulch. During crop season, soil moisture content was higher by 12-28% at 10 cm, 11-20% at 20 cm, 7-13% at 30 cm and 5-12% at 40 cm soil depth under mulch over no-mulch.
- Soil microbial activities like soil dehydrogenase and SMBC were found higher *i.e.*, 7.40 µg of TPF/g and 833.0 g/kg of soil, respectively in case of mulch over on-mulch.
- 32.5, 20.6 and 24.0% higher nodules per plant were recorded in mulch over no-mulch at 30, 60 and 90 DAS, respectively. Similarly, chickpea yield was higher in mulch (656 kg/ha), followed by stubbles (510 kg/ha) and lowest in no-mulch (386 kg/ha).



Soil moisture dynamics under different conservation practices



Crop Protection

DISEASES

Wilt

Chickpea

Total 784 genotypes were screened against *Fusarium oxysporum* f.sp. *ciceri* (race 2) in wilt-sick plot. Genotype JG 62 used as susceptible check showed 100% mortality. *Kabuli* chickpea lines IPCK 13-192, -194, -203, -204, -205, -209, -211 and IPCK 13-212 showed resistant reaction, whereas lines IPCK 13-195, -206, -213, -229, -248 and IPCK 13-186 showed moderately resistant reaction. In *desi* chickpea, IPC 2013-01, -03, -12, -21, -23, -25, -83, -84, -97 and IPC 2013-128 were found resistant and lines IPC 2013-16, -21, -37, -48, -63, -78, -81, -105, -110, -119, -136 and IPC 2013-146 were moderately resistant.

Genotypes from ICRISAT *viz*., ICCV 07112, -08102, -08119, -05530, -07140 and ICCV 8503 were resistant, whereas ICCV 08101, -98503, -8115, -07309, -08122 and ICCV 08121 showed moderately resistant reaction.

Thirty chickpea genotypes from AICRP were found resistant, whereas 29 genotypes were moderately resistant. Of the wilt resistance donors, JG 315, JG 74, DCP 92-3 and KWR 108 were found resistant, whereas GPF 2 showed susceptible reaction.

Among 96 promising lines, eight *viz*., IPCK 12-310, IPC 2009-43, IPC 07-50, IPC 10-152, IPCK 12-258, IPC 2008-10, IPC 2010-185, IPCK 12-306 showed resistance rection. Twenty one lines (BG 112, IPC 2010–61, IPCK 12–03, IPC 2007–56, IPC 2009–187, IPC 2007–50, IPC 10–28, IPCK 12–92, KGD 1253, IPC 2010–3, H 06-15, IPCK 12–198, IPCK 12–99, GL 27103, IPC 08–100, IPC 05–59, IPCK 12–154, IPC 2010–207, GLK 46, IPC 2010–128, H 04 – 06) were moderately resistant.

Lentil

Management

Seed treatment with talc based formulation of *Trichoderma harzianum* isolate 31 (IPT 31) reduced plant mortality by 45% and increased yield by 25%, whereas seed treatment with culture filtrate of IPT 31 reduced plant mortality by 44% and increased grain yield by 18%. Results indicated that seed treatment with culture filtrate of IPT 31 was as effective as seed treatment with talc based formulation of IPT 31 in reducing the plant mortality and increasing grain yield. Seed treatment with carbendazim or carbendazim+vitavax was also effective in reducing plant mortality and increasing grain yield.

Variability in morphological characters of *F. oxysporum* f.sp. *lentis* isolates

Number of septa in microconidia and size of macroconidia (length and breadth) were studied in isolates of *F. oxysporum* f.sp. *lentis*. Number of septa in macroconidia varied between 1-5. Macroconidia in majority of the isolates (23) had 1-3 septation, three with 2-4 septa and four with 3-5 septa, while others were with only 1-2 septa. Length of the macroconidia also varied in different isolates between 5-9.43µm. In majority of isolates (24), size of macroconidia varied between 5 - 8 µm, five with length between >8 - 9 µm and four between >9–9.43 µm. As far as breadth of macroconidia is considered, 22 isolates had it between >3-4 µ, between 2-3 µm in seven isolates and between >4 -4.47 µm in four isolates.

Host plant resistance

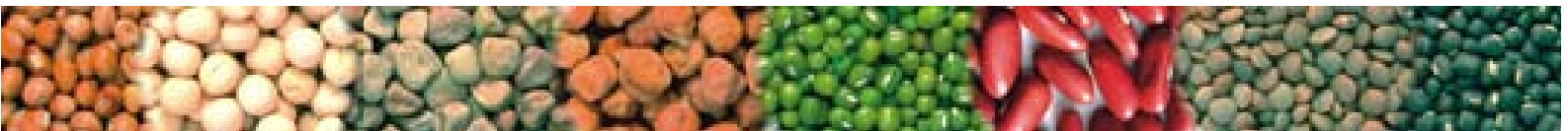
One hundred genotypes were sown in wilt sick plot and wilt incidence was recorded. Data indicated that seven *viz*., IG 3558, IG 4175, IG 4073, IG 4702, IG 4303, IG 3673 and IG 4162 were resistant with less than 10% wilting, whereas 39 genotypes were moderately resistant with 10-20% wilt incidence. Rest showed more than 20% wilting, highest being 55% in genotype IGG 5115. Fifty six genotypes screened last year were again screened against wilt. Genotype L 4076 and LL 1114 showed resistant reaction with <10% wilt, whereas 26 genotypes *viz*., LL 1210, LH 484-8, LL 1231, RVL 48, IPL 315, KLB 345, LH 08-10, IPL 215, VL 143, IPL 81, PL 117, IPL 324, PL 101, IPL 531, DPL 15, DL 11-5, PL 122, PL 104, VL 521, KLB 314, IPL 319, PL 099, IPL 221, NDL 11-1, NDL 11-2, IPL 220 and RLG 147 were moderately resistant (10-20% wilting).

Dry root rot

Chickpea

Morphological and pathogenic variability of *Rhizoctonia bataticola* isolates

Total of 25 *R. bataticola* isolates were studied for morphological and pathogenic variability. Variability was observed in sclerotial diameter, growth rate of mycelium, type of growth, pathogenicity and time taken for sclerotia formation. Based on size, Rb 48 (102.3 µm) produced large sized sclerotia, followed by Rb 30 (97.88 µm) and R 65 (92.26 µm), while small sized sclerotia was observed in Rb 29 (58.90 µm), followed by Rb 14 (62.78µm). The growth rate of mycelium was highest in Rb 22 (50.6 mm/day), followed by Rb 29 (49.6 mm/day) and Rb8 (49 mm/day), while lowest was observed



in Rb 65(30.3 mm/day). Fifteen isolates produced scanty growthof mycelium and 10 isolates produced fluffy type of growth. Based on pathogenicity on mungbean, isolates were grouped in to 3 categories *viz*., highly pathogenic (17) causing more than 50% mortality, moderately pathogenic (7) causing 30-50% seedling mortality and one isolate (Rb 30) as weakly pathogenic.

Cross pathogenicity of *R. bataticola* on various pulses

Cross pathogenicity of *R. bataticola* (Rb 9) isolated from chickpea was tested on various pulses *viz*., pigeonpea, chickpea, mungbean, urdbean and cowpea. Isolate was highly pathogenic on chickpea causing 89.3% seedling mortality, followed by pigeonpea (83.3%), mungbean (81.6%), urdbean (49.3%) and cowpea (15.2%).

Identification of resistance donors for wilt

Twenty land races and 24 wilt resistant lines were screened in lab by paper towel method and among 20 land races none was found resistant against dry root rot pathogen. Among wilt resistant lines, 6 *viz*., IPC 2005-27, -30, -34, -44, -46 and IPC 2005-64 were found promising. Sowing of 44 entries was carried out in *Rb* sick tanks, but disease expression was very low due to heavy rainfall.

Management of DRR by *Trichoderma* strains

Twenty-two *Trichoderma* isolates belonging to various species were evaluated *in vitro* against *R. bataticola*. Highest inhibition was observed in IPT 7 (79.63%), followed by IPT 14 (73.90%) and IPT 3 (70.74%), while lowest in IPT 16 (51.85%), followed by IPT 10 (52.59%).

Phytophthora stem blight

Pigeonpea

Host resistance

One hundred twenty lines were screened against Phytophthora stem blight (*Phytophthora drechsleri* f.sp. *cajani*) under natural infestation. UPAS 120 was sown as check after every two rows of test entry. UPAS 120 recorded 80% incidence of the disease. Six lines (IIPA 2013-1, IPA 2013-2, ICP 15761, WDN2–275, ICP 15685–1, WD-5–2) showed disease incidence up to 10%, while 26 lines (WDN 1–156, IPA 2013-7, WDBCE 4, IPAC 3, WDBCE 2, IPA PB -7 – 2- 1- 7, WDN 2–75, WDBCE 3, IPAC 3–1, WDBCE-9, IPAC 66–8 (A 6, 480), IPAC 3, IPAC 2–3, IPAC 2, IPA 2013-11, WD-2, WDN 2–152, IPA 2013-10, IPAC 79, IPAC 12-1, IPAC 68–4, IPA-2013-8, WDN 2–147, WD 35, WDN 1-111, WDN 2–199) showed disease incidence between 10.1-30%.

Viral Diseases

Mungbean

Management

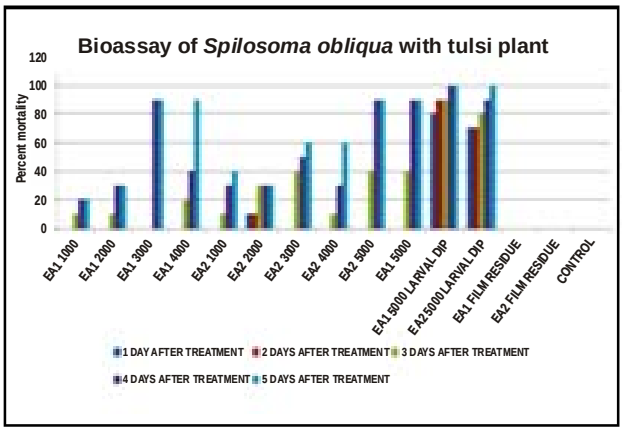
Among eight treatments used for management of viral diseases in mungbean cv.T 44 (*kharif*), seed treatment with imidaclorpid 17.8SL @5g/kg seed and foliar sprays of Nurelle D505 @ 0.1% at 15 and 45 days of sowing enhanced the grain yield significantly over control. However, there was no significant effect on reduction of viral diseases (yellow mosaic and leaf curl/necrosis) in any of the other treatments.

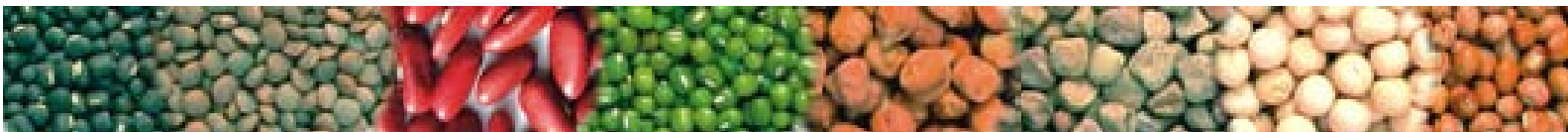
INSECT PESTS

Bio-prospecting of Botanicals for their Insecticidal Activity against Major Insect Pests of Pulses

Spilosoma obliqua

Plant extracts of *tulsi*, *Ocimum sanctum* and *Aloe vera* were extracted in ethyl acetate and methanol fractions. Bioassay was conducted on 2nd instar larvae of *Spilosoma obliqua* and was found that larval dip method resulted in highest mortality, followed by leaf contamination method and no mortality in film residue method. The pre sent result indicates that ethyl acetate fraction of *tulsi* has some metabolites which has both contact and stomach poison activity.





Thrips

Development of management strategies against thrips

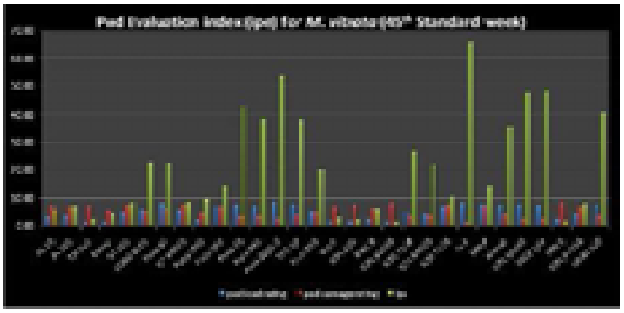
The population of thrips in summer mungbean (cv. Meha) ranged from 8.8 to 22.5/5 plants, whereas in urdbean (cv. Uttara) it ranged from 3.7 to 10.9/5 plants. The highest incidence of thrips was observed in 16th SMW in mungbean and 18th SMW in urdbean. In *kharif* season, population of thrips in mungbean ranged from 10.7 to 16.2/5 plants, whereas in urdbean it was 2.2 to 5.4/5 plants. Among the predators of thrips, *Brumoides suturalis, Coccinella transversalis, Cheilomenes sexmaculata, Micraspis discolour, Coccinella septempunctata, Phrynocaria perrotteti* were predominant in mungbean ecosystems. In mungbean and urdbean, no leaf curl disease was observed. *Megalurothrips distalis* (Karny) and *Caliothrips indicus* Bagnall were recorded in summer and *kharif* mungbean and urdbean. More thrips population was observed in mungbean sown before a fortnight *i.e.*, 14.2/5 plants, whereas 11.5/5 plants were recorded in normal date of sowing.

Effect of spacing in mungbean showed that narrow row-to-row spacing of 20 cm attracted more thrips as compared with wider spacing of 30 cm. Spraying of thiomethoxam 25WG registered lowest number of thrips (5.6/5 plants), whereas the highest number of thrips (29.4/ 5 plants) was recorded from untreated control. Highest grain yield (1557 kg/ha) was recorded in thiomethoxam 25WG treatment, followed by imidacloprid 17.8SL (1509 kg/ha), which were significantly superior over control.

Maruca vitrata

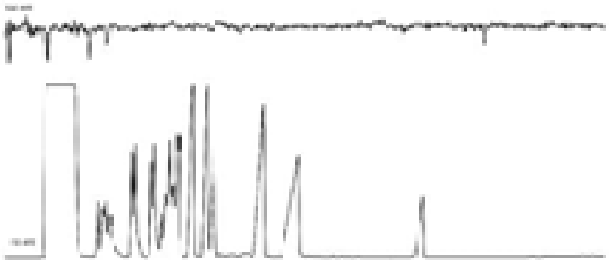
Eco-friendly management of spotted pod borer in short duration pigeonpea

Thirty short duration pigeonpea lines were screened for evaluating host reaction to *Maruca vitrata* under field condition and pod evaluation index (Ipe) was calculated at pod formation stage based on the pod load and pod damage rating. Genotype Pusa 2002-2 and JA 4 were found to have Ipe >50. Similarly, lowest pod damage was recorded in JA 4, followed by ICPL 91045, DSLR 129, Pusa 2002-2 and Pusa 2001. The



larvae were reared in laboratory using two different natural diets (pigeonpea flowers and soaked seeds). The per cent pupation was 84.6 and 81.8, while the adult emergence was 68.2 and 72.2%, respectively.

GCEAD analysis was carried out at NBAII, Bangalore for identification of kairomones from pigeonpea plant volatiles. The volatiles giving peak response were identified as linalool, Limonene, Myrcene, t-Muurolol and Nerolidol by using GCMS. The electroantennogram (EAG) response of virgin adult females (2.32 milli volts) of *M. vitrata* with pigeonpea leaf volatiles was higher than the mated females.

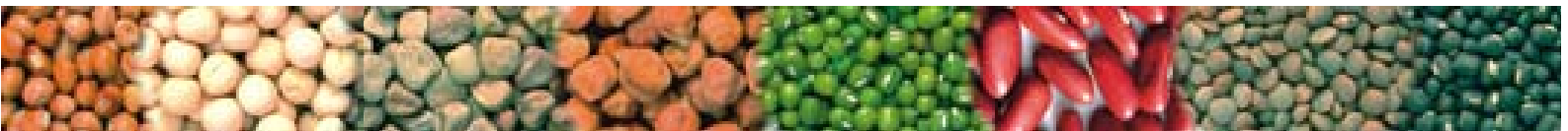


GC/MS: The EAD active extract were injected into GC/MS for the identification of probable compounds. Some of the compounds like linalool , Limonene, Myrcene, t-Muurolol , Nerolidol

Bio-Ecology of Borer Complex and Sucking Pests Infesting Long Duration Pigeonpea and Their Management

Determination of the bio-ecology of pod borer complex

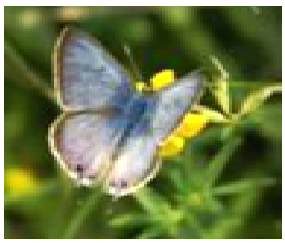
It was observed that jassids (*Empoasca kerri*) was infesting long duration pigeonpea crop in its vegetative stage which resulted yellowing of leaf margins. A lepidopteran larvae *i.e.*, leaf webber (*Grapholita critica*) were found prevailing up to November end. Ash weevil (*Mylloceros* spp adults were common which found nibbling leaf edges. Thrips (*Megaleurothrips distalis*) was found feeding in the flowers. Blister beetle (*Mylabris pustulata*) was voraciously feeding flowers. A hymenopterous pest, pod wasp (*Tanaostagmides cajaninae*) prevailed at pod initiation stage, damaging immature pods only. At reproductive stage of the crop, insect pest prevailed broadly comprised of five groups *viz.*, Lepidopteran, Hemipterans, Dipteran, Hymenpteran and Coleopterans. Podfly (*Melanagromyza obtusa*), *Helicoverpa armigera, Lampides boeticus*, plume moth (*Exelastis atomosa*) were found as potential pests. Pod weevil (*Apion clavipes*) was also prevailing throughout. Pod bugs (*Clavigralla gibbosa, C. horrens* and *Riptortus* spp and *Nezara virudula* remained prevalent right from pod formation to maturity stage and caused severe damage. The pests were observed from September to April months.



Life table of pod borers in late maturing variety of pigeonpea (NDA 1)

Blue butter fly (*Lampides boeticus*)

The survival of different stages of *L. boeticus* showed 40% mortality in the overall development from egg to pupae. The maximum numbers of eggs (m_x=47.4) were laid on the 2nd day with an average fecundity of 130.60 eggs per female in the approximate generation times of 48.28 days. The accurate and approximate estimate rate of increase was 0.07809 and 0.0780 times, respectively. The finite rate of increase was 1.081 female/female/day and the time required to double the population was 8.89 days. The maximum population was contributed by larval stage (62.24%) among the entire life cycle.



Blue butterfly

Plume moth (*Exelastis atomosa*)

The demography of plume moth was studied in the laboratory at ambient temperature on pigeonpea. Raw data were analyzed based on the age-stage, two-sex life table. The net reproduction (RO) with total female births of 149.69 clearly reflects that this pest might be able to multiply 149.69 times at the terminal of each generation. The data on intrinsic rate of increase of *E. atomosa* indicated the innate capacity for increase as 0.1135 females/female/day with a finite rate of increase (l) of 1.121 females/female/day. Thus, the population would be able to multiply weekly @ 2.236 females / female/day. The doubling time (6.027) with a potential fecundity of 377.18 eggs was estimated. The mean length of generation registered 44.13 days.

Plume moth

Pod sucking bugs (*Clavigralla gibbosa*)

The parasitisation of *Clavigralla gibbosa* was recorded due to *Gryon* sp, which is egg parasitoid. The fresh eggs are more prone to parasitize during oviposition to 36 hrs. There were no traces of egg parasitization in those eggs which were more than 84 hrs old. As high as 75% parasitization was observed in 25 to 26 hour old eggs (Table 2).

Pod bug

Podfly *Melanagromyza obtusa*

The temperature threshold of podfly at varying constant temperatures revealed that there was no egg hatch at 6°C and 9°C. At 12°C eggs and larval stages could survive, but subsequently 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 48.65, 196.55 and 144.37 for egg, larva and pupa, respectively (Table 3).

Table 2: Parasitization of *Clavigralla gibbosa* infesting pigeonpea by *Gryon* sp

Egg age(h)	No. of eggs	Parasitized eggs (number)	% parasitization
00-12	16	11	68.75
13-24	5	2	40.00
25-36	24	18	75.00
37-48	09	04	44.44
49-60	20	06	30.00
61-72	12	02	16.67
73-84	15	02	13.33
85-96	10	0	0
97-108	16	0	0
109-120	11	0	0
121-132	9	0	0

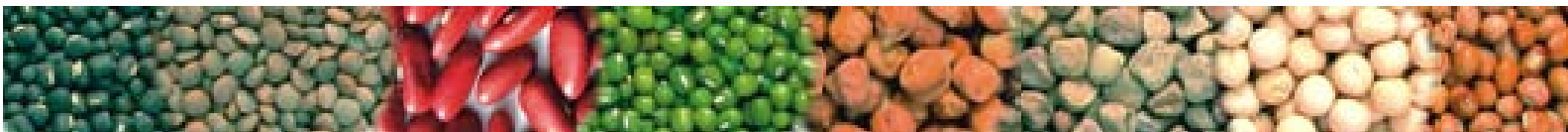
Table 3: Threshold temperature on varied temperature exposure to podfly

Temp. °C	Temperature accumulated (Egg stage)	Temperature accumulated (Larval stage)	Temperature accumulated (pupal stage)
6	No egg hatch		
9	No egg hatch		
21	57.26	230.98	143.95
24	47.34	206.76	145.87
28	58.75	216.32	166.18
32	-	-	-
36	No egg hatch 48.65*	196.55*	537*

* Mean: DD accumulation of temperatures of 12, 15,18,21,24 and 28°C

Screening against borer complex

Total 162 germplasm lines and breeding material of pigeonpea were screened for natural infestation due to insect pests, particularly borer complex. Per cent pod damage due to borers was recorded in 500 mature pods collected from 4-5 plants by stripping all the pods from 5 or 6 branches/plant of each cultivar. Based on the characteristic damage symptom of the "window" or exit hole, podfly damaged pods were counted and those with no external damage symptoms were then opened and the contents examined. Seventeen genotypes that had pod damage below 5% will be revaluated next year. Cultivar NDA 1 was used as check.



Bio-efficacy of Newer Insecticide Molecules against Major Pests of Pigeonpea

Bio-efficacy of newer insecticides *viz*., Coragen, Fame, Indoxacarb, Spinosad and Bollcure (crude) was evaluated with two dosages for management of pigeonpea pod borer complex. Mean reduction of *H.armigera* larval population 7 and 14 days after treatment exhibited superiority of Flubendiamide (Fame) @0.75 ml/l, which resulted in reduction to the extent of 95.6 and 94.3% over control, respectively. Flubendiamide was quite effective against plume moth larvae, 7 and 14 days after spray, thereby registered 82.5 and 90.7% reduction over control, respectively. Podfly damage registered pod damage merely 6.5% and grain damage with minimal 5.2% as against untreated control (18.5%). Flubendiamide treated plots registered yield of 14.7 q/ha as against 7.9/ha in untreated control. Other treatments with economic feasibility were Indoxacarb 14.5SC @0.75 ml/l and Spinosad 45SC 0.4 ml/l. Bollcure, a botanical product registered its superiority consistently over the control. The lower doses of each molecule (sub-lethal dose) were in parity to Bollcure.

NEMATODES

Root Knot Nematode *Meloidogyne javanica*

Pigeonpea

Of the 15 lines and eleven cultivars screened, three lines (BRG 11-1, BRG 10-2 and RVKT 260) were found resistant against *Meloidogyne javanica* based on gall index. Three lines Pusa 2012-1, VLA 11, TDRG 4 and three cultivars were observed moderately resistant. Rests all were susceptible.

Mungbean

Out of 31 entries, seven *viz*., GM 04-02, VGG 04-011, Pusa 1271, MH 2-15, DGG 5-4, ML 1907 and MH 805 were found resistant, whereas seven others *viz*., AKM 09-2, AKM 10-13, DGG 1, AKM 8802, IPM 02-14, Pusa 0672 and IPM 02-3 gave moderately resistant reaction and rest were susceptible.

Urdbean

Among 31 entries, only one entry KKB 05011 was found resistant and two entries RUG 10 and IPU 10-23 were observed moderately resistant. Rest were susceptible.

Chickpea

Thirty seven genotypes were screened under micro plot as well as pot conditions. Based on gall index under micro plot conditions, four genotypes *viz*., CSG 8962, ICC 15626, ICC 3428 and Pusa 512 were found resistant and eight genotypes *viz*., ICC 15646, ICC 10152, ICC 117653, ICC 14287, ICC 14780, ICC 15861, ICC 16563 and ICC 500 were observed as moderately resistant. In pot culture screening, only one genotype ICC 15626 was found moderately resistant and rest were susceptible. This indicated that genotypes observed resistant or moderately resistant under micro plot/field conditions need to be confirmed under pot culture.

Lentil

Out of 58 entries screened under micro plot condition, nine *viz*., IPL 224, RLG 157, DPL 62, IPL 406, IPL 215, PL 135, RKL 604-01, VL 145 and RKL 607-01 showed resistant reaction. Ten lines *viz*., IPL 315, IPL 533, LH 84-8, RLG 147, IPL 219, IPL 326, L 4590, L 4711, PL 141 and LL 1161 were observed as moderately resistant, which need further confirmation. Rest were susceptible.

Fieldpea

Out of 48 entries screened under micro plot condition, none was found resistant. However, seven entries *viz*., IPFD 12-2, IPFD 11-5, NDP 1200, RFP 2004-4, IPFD 12-8, KPF 10-28 and RFP 72 were observed as moderately resistant. Rest were susceptible.

Pathogenicity of Lesion Nematodes in Chickpea

In the trial on pathogenicity of lesion nematode in chickpea in plastic pots, different inoculum levels of nematode were adjusted by adding sterilized soil to the infested soil or by adding the nematodes in the soil. Nematode inoculum levels were taken 10, 100, 500, 1000, 5000 and 10000 nematodes per pot along with un-inoculated check. Four seeds of chickpea variety DCP 92-3 were sown in the pots and three plants were retained after germination in each pot. Trial was kept for 3 months before recording the observations on growth characters and nematode multiplication. Plant height, fresh and dry shoot weight and pods reduced significantly in treatments where 1000 nematodes and above were inoculated per pot as compared to check, where as fresh and dry nodule weight, root weight and branches were significantly reduced at nematode inoculum level of 5000 per pot and above (Table 4). There was increase in root and soil populations at the end of experiment with increase in initial inoculation. However, the nematode multiplication rate decreased with increase in the inoculum level. It was highest 12.1 with minimum inoculum level of 10 nematodes per pot and lowest 2.9 with maximum inoculum level of 10000 nematodes per pot.

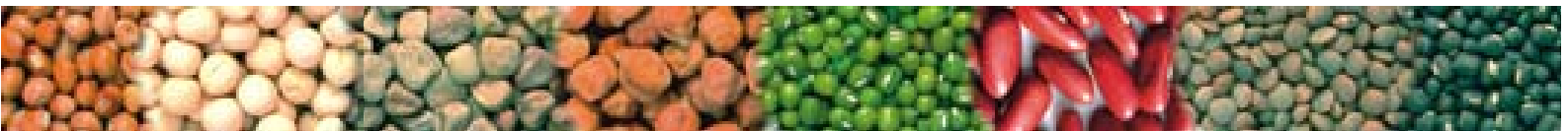


Table 4: Plant growth characters and root lesion nematode multiplication in different treatments

Average of four replications

Treatment	Fresh nodule wt. (g)	Dry nodule Wt. (mg)	Plant height (cm)	Fresh shoot Wt (g)	Dry shoot Wt (g)	Av. branches	Pods	Root population	Soil population	Total population	Multiplication rate
Check	2.22	370	26.0	13.46	3.65	12.0	14.3	-	-	-	-
10 N	2.44	409	27.2	13.39	3.56	11.3	11.5	70 (8.3)	51 (7.1)	121 (11.0)	12.1
100 N	2.35	382	25.4	13.25	3.42	11.0	12.8	477 (21.5)	378 (19.4)	855 (29.1)	8.5
500 N	2.16	381	25.6	12.51	3.18	10.8	9.0	1738 (41.1)	1885 (43.2)	3623 (60.1)	7.2
1000 N	1.84	341	25.0	11.55	2.87	10.5	7.3	3507 (59.2)	2280 (47.0)	5787 (75.9)	5.8
5000 N	1.51	308	24.6	9.44	2.72	9.5	6.3	8778 (93.5)	6570 (80.9)	15348 (123.8)	3.1
10000 N	1.16	278	24.0	8.52	2.21	9.2	3.8	12742 (112.5)	16160 (127.0)	28902 (169.7)	2.9
CD at 5%	0.45	55	2.0	1.81	0.67	1.6	6.4	(9.7)	(8.5)	(9.4)	1.7

N: Lesion nematodes

'Figures in parentheses are square root transformations

Standardization of screening technique using nematode multiplication and lesions on the roots

The experiment was carried out in plastic pots filled with steam sterilized soil. Three chickpea seeds of cv. DPC 92-3 were sown in each pot and one plant was retained after germination. Five levels of inoculum 250, 500, 1000, 2000 and 3000 nematodes per pot were added. Two months after inoculation, the plants were removed and lesions were counted on the roots along with nematode multiplication. The number of lesions were 25, 80, 131, 142 and 131 with 250, 500, 1000, 2000 and 3000 nematode inoculation, respectively. Similarly, rate of nematode multiplication was 4.8, 3.7, 3.5, 2.4 and 2.3 when 250, 500, 1000, 2000 and 3000 nematodes were inoculated (Table 5). The counting of lesions on the roots was not found feasible. The nematode multiplication index of the accessions in relation to highly susceptible check was proposed for assessing the reaction of the plant to *Pratylenchus*. The nematode multiplication index (NMI) could be calculated as:

$$NMI = \frac{\text{Total nematode population multiplied on test accession}}{\text{Total nematode population multiplied on susceptible check}} \times 100$$

Based on the NMI the scale for resistance was proposed as follows:

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

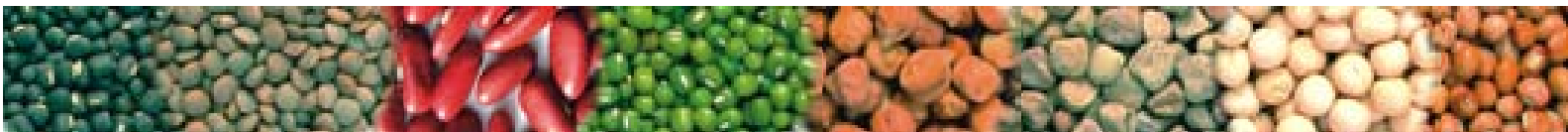
Table 5: Root lesions and nematode multiplication with different inoculum levels of *Pratylenchus* in chickpea plants

Inoculation level	No. of lesions	Root population	Soil Population	Total population	Multiplication Rate
250	25	658	540	1198	4.8
500	80	1007	855	1862	3.7
1000	131	1950	1524	3474	3.5
2000	142	2712	2050	4762	2.4
3000	131	4278	2500	6778	2.3

Biological Control of *M. Javanica* and *H. Cajani* by *Paecilomyces lilacinus* in *Vigna* and Chickpea

Four strains of *Paecilomyces lilacinus viz.*, NBAII 56, 57, 58 and 72 were procured from NBAII, Bangalore to test nematode management in pulses. Efficacy of these strains were tested in different studies *viz.*, egg mass assay, cyst assay, adult female assay and effect on egg hatching. The results showed that all strains were equally effective in infection and suppression of nematode growth in laboratory condition. Green house and micro plot study was conducted to test its potential for management of root knot nematode in *Vigna* crops during *kharif* and chickpea in *rabi* season. Results showed that during *kharif* the strains were effective in suppression of nematode population and during *rabi* the effect was moderate.

Compatibility test of *Trichoderma* with *Paecilomyces* was carried out. *Trichoderma* is faster than *P. lilacinus* and there is no adverse effect on each other. Compatability test of *Fusarium oxysporum* f.sp. *ciceri*, *F. udum* and *Rhizactonia bataticola* was also carried out. *P.*



lilacinus found to have compatible relationship with all these organisms.

EXTERNALLY FUNDED PROJECTS

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

A survey was conducted in five district of Uttar Pradesh (Agra, Mathura, Aligarh, Bulandshahar and Meerut) and IIPR farm. Total 109 samples of different crops (Chickpea, lentil, rajmash, mungbean, urdbean, cowpea, fieldpea, wild *Vigna*, dolichos and ageratum weed) were collected and processed for the detection of associated viruses. Total DNA and RNA from 93 and 16 samples, respectively were successfully extracted for detection and molecular characterization of associated viruses.

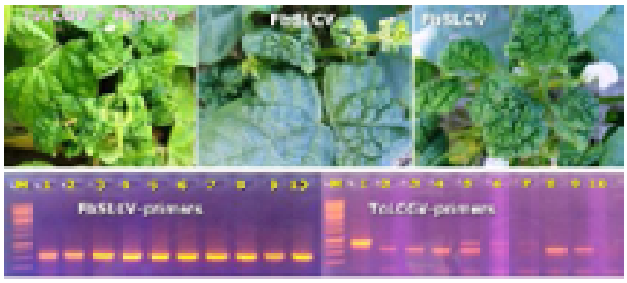


Fig. 8: Leaf curling/crumpling symptoms on rajmash. Gel photographs of PCR amplified products.

Leaf curling/crumpling symptoms on rajmash were observed and ten such samples were tested for detection of FbSLCV and ToLCGV in the PCR using specific primers. All the samples were found positive with FbSLCV, however, only three samples gave positive reaction with ToLCGV also in which one gave very strong positive reaction. This indicates that three samples had mixed infection (Fig. 8). *Tomato leaf curl Gujarat virus* was characterized for the first time from rajmash. Leaf curling, reddening of leaf and stunted growth in lentil plants were observed and six such samples were processed for detection of viruses. Two of these samples were processed using RCA technique for getting the whole genome of the virus. Both samples gave 2.7kb DNA fragments as a result of restriction digestion with enzymes and this indicated that these samples had the infection of some gemini viruses (Fig. 9). The 16 pairs of primers specific for the detection of 6 viruses have been designed by primer-blast software as well as manually using virus sequences obtained from the infected samples of pulse crops. Simplex-PCR for the detection of Tomato leaf curl New Delhi virus, Tomato leaf curl Gujarat virus, French bean leaf curl virus and French bean severe leaf curl virus has been standardized.

Fig. 9: Symptoms of viral etiology on lentil plants. Gel photograph of RCA products restrict digested with enzymes yielded 2.7kb DNA fragments.

Two kits named as "LYMVs PCR Diagnostic Kit" (Fig. 10) and "LYMVs Direct PCR Kit" (Fig. 11) have been developed for detection of legume yellow mosaic viruses (MYMIV, MYMV, HgYMV, DoYMV). Multiplex-PCR Kit for detection of four viruses (MYMIV, MYMV, HgYMV and DoYMV) has also been developed. LYMVs PCR Diagnostic Kit consists of a working protocol, four pairs of primers specific for amplification of target virus(es) in the samples, DNA of all the four target viruses to be used as "Positive Control", master mix (2x) and nuclease free water.

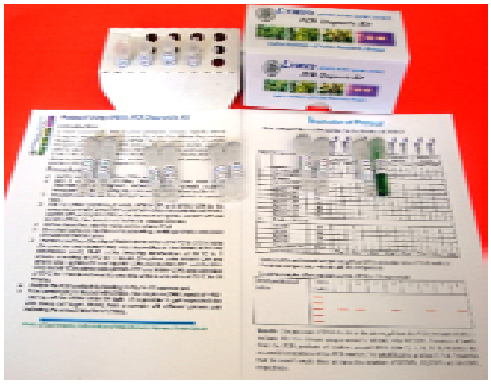
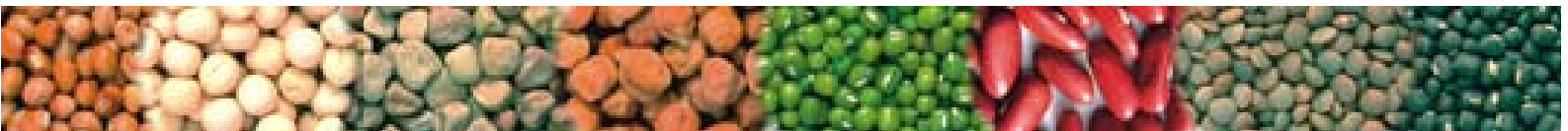


Fig. 10: LYMVs PCR Diagnostic Kit

LYMVs Direct PCR Kit is similar to LYMVs PCR Diagnostic Kit. The only difference is in the PCR master mix (2x). In this PCR master mix, Phire Hot Start II DNA Polymerase and 2X Phire Plant PCR Buffer are used, which does not require isolation of DNA from the sample and instead the sample is directly used in the recation mixture. Hence this kit named as "LYMVs Direct PCR Kit". This kit consists of a working protocol, four pairs of primers specific for the amplification of target virus in the samples, DNA of all the four target viruses to be used as "Positive Control", 2x Phire Plant PCR Buffer, Phire Hot Start II DNA Polymerase and nuclease free water.



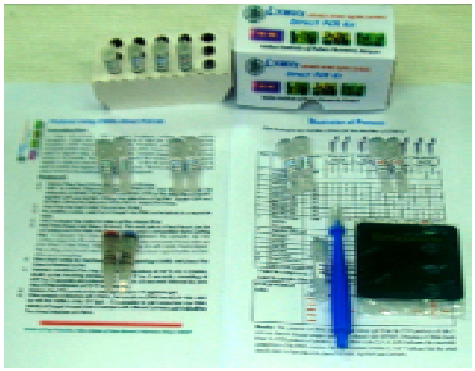


Fig. 11: Direct PCR Kit

Out-reach Project on Diagnosis and Management of Leaf Spot Diseases of Field and Horticultural Crops: Cercospora Leaf Spot of Mungbean and Urdbean

Colony characters of *Cercospora canascens*

Fourteen isolates of *Cercospora canescens* were grown on PDA at five different temperature levels (20, 25, 30, 35 and 40^{0}C). None of the isolates could grow at 40^{0}C. Colony diameter ranged between 16.3-30.3 mm at 30^{0}C, between 15.1-26 mm at 25^{0}C and between 12.1-27 mm at 20 ^{0}C. Data indicated that temperature between 25-30^{0}C was best for the optimum growth in most of the isolates. Most of the isolates had fluffy growth pattern with grayish white mycelium. In some isolates pinkish pigmentation was observed in the substrate. Sporulation could not be observed in any of the isolates at any temperature.

Variability in pathogenicity levels

Tests were conducted using detached leaf from 15 day old plants of mungbean variety Kopergaon and 15 day old plants grown in pots. Fourteen isolates of *Cercospora canescens* were used. Detached leaves were surface sterilized with 5% sodium hypochlorite, inoculated by placing of 2.5 mm mycelium disc of 15 day old culture of *C. canescens* isolate and incubated at 27^{0}C, 90% humidity and 12 hrs light and darkness cycle. Fifteen day old plants grown in pots were inoculated *in situ* by spraying the mycelial suspension of 15 day old culture of *C. canescens* isolates and maintained under high humidity for 48 hrs after inoculation. Isolates varied in their pathogenic ability in terms of number of spots per leaf, which was more when plants were inoculated with aqueous suspension of mycelium in most of the isolates (3–8 spots/leaf) than in case of detached leaves (1-6 spots/leaf). Based on number of spots/leaf in spray inoculated plants, the isolates were grouped in three categories as weakly pathogenic (0.1 – 4.0), moderately pathogenic (4.1 – 7.0) and highly pathogenic (7.0 – 10.0).

Effect of different media

Different media were used to evaluate their suitability for growth and spore induction using two isolates CLS 72 and CLS 79. These isolates were grown on nine different solid media (Potato carrot agar, peptone dextrose agar, fungal agar, czapek dox agar, V8 juice agar, rose Bengal agar, yeast extract dextrose agar, oat meal dextrose agar, potato dextrose agar) to ascertain the best medium for growth of the pathogen. Average radial growth of the mycelium was taken separately for both isolates after ten days of incubation at 27^{0}C. The best growth (colony diameter 42-43 mm) of the fungus was observed on PDA media, followed by fungal agar and yeast extract dextrose agar (colony diameter 40-41.5 mm). Oat meal dextrose agar and potato carrot agar media were also good in supporting the growth of both the isolates. Sporulation was, however not observed in any of the media. In most of the media, initial mycelial growth was slow, fluffy with pale white aerial mycelium. Later, grayish and pinkish pigmentation was prominent.

Induction of sporulation in *Cercospora canescens* culture

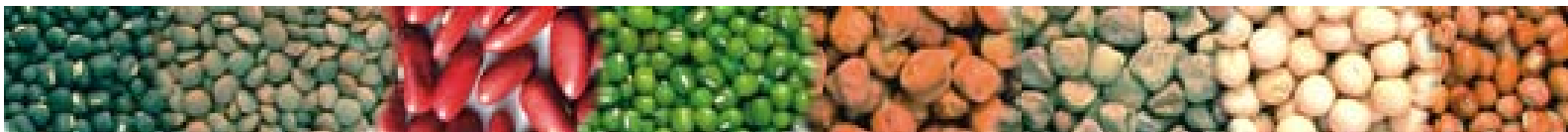
Sporulation in culture of *Cercospora* is not commonly observed. To induce sporulation in culture, fourteen isolates *viz.*, CLS 87, CLS 27, CLS 77, CLS 72, CLS 73, CLS 81, CLS 34, CLS 78, CLS 75, CLS 55, CLS 80, CLS 74, CLS 79 and CLS 71 were grown on various organic substances *viz.*, bajara grain, ground bajara grain, jowar, ground maize, wheat and barley at 25^{0}C. Sporulation was not observed in any of the media.

Management of foliar diseases through bio-agent and elicitors

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, IPT 21 and Pseudomonas were used. Elicitors like salicylic acid and amino butyric acid were also evaluated for their role in disease management in mungbean. Data indicated that seed treatment with IPT 10+21 and 2 foliar sprays of the same in consortium at 30+45 DAS was best with lowest disease incidence (12.66%). This was followed by seed treatment with IPT 10+IPT 11 and 2 foliar sprays of the same in consortium at 30+45 DAS with the disease incidence as 15.66%. Results indicated that *Trichoderma* isolates in consortium are effective in reducing the CLS severity significantly.

Integrated management of CLS

Experiment was conducted to integrate chemical and biological approaches to develop an integrated



management strategy for fungal foliar diseases in *kharif* mungbean. Treatments involved seed treatment either with bio-agent (*Trichoderma* isolate IPT 10) or with carbendazim. Data showed that the experiment involving seed treatment with bio-agent (*Trichoderma* isolate IPT 10) and two foliar spray of carbendazim (1.0g/l) + Dimethoate (1.0ml/l) at 30+45 DAS resulted in minimum disease severity (0.66%) and maximum grain yield (778 kg/ha). Data indicated that incorporation of an insecticide with fungicide helps increasing the grain yield.

Host plant resistance

Total 148 genotypes of mungbean and urdbean were screened in the nursery. CLS infected ground leaves of mungbean were sprayed over genotypes to increase disease buildup. Genotypes were graded on 1-9 scale. None of the mungbean genotypes was found resistant to CLS, however five genotypes *viz.*, HUM 16, GG 46, AKM 8803, Co 4 and BM 11 were moderately resistant. Six urdbean genotypes *viz.*, EL 48, 15/7, PLU 707, IPU 99-219, MP 19 and IPU 98/136 showed resistant reaction. Disease reaction of rest of the genotypes was susceptible to highly susceptible.

Reaction of some wild accessions of *Vigna* to CLS in field

Vigna radiata (acc. nos. TCR 81, 82, 219, JAM/09-29,), *Vigna mungo* (TCR 41, 42, 43, 44, 45), *Vigna mungo* var. *mungo* (acc. nos.TCR 31, 33, 34, 35, 38), *Vigna radiata* var. *radiata* (acc. nos.TCR 78, 73, 74, 0, 75), *Vigna radiata* var. *sublobata* (acc. nos.TCR 218, 64, 238, JAP/10-36), *Vigna mungo* var. *sylvestris* (acc. nos.TCR 265, 256, 254, 260, 390), *Vigna radiata* var. *setulosa* (acc. nos.TCR 71, 67, 8, 110, JAP/10-47) *V. pilosa* (TCR 122, 127), *V. dalzelliara* (acc. nos.TCR 204, 199), *V. vexillata* (acc. nos.TCR 157, 160), *V. tritobata* (acc. nos.TCR 83, 84, 86, LRM/13-43, 34, 32, 24, 30, JAP/10-5, 9, 7, TCR-192, 243, 305, 319, 320, 513), *V. umbellate* (acc. nos.TCR 88, 89, 91, 92, 93, PRR-2007-2, 2008-2, RB-5-1, TCR-87, 90, 94, 95), *V. acontifolia* (acc. nos.LRM/13-11, LRM/13-44), *V. stipulaceae* (acc. nos.LRM/13-33, 26, 37, 38, 36), *V. hainiana* (acc. nos.TCR 314, 24, 29, 315), *V. glabrescence* (acc. no.TCR 20), *V. trinervia* (acc. no.JAP/10-51), *V. unguiculata* (acc. nos.TCR-284, NSB-007) and Urd seed (85) were found resistant to CLS, whereas accessions *Vigna radiata* (TCR 80), *Vigna radiata* var. *radiata* (TCR 79), *Vigna radiata* var. *sublobata* (TCR 188, 239, 7), *Vigna mungo* var. *sylvestris* (TCR 262), *V. pilosa* (TCR 123,), *V. dalzelliara* (TCR 9, 10, 325), *V. unguiculata* (TCR 279) and Mung seed I (12) were moderately resistant.

Influence of weather on disease development

CLS disease development was studied in two mungbean varieties *viz.*, Kopergaon and Narendra Mung 1. Fifty plants of each genotype were tagged and observation on disease was recorded at weekly intervals. CLS was first noticed on 13 September in both the genotypes and gradually increased, and by the end of October it reached 16.40 and 17.50, respectively in Kopergaon and Narendra Mung 1 (Table 6). Data indicated that minimum temperature around 22 ^{0}C or below helps develop disease more quickly.

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

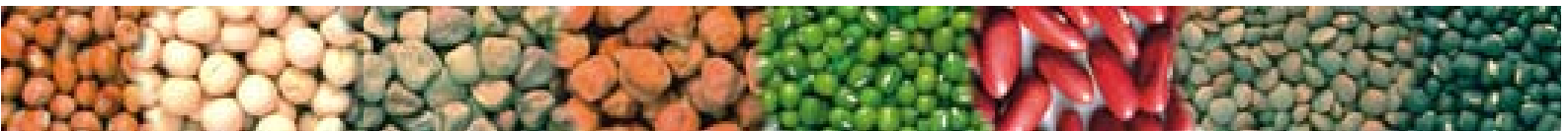
Pigeonpea Wilt

Biodiversity

Fifty isolates of *Fusarium udum* were subjected to their pathogenic potential on pigeonpea wilt differentials. Based on reaction of differential genotypes, 33 isolates were categorised in to 7 variants. Seventeen isolates however could not be grouped in any of the seven variants. Most of the isolates (13) resembled variant 1, whereas 8 and 6 isolates resembled variant 2 and 3, respectively. Three isolates resembled variant 4, whereas one isolate each belonged to variant 5, 6 and 7, respectively. Results indicated vast pathogenic diversity in isolates of wilt pathogen, *Fusarium udum*.

Table 6: Cercospora leaf spot development in Narendra Mung 1 and Kopergaon

Date	Mean % disease		Temperature ^{0}C		Relative humidity (%)		Evaporation rate (mm/days)	Wind speed (km/hr)		Sunshine hrs.	Rainfall
	NM 1	Kopergaon	Max.	Min.	8.30	17.30		8.30	17.30		
16.9.13	0.00	0.00	33.2	24.2	73	64	4.25	0.07	0.67	7.00	1.25
23.9.13	0.50	0.40	34.1	24.1	76	68	5.25	1.14	3.67	7.15	0.48
30.9.13	1.00	1.50	32.4	23.0	76	73	7.88	0.9	4.22	5.31	20.00
7.10.13	3.50	3.00	30.17	22.5	85	75	3.33	0.54	3.40	5.17	1.11
14.10.13	8.50	7.80	30.51	21.18	76	69	3.82	0.56	1.9	5.91	0.58
21.10.13	12.33	13.42	32.14	19.24	72	53	4.02	0.01	0.87	7.72	0.00
28.10.13	16.40	17.50	32.37	17.88	70	55	4.48	0.01	0.91	7.8	0.00



Host resistance

Total 398 entries of pigeonpea were screened against wilt. Of the 30 wilt donors screened, IPA 383B showed highly resistant reaction, whereas six genotypes (GPS 33, BSMR 853, PI397430 Sel, ICP 89048, ICP 93012 and AWR 74/15) were recorded as resistant. Nine others were moderately resistant, whereas 14 showed susceptible reaction. Out of fourteen promising lines of IIPR Kanpur screened in wilt sick plot, four lines *viz*., DPPA 85-3, DPPA 85-13, IPA 38 and ICP 7200 were found moderately resistant, while others were susceptible. None of the nine long duration pigeonpea lines received from Pigeonpea Coordination unit was resistant. Only one line IPA 2012-2 showed moderately resistant reaction. All the ten lines received from Coordinator, Hybrid Pigeonpea Project (NFSM) showed highly susceptible reaction to wilt. Of the eleven wilt differentials, none showed resistant reaction. ICP 9174, ICP 8859, ICP 8858, C 11 and ICP 8863 showed moderately resistant reaction with mortality between >10-30%, whereas MA 3, MAL 13, BDN 1, BDN 2, MAL 13 and Bahar showed susceptible reaction. Of the 18 multi-disease resistant (MDR) lines, only one line GPS 30 showed resistance, whereas 5 lines *viz*., PH 1063, IPA 16 F, MAL 19, ICP 8859 and BSMR 843 showed moderate resistance to wilt.

Chickpea Wilt

Biodiversity

Fifty nine isolates of *F. oxysporum* f. sp. *ciceri* were tested for their pathogenic potential on 14 differential genotypes. Disease reaction of differential genotypes indicated presence of 4 races (race 2, 3, 4 and race 5). Majority of the isolates (42) resembled race 2 of *F.oxysporum* f. sp. *ciceri*.

Host plant resistance

Twenty four lines of chickpea known for their resistance to wilt were further screened in the wilt sick field. Eighteen *viz*., IPC 2005–3,–15,–18, –19, –24, –30, –34, –35, –37, –41A, –41B, –44, –45, –46, –54, –62 and IPC 2005 –64 maintained resistant reaction, whereas five lines *viz*., IPC 2004–34, IPC 2005–8, –26, – 27 and IPC 2005 – 59 turned into moderately resistant.

Management

Fifteen isolates of *Trichoderma* received from Project Coordinator, Phytofura were evaluated for their efficiency against chickpea wilt. Six isolates *viz*., T 2, T 3, T 4, T 5, T 9 and T 12 reduced the wilt by 32-39%. Two isolates T 7 and T 10 appeared least effective as the reduction in wilt was less than 10%, whereas other seven isolates reduced wilt around 25%.

Molecular Diagnostics: Development of Diagnostic Marker for Identification of *Fusarium* Sp.

To develop the diagnostic markers species specific for races and variants, SRAP-RGA and RAPD markers were employed for genome wide scanning in reference set of six races and five variants. For molecular analysis, 26 SRAP-RGA coupled markers combinations were screened and ten unique reproducible bands specific to races (1 and 5) and variants (1, 3 and 5) were found and successfully sequenced seven PCR eluted samples. Based on the sequence information obtained from the sequence data, seven primer pairs specific to race and variant were designed and validated in reference set. Based on the result, only one primer specific to race 5 was able to reproduce exactly the same as in reference set. The sequence synteny was also confirmed by using NCBI-BLAST analysis. A schematic diagram for development of diagnostic marker through SRAP-RGA is shown in Fig. 12.

Degenerate primer *viz*., random amplified polymorphic DNA (RAPD) markers were also deployed to develop appropriate diagnostic markers to identify *F. udum* and *F. oxysporum* f. sp *ciceri* in reference set of six races and five variants identified in IIPR, Kanpur. Total 39 RAPD markers were screened, where ten

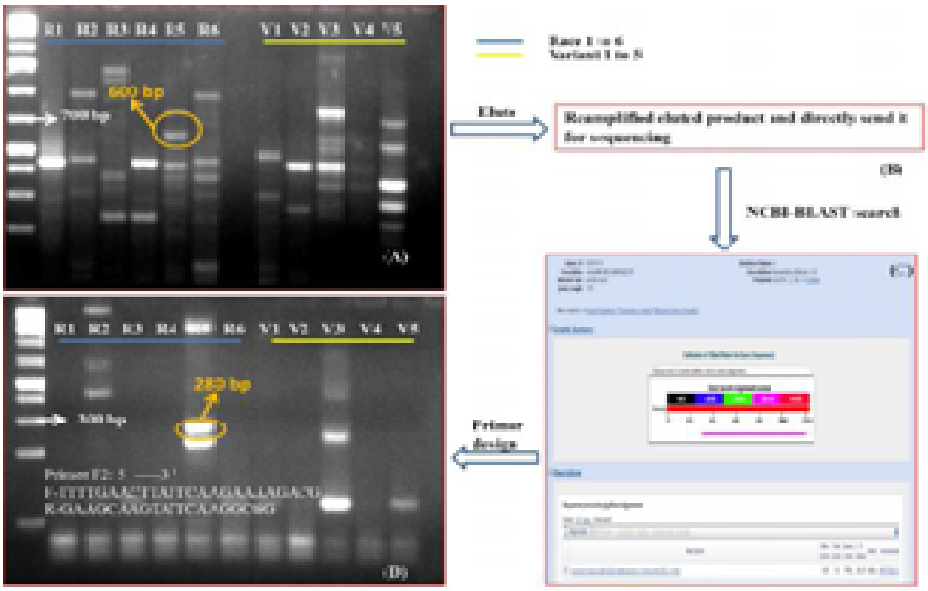
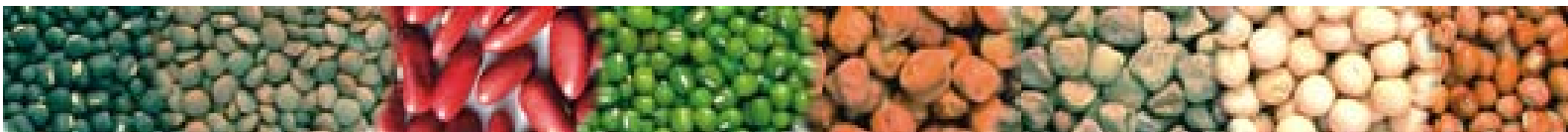


Fig. 12: A schematic diagram for development of Race-5 specific diagnostic marker. [M: 1 kb plus ladder]



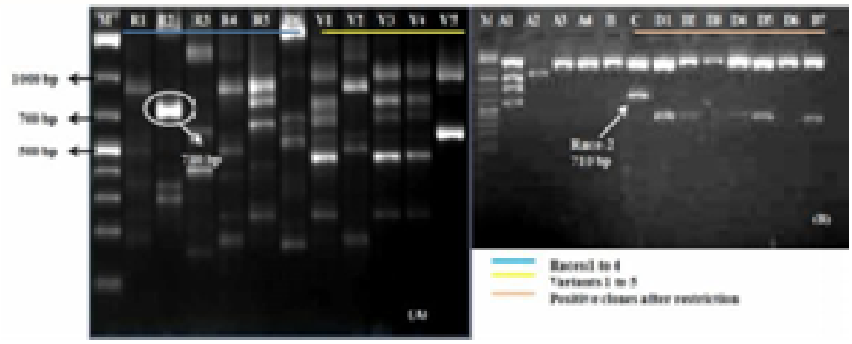


Fig. 13: Gel photograph (A) showing unique band for race 2 and Gel photograph (B) showing restriction pattern of positive clones plasmid. [M: 1 kb plus ladder]

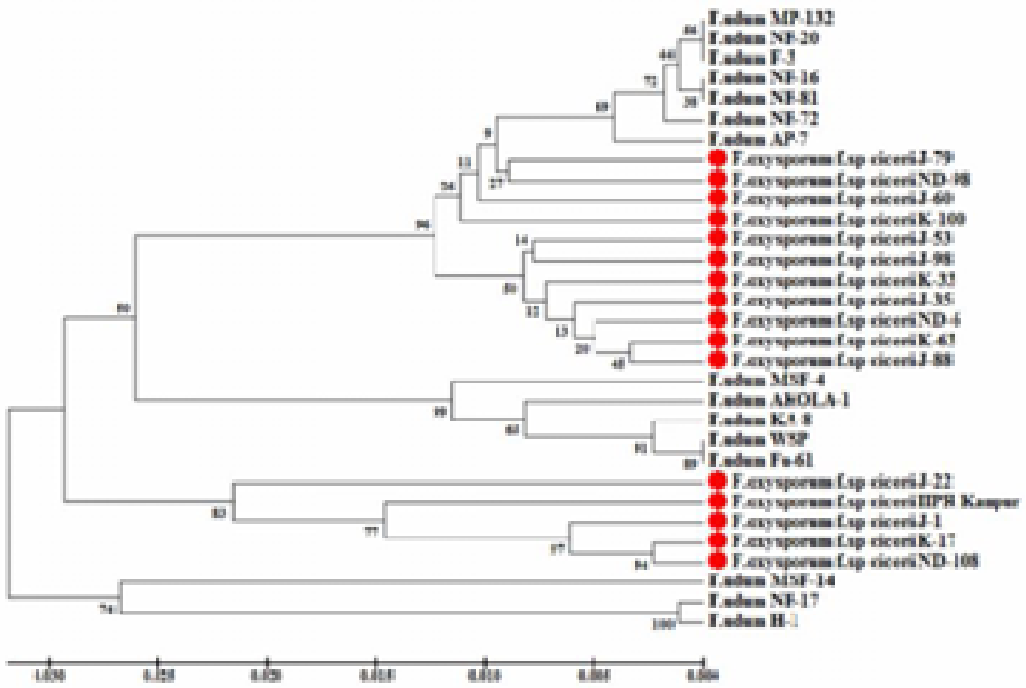
markers gave 13 unique bands for the particular race as shown in Table 7. The unique amplicon amplified by the RAPD primers (Fig. 13A) was excised and purified using the QIAquick Gel extraction kit from 0.8% agarose gel and cloned into pTZ57R/T vector. The recombinants were screened through blue/white selection in LB/Ampicillin/X-gal/IPTG plate and positive recombinant plasmid was isolated from each overnight grown colony and presence of insert was confirmed by restriction digestion using *Xba*I and *Sma*I restriction enzymes (Fig. 13B). Two of the recombinants gave positive result of restriction digestion and were sequenced by outsourcing using vector specific universal promoter primer (M13). These sequence will be further use for diagnostic primer designing.

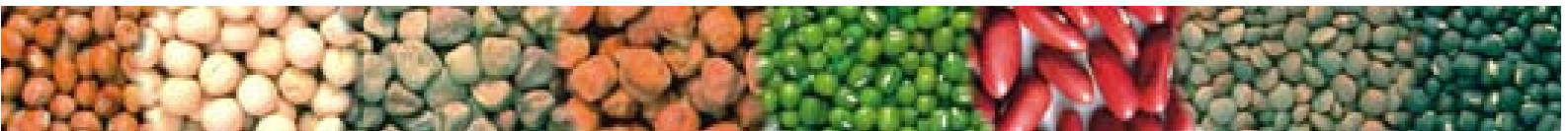
Table 7: List of reproducible unique bands derived from RAPD primers

Primer name	Specific organism	Size (bp)
OPO-02	Race-6 and Variant-5	390 and 2000
OPO-07	Race-6	880
OPO-08	Race-3	710
OPP-10	Race-6 and Variant-5	250 and 1200
OPP-13	Race-3 and Variant-5	230 and 320
OPP-14	Race-4	500
OPO-04	Race-4	320
OPL-02	Variant-5	680
OPP-09	Race-2	250
OPL-01	Race-3	450

Sequence Variation in Internal Transcriber Spacer Region of *Fusarium udum* and *Fusarium oxysporum f.* sp. *ciceri*

Internal transcriber spacer (ITS) regions are known to be the highly conserved domain across the eukaryotic genome. To classify the *Fusarium* species, ITS marker system was used to amplified ITS fragments (680-800bp) of 34 isolates representing *F. udum* as well as *F. oxysporum f.* sp.*ciceri* and these region were sequenced by outsourcing (Bangalore Genei, India). The nucleotide sequences were subjected to BLAST analysis (http://www.ncbi.nih.gov/index.html) to find out the synteny between the species. A phylogenetic tree was reconstructed following UPGMA algorithum using the MEGA 5.2 software with 100 bootstrap replicates (Fig. below).





Developing Strategic and Holistic Pest Management Modules in Legume Based Cropping System and Its Authentication

Insect pests and disease dynamics in chickpea *vis-à-vis* biotic and abiotic factors

The occurrence of *H. armigera* larvae was noticed in 10th standard meteorological week with intensity of 0.07 larva/plant and reached maximum at 13th standard week with intensity of 0.27 larva/plants and 12.06% pod infestation.

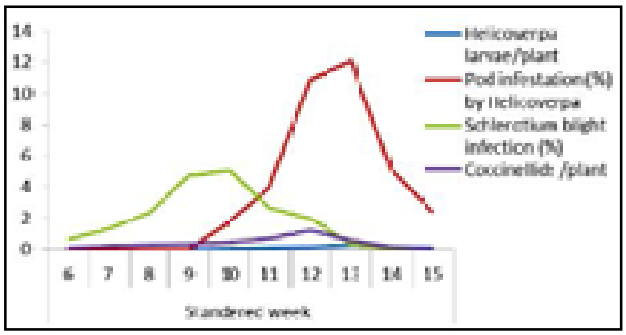


Fig. 14: Insect pest, disease and natural enemies dynamics in chickpea

The *schlerotium* blight on chickpea appeared in 6th SMW with 0.67% infection and reached higher, recorded during 10th SMW with 5.00% incidence. Thereafter, it declined in subsequent weeks. Intensity of coccinellid was noticed in 6th SMW with 0.13 individual/plant and recorded as high as 1.23 individuals/plant in 12th SMW (Fig. 14).

Development of integrated pest management modules in chickpea cropping systems

Application of full IPM components, STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole was found most effective with minimum larval intensity 0.10/plant after one day, 0.07/plant at 3 days, 0.07/plant at 7 days, 0.03/plant at 21 days, zero level at 28 days and mean larval population 0.05 /plant was noticed, followed by WST-FIR-Sole-NSKE-Chlorantraniliprole which provided 0.17, 0.13, 0.10, 0.03, 0.00 larvae/plant at respective days and mean larval population 0.09/plant was noticed (Table 8).

Application of full IPM components, STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole was found most remunerative with minimum pod infestation 4.97, 4.08, 2.49, 1.42, 0.00 per cent and mean infestation 2.59% noticed, followed by effective module WST-FIR-Sole-NSKE-Chlorantraniliprole with 5.60, 4.98, 3.62, 2.36, 0.00 per cent pod infestation, respectively (Table 9).

The IPM component STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole was found most effective based on larval intensity and pod infestation, but maximum yield was recorded by WST-FIR-Sole-NSKE-Chlorantraniliprole with 15.56 q/ha. The maximum economic yield Rs. 58,330/ha was noticed with STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole, followed by STT-FIR- Ic.Coriander-Indoxacarb-Spinosad with economic yield Rs. 57,870/ ha (Table 10).

Table 8: Effectiveness of IPM modules based on larval intensity of *H. armigera* in chickpea

IPM Module	*H. armigera* larval intensity/plant after application of full IPM modules					
	1 day	3 days	7 days	14 days	21 days	Mean
STT-FIR-Ic.Coriander-NSKE-Flubendiamide	0.30	0.27	0.23	0.17	0.13	0.22
STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole	0.10	0.07	0.07	0.03	0.00	0.05
STT-FIR- Ic.Coriander-Indoxacarb-Spinosad	0.20	0.17	0.13	0.07	0.03	0.12
WST-FIR-Sole-NSKE-Flubendiamide	0.27	0.23	0.20	0.13	0.10	0.19
WST-FIR-Sole-NSKE-Chlorantraniliprole	0.17	0.13	0.10	0.03	0.00	0.09
WST-FIR-Sole-Indoxacarb-Spinosad	0.23	0.20	0.17	0.10	0.07	0.15

Table 9: Effectiveness of IPM modules based on pod infestation by *H. armigera* in chickpea

IPM Modules	% pod infestation by *H. armigera* after application of full IPM modules					
	1 day	3 days	7 days	14 days	21 days	Mean
STT-FIR-Ic.Coriander-NSKE-Flubendiamide	10.80	9.00	7.21	6.13	3.96	7.42
STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole	4.97	4.08	2.49	1.42	0.00	2.59
STT-FIR-Ic.Coriander-Indoxacarb-Spinosad	7.43	6.18	4.72	3.09	0.72	4.33
WST-FIR-Sole-NSKE-Flubendiamide	9.65	8.19	6.20	5.11	2.55	6.34
WST-FIR-Sole-NSKE-Chlorantraniliprole	5.60	4.98	3.62	2.36	0.00	3.31
WST-FIR-Sole-Indoxacarb-Spinosad	8.65	7.15	5.64	4.14	1.68	5.45

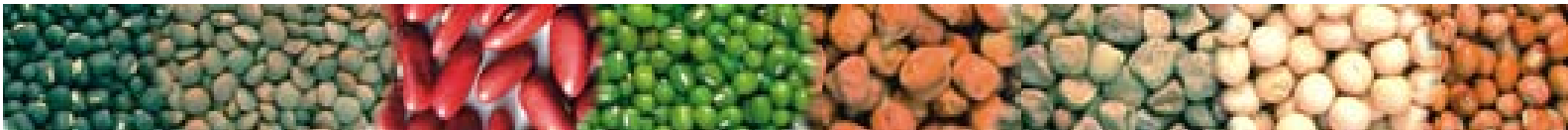


Table 10: Economics of IPM modules in relation to chickpea yield

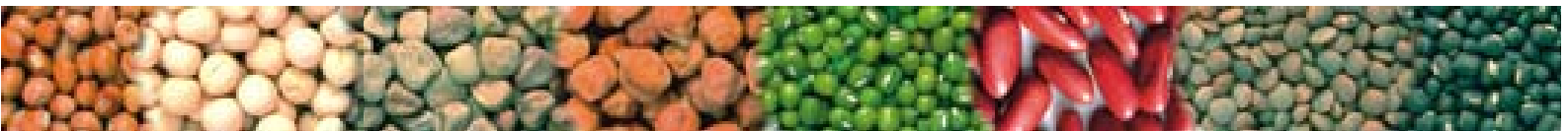
IPM Module	Yield (q/ha)		Economic yield (Rs./ha)	Additional income (Rs./ha)	Total cost of IPM modules (Rs./ha)	Cost benefit Ratio
	Chickpea	Coriander				
STT-FIR-Ic.Coriander-NSKE-Flubendiamide	13.28	1.37	52855	21355	4408	1: 4.84
STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole	15.00	1.40	58330	26830	4916	1: 5.46
STT-FIR- Ic.Coriander-Indoxacarb-Spinosad	14.92	1.38	57870	26370	6030	1: 4.37
WST-FIR-Sole-NSKE-Flubendiamide	14.50	-	43500	12000	4408	1: 2.72
WST-FIR-Sole-NSKE-Chlorantraniliprole	15.56	-	46680	15180	4916	1: 3.09
WST-FIR-Sole-Indoxacarb-Spinosad	14.81	-	44430	12930	6030	1: 2.14
Control	10.50		31500	-	-	-

The results showed that application of STT-FIR-Ic.Coriander-NSKE-Chlorantraniliprole was found more economic with highest cost benefit ratio 1:5.46, followed by STT-FIR-Ic.Coriander-NSKE-Flubendiamide (1:4.48), and STT-FIR- Ic.Coriander-Indoxacarb-Spinosad (1:4.37). The module ST-FIR-Sole-Indoxacarb-Spinosad was found least effective in comparison of other IPM modules.

Crop Pest Surveillance and Advisory Project (CROPSAP)

During 2013-14, pigeonpea pest and disease management advisories were communicated online to more than 100 stakeholders and beneficiaries during 38 SMW to 52 SMW.

Similarly, the pest and disease advisories though e-governance was transmitted during 46th SMW to 7th SMW to different Talukas of the state agriculture departments and other stake holders associated with CROPSAP.



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

One hundred chickpea genotypes including released varieties and ICRISAT Minicore were sown under (i) normal and late sowing with irrigation, and (ii) normal and late sowing without irrigation. The results indicated that no significant changes occurred in weight of hundred seed weight (Table 11) suggesting that sink development under combined stress is not significantly affected. Growth of the crop or biomass accumulation was severely affected under late sown condition when crop was subjected to both stresses such as heat and drought, which influenced grain yield (Fig. 15) through drastic reduction of pod number, filled pods and biomass. Reduced biomass could be due to shorter maturity period, advanced flowering, less number of fruiting branches, followed by rapid senescence.

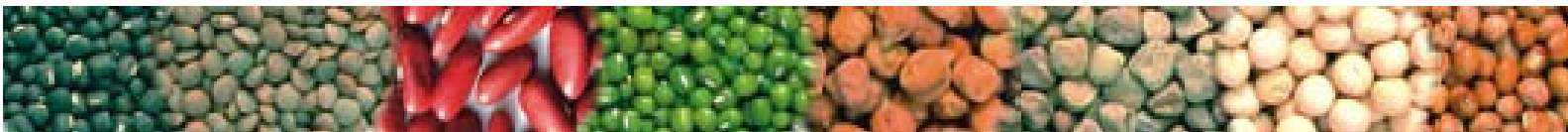
Based upon grain yield under late sown without irrigation conditions, top 15 genotypes were identified as tolerant to both heat and drought (Table 12). Better performing genotypes were attributed by higher leaf area index, higher nodulation at initial stages. Genotypes showing higher initial leaf area index and biomass under combined stress were Katila, Avrodhi, Vaibhav, GCP 105, JG 11, BG 396, Vijay, RSG 888, BGD-72, GNG 469, GNG 1958 and vishal. Some of these

Table 11: Yield attributing traits under different combination of stresses

Treatment	Mean Flower (days)	POD 1st (days)	Maturity (days)	Bio (Kg) /plot	Wt (kg)	Total pods	Filled pods	Empty pods	Ratio E/F pods	Seed number	Seed wt (kg) /plot	100 seed wt. (g)
					3 plants							
Normal irrigated (No stress)	87.6	97.1	135.5	0.788	0.060	134.5	121.6	15.5	0.13	159.6	25.6	18.1
Late irrigated (Heat)	64.6	70.6	105.0	0.392	0.031	83.6	72.2	11.4	0.16	96.0	14.3	17.8
Normal rainfed (Drought)	84.4	94.4	133.1	0.788	0.053	124.8	115.5	9.6	0.08	161.5	25.6	18.0
Late rainfed (Heat x Drought)	64.7	70.8	103.3	0.254	0.024	57.9	48.4	9.5	0.20	63.8	9.8	16.8
LSD (0.05)	4.2	3.6	1.4	0.133	0.006	12.6	14,5	0.6	0.02	17.3	2.4	1.8

Table 12: Selected genotypes having tolerance to heat and drought or both the stresses

Heat	Heat and drought	Drought	Sensitive to both drought and heat
JG 63	Rajas	BDG 72	--
ICC 1205	Vijay	Katila	Kripa
ICCV 92944	RSG 143-1	ICC 4958	ICC 5912
GNG 1488	Vishal	ICCV 10	ICCV 2
JG 11	ICC-1098	K 850	JKG 1
BDG 72	RSG 44	GNG 1488	ICC 10685
Dohad Yellow	RSG 902	GPF 2	Pusa 1053
GPF 2	RSG 888	Dohad Yellow	ICC 2720
ICC 4958	Digvijay	Annegiri	PBG 5
Vishal	Katila	C 23(M-10)	ICCV 10
GJG 3	Annegiri	GNG 469	Pant G 114
BG 396	JG 74	ICC 4958	--
Annegiri	GJG 3	GNG 1958	--
JG 74	ICC 4958	BG 396	--
Avrodhi	Avrodhi	Pusa 391	--



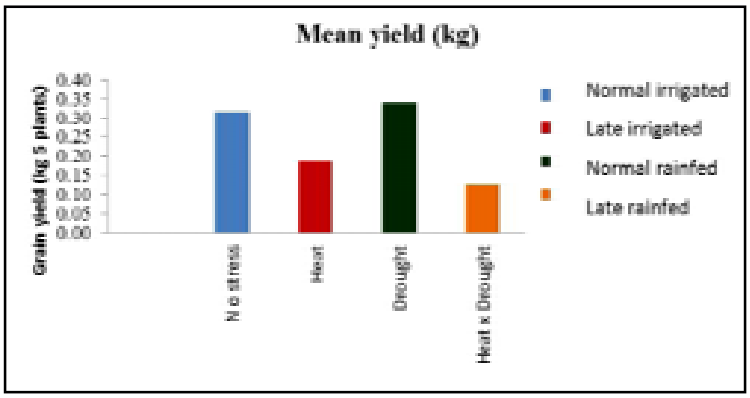


Fig. 15: Mean yield under different stress condition

genotypes showed combined tolerance to drought, heat or both (Table 12). Higher grain yield was associated with low isotope discrimination and combined tolerance with higher grain yield appeared to be supported by inherent characters of genotypes with higher water use efficiency (low 13 C discrimination). The results indicated that high initial biomass supported by large number of fruiting branches and profuse nodulation could be essential traits for tolerance to both heat and drought stresses combined together.

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

Screening under laboratory condition

Thirty seven selected pigeonpea genotypes were evaluated for high temperature tolerance employing a technique called Temperature Induction Response (TIR), where four days old seedlings were exposed to induction temperature (30°C to 42°C for 3 hours), followed by lethal temperature (54°C for 3h). The genotypes showing maximum or less survivability and recovery growth at 54°C for 3h were considered to be high temperature tolerance and susceptible genotypes,

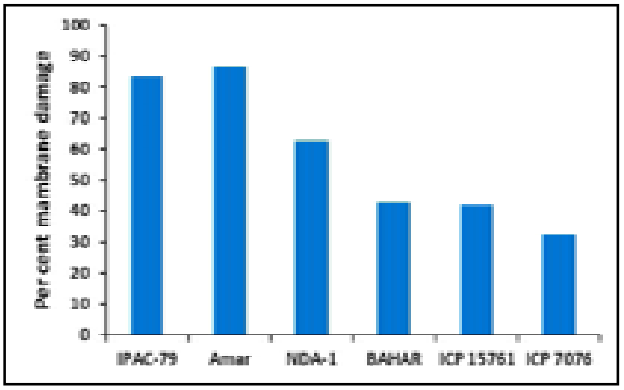


Fig. 16: Per cent membrane damage in thermo-tolerant and sensitive genotypes

respectively. Genotypes like ICP 15761 and ICP 7076 were identified as heat tolerant and IPAC 79, ICP 11477, Amar and IPA 9F as temperature susceptible genotypes.

The physiological basis of thermo tolerance was studied with contrasting genotypes through membrane integrity. The identified thermotolerant genotypes possessed relatively low membrane damage as compared to thermosensitive genotypes. The oxidative stress damage was relatively less in the thermo-tolerant genotypes (Fig. 16).

Field screening

Total 145 pigeonpea genotypes were evaluated in field for the tolerance to cold and high temperature. The reaction of genotypes to cold was recorded on first week of February, 2014 on the rating scale of 1 to 3 based on leaf drying, stem drying, bud and flower dropping and total plant mortality. From the observations, genotypes *viz.*, IPAC78, GRG 2009-3, IPAC 245,, IPAC85, IPA 80, IPAC 78, IPA 16F, NDA 1, IPA 114, IPAC 76, IPA 16F, Amar, IPA 127, IPA 77, ICP 15761, ICP 7076 and IPAC 246 showed less flower and pod drop in peak winter as compared to other genotypes.

Osmotic potentials were recorded in 145 pigeonpea genotypes in early sowing for assessing the cold tolerance. Osmotic adjustment in leaves increased with the cold stress in tolerant genotypes and reached close to 1.31 MPa. Genotypic variation in OA (ranging from 0.25 to 1.31 MPa) was significant.

Electrolyte leakage of leaves was measured at temperature 40^{0}C (C 1) and subsequently the same at 100^{0}C (C 2). The ratio C 1/C 2 represented the membrane injury index (MII). The genotypic variation in the MII was apparent. Genotypes *viz.*, GRG 2009-3, IPAC 245,, IPAC 85, IPA 80, IPAC 78, ICP 15761, ICP 7076, IPA 16F, NDA 1, IPA 114, IPAC 76, IPA 16F and Amar showed the lowest MII suggesting higher membrane stability at cold stress condition.

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

A field experiment was conducted to study the physiological response of 100 mungbean genotypes to photo-thermo periods and identification of insensitive genotypes for different photo-thermal regimes. Observations on phenology, plant height, pod number and seed yield per five plants were taken for different traits (Table 13).

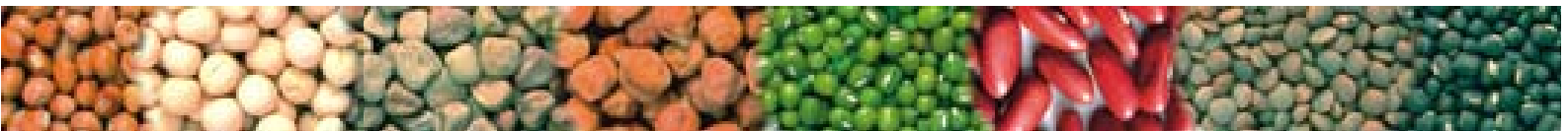


Table 13: Data on different trials of mungbean genotypes

Character	Genotypes
Plant height (>40 cm)	PDM 54, IPM 99-125, Pusa Vishal, PDM 139 PDM 11, IPM 03-1, Asha, NM1, K 851, ML 729, Pusa Bold 2, PDM 288 ML 5, Pusa 672, PDM 178
Early flowering (< 40 days)	PDM139, PDM 54, PDM 281, PDM 191, PDM 178, IPM 02-1, IPM 05-1, IPM 02-03-2, K 851
Early podding	IPM 409-4, IPM 05-3-22, IPM 205-7, IPM 05-2-8, IPM 03-3, IPM 03-2, IPM 03-1, IPM 2k-14-100
Early maturity	PDM 54, IPM 99-125, PDM 139 PDM 11, IPM 03-1, Asha, NM 1, K 851, ML 729, PDM 288 ML 5, Pusa 672, PDM 178, K 851
Number of seeds/ pod (>12) Low yielding	IPM 03-02-2, IPM 02-03-03, IPM 02-16, IPM 02-19, IPM 03-3, IPM 205-7, IPM 312-43K, IPM 05-03-22, ML 682, Co 5, Ganga 8, NM-1
Medium yielding (200-300gm)	PDM 139, PDM 54, PDM 281, IPM 02-10, IPM 02-14, IPM 03-1, IPM 03-2, IPM 05-2-8, IPM 409-4, IPM 306-6, IPM 306-1, IPM 9901-1, IPM 06-5, ML 512, ML 515, China Mung 1, BM 63, BDYR 1, OUM 115, OBGG 52, Co 6, Co 7, K 851, LGG 460, OMG 1030
High yielding (>300 gm)	PDM 191, PDM 178, PDM 84-143, PDM 288, IPM 99-125, IPM 02-1, IPM 02-03-1, IPM 2K 14-9, Pusa Bold 2, Pusa Vishal, Pusa 9531, Pusa 672, ML 5, BDYR 2, CoGG 912, Indore Mung

Screening of Lentil Genotypes for Improved Tolerance to Drought under Rainfed Condition

A core collection of 250 genotypes was evaluated with six checks *viz*., JL 1, DPL 58, DPL 62, DPL 15, IPL 406 and K 75 for morphological traits. The data were recorded for qualitative and quantitative characters including early maturity, days to 50% flowering, plant height, pods/5plant, seeds/5 plants pods (nos.), days to maturity, seed coat colour, seed shape, 100-seed weight and yield/5 plant. Salient findings are summarized as follows.

Days to flowering

The early genotypes attained flowering in 62-70 days, while late flowering genotypes took longer time (84 days) to flower. The average temperature ranged between 4.0^{0}C to 17.3^{o}C for flowering.

Pod set

The pod formation took place in early flowering genotypes, but no seeds were formed and pods were empty. The average total pod set was much higher in the late flowering genotypes. None of the genotypes was able to set seed in pods at low temperature (5^0/8^{0}C).

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

Non-destructive analysis of moisture and protein content in chickpea by Near Infrared Reflectance Spectroscopy (NIR)

NIR is a rapid instrumental technique for the moisture and protein analysis. The Whole Grain Analyser was used to analyse moisture and protein content in grains of 280 chickpea genotypes of ICRISAT mini-core based on pre-installed and calibrated internal software. The mean protein content was 21.8% which ranged from 19.1 to 31.9%, with an AVDEV value of 1.033, whereas the mean moisture content was 10.7% and varied from 8.8 to 14.5% with AVDEV values of 0.570 in the 280 genotypes. Statistical analysis of the results showed that the r^2 values ranged from 0.86 to 0.92 between Kjeldahl and NIRS protein values, and average coefficient of variability of 4.3%. The near infrared (NIR) spectroscopy provides a rapid, low-cost and accurate method for chemical analysis, which requires almost no sample preparation.

HPLC analysis for saponin content in chickpea and lentil genotypes

Separation of the soya saponins was achieved on a reversed phase C 18 column (150 mm x 4,6 mm, 5µm). A calibration graph was constructed by plotting the peak areas corresponding with sapogenol A and B versus different concentrations of standard solutions. Sapogenol A and B were quantified using this calibration graph. Mature seeds of 30 chickpea and 18 lentil genotypes were analysed for Sapogenol A and Sapogenol B content. The Sapogenol A and B content ranged from 37.49 to 212-.5 mg/100 g and 81.01 to 544.74 mg/100g in chickpea genotypes, whereas in lentil genotypes the values ranged from 73.56 to 282.55 mg/100g and 105.19 to 438.46 mg/100g, respectively (Table 14).

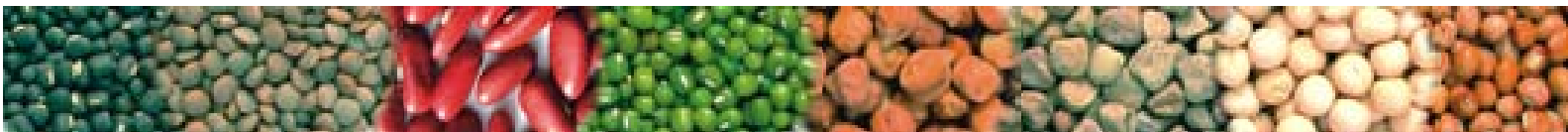


Table 14: Mean and range of saponin content in chickpea and lentil genotypes

Chickpea	
No. of genotypes tested	30
Mean	349.82 mg/100 g
Range - Total saponin content	157.75 to 756.79 mg/100g
Lentil	
No. of genotypes tested	18
Mean	384.33 mg/100g
Range - Total saponin content	187.38 to 721.01 mg/100g

Estimation of phytic acid and polyphenols in lentil

Presence of phytic acid and polyphenols is considered detrimental to the nutritional quality of grains as it binds tightly to important mineral nutrients such as iron and zinc. The phytic acid and polyphenol were estimated in 39 lentil genotypes. The phytic acid ranged between 0.130 to 2.00% with mean values of 0.715%, whereas the polyphenols ranged between 1.17 -6.14 mg/g with mean value of 3.46 mg/g (Fig. 17, 18 & 19).

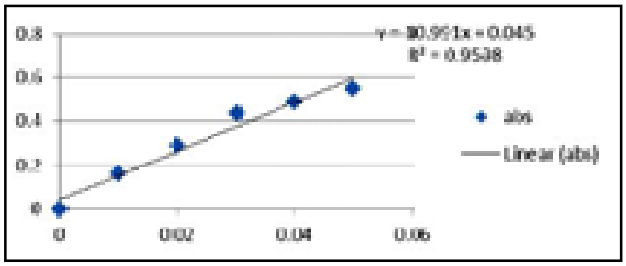


Fig. 17: Standard plot for estimation of phosphorous

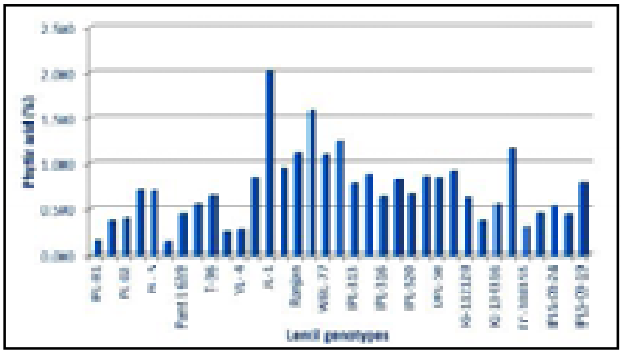


Fig. 18: Phytic acid content in lentil genotypes

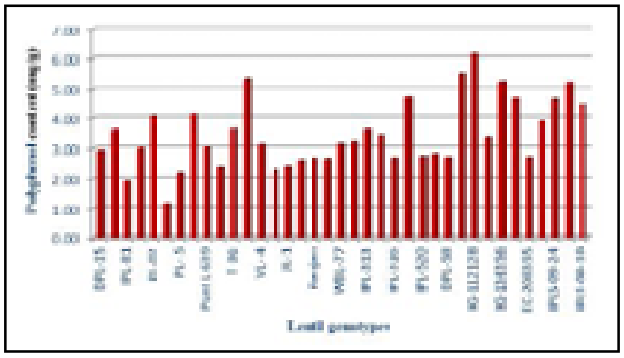


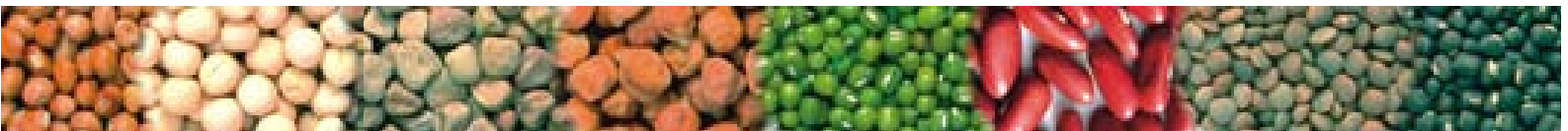
Fig. 19: Polyphenol content in lentil genotypes

Estimation of antioxidant activity in lentil

The antioxidant activity of the lentil grains of 39 genotypes were tested using 2,2-diphenyl-1-picryhydrazyl (DPPH) radical scavenging assay. The antioxidant activity ranged between 0.178 -1.080mmol TROLOX/g (Table 15). Genotype JL 3 showed maximum antioxidant activity (1.080), whereas, IPL 313 had minimum antioxidant activity (0.178).

Table 15: Antioxidant activity in lentil genotypes

Genotype	Antioxidant activity µmol TROLOX /g
DPL-15	0.486
DPL-62	0.555
IPL-81	0.473
IPL-406	0.435
PL-02	0.519
Pant L 04	0.440
PL- 5	0.494
Pant-L 406	0.604
Pant L 639	0.339
K-75	0.369
T-36	0.578
VL -1	0.292
VL- 4	0.273
L-9-12	0.649
JL-1	0.534
JL-3	1.080
Ranjan	0.369
Narendra M-1	0.539
WBL-77	0.188
WBL-58	0.209
IPL-313	0.178
IPL-315	0.204
IPL-316	0.212
IPL- 319	0.193
IPL-520	0.441
IPL-526	0.372
DPL-58	0.305
IG-112108	0.371
IG-112128	0.288
IG-134327	0.329
IG-134356	0.313
IG-129214	0.308
EC-208355	0.285
IPLS-09-14	0.333
IPLS-09-24	0.517
IPLS-09-7	0.354
IPLS-09-19	0.486
Range	**0.178-1.080**
Mean	**0.401**
AVDEV	**0.129**



Anti-nutritional Components of Lathyrus and Their Removal by Processing

Wide variability was observed in most of the anti-nutrients *viz.*, polyphenols, tannins and phytates in 80 genotypes of lathyrus. The genotypes were clustered in 12 groups based on their source of collection. Total phenols were present in the range of 0.66 to 3.31 mg/g in all the genotypes. RLK group had the highest mean total phenol of 2.04mg/g, whereas AKP, VKS, VKG, LSD, Sel 504, PBJ and Pusa groups had less than 1.0 mg/g total phenols. Phenols have dual role in pulses *i.e.*, acts as anti-nutrient which reduces the digestibility and availability of protein, amino acids and starch; and acts as anti-oxidant and provide protection against cancer by scavenging free radicals. The tannins were present in the range of 4.52 – 7.60 mg/g with an average of 5.96 mg/g in seeds. Lowest tannins were observed in AKP and LSD groups, whereas EC, IC, ET, RLK and JBT had highest tannins in their seed. Phytates were present in the range of 9.10 to 16.43 mg/g in all the genotypes. High phytates were present in the seeds of IC, EC, ET, JBT and PBJ groups. High phytates enhances the germination of seed and also help in protection against cancer, but reduces the availability of minerals such as iron, zinc and calcium. Lathyrus has been found to contain high protein. The soluble protein was present in the range of 21.52 to 28.56% in different groups. Highest mean soluble protein was found in the seeds of PBJ, JBT, IC, ET, VKS and EC groups. Mean soluble protein in grains was 25.82% (Table 16).

BOAA is the major anti-nutrient in the seed of lathyrus as it causes neurotoxic effect causing crippling of appendages and loss of growth in infants and children. Technology for lowering BOAA was, therefore developed. Heating the dehusked grains of lathyrus at 120°C and 150°C for 2 hours removed 45.7 to 46.9% of total BOAA/ODAP. Soaking of grits of dehusked grain of lathyrus in acidic or alkaline solution for 30 – 60 min at 80 – 100 °C and discarding the soaking solution also helped in removing 82.43 to 92.43% of total BOAA.

The dehusked grains of 14 lathyrus genotypes were also subjected to pressure cooking. The range of BOAA/ODAP in dehusked grain (*dal*) of these genotypes was 0.48 to 1.19 mg/g. The phytate content in these genotypes was found in the range of 10.77 – 12.00 mg/g and a loss of 10.85% of total phytate was observed during cooking of dehusked grain. Total phenols and tannins also decreased remarkably during cooking and a loss of 22.69 and 51.31%, respectively was registered.

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

Endophytic bacteria in seeds of pigeonpea

Studies on endophytic bacteria colonizing pigeonpea seeds revealed presence of different bacteria in radical and plumule at the seedling stage. Purified cultures of these bacteria were characterized using biochemical tests and antibiotic resistance profiling (Table 17). In general, all the isolated strains showed

Table 16: Variability in total phenols, tannins, phytates and protein in lathyrus genotypes

Genotype	Total phenols (mg/g) (Range)	Tannins (mg/g) (Range)	Phytates (mg/g) (Range)	Soluble protein (%) (Range)	Mean (%)
RLK (42)	0.92 – 3.31	4.62 – 7.21	9.10 – 13.64	21.52 – 28.56	25.35
Pusa (2)	0.74 – 0.93	5.63 – 5.88	11.59 – 11.64	24.07 – 26.14	25.10
AKP (2)	0.76 – 0.78	4.52 – 5.29	10.51 – 11.93	24.49 – 25.57	25.03
VKS (13)	0.70 – 1.24	5.05 – 5.96	11.87 – 15.11	24.18 – 28.04	26.75
VKG (4)	0.66 – 0.96	4.70 – 5.70	11.99 – 15.58	22.11 – 26.20	24.12
PBJ (3)	0.81 – 1.10	5.68 – 5.92	13.52 – 15.55	26.98 – 28.07	27.69
JBT (4)	1.19 – 1.57	5.36 – 6.88	13.56 – 15.78	27.12 – 27.86	27.49
IC (4)	1.27 – 1.55	6.68 – 7.60	15.09 – 16.43	27.10 – 28.04	27.60
EC (3)	1.11 – 1.69	6.99 – 7.39	14.63 – 15.47	24.98 – 27.75	26.70
ET (1)	1.15	6.34	15.79	27.01	27.01
LSD (1)	0.93	4.90	12.28	23.73	23.73
Sel 504 (1)	0.95	5.88	10.68	21.95	21.95
Overall range	0.66 – 3.31	4.52 – 7.60	9.10 – 16.43	21.52 – 28.56	25.82

(Figure in parenthesis indicate number of genotypes)

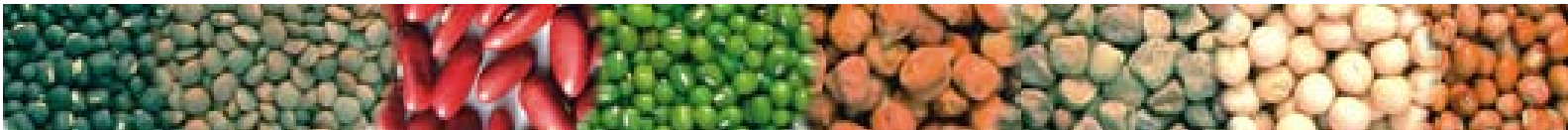


Table 17: Antibiotic resistance profile of endophytic bacteria isolated from radical, plumule and cotyledon of germinated pigeonpea seedling

Sl. No.	Tissue	Isolate No	Antibiotic Sensitivity*						
			Streptomycin (250 ppm)	Penicillin (100 ppm)	Tetracycline. (250 ppm)	Kanamycin (250 ppm)	Chloroam-phinicol (250 ppm)	Rifampicin (5 ppm)	Gentamycin (50 ppm)
1	Plumule	P1	(+)	(-)	(+)	(-)	(-)	(+)	(+)
		P2	(+)	(-)	(-)	(+)	(+)	(+)	(+)
2	Radical	R1	(+)	(-)	(-)	(+)	(-)	(+)	(+)
		R2	(+)	(-)	(+)	(-)	(+)	(+)	(+)
3	Cotyledon	C1	(+)	(-)	(-)	(+)	(-)	(+)	(+)
		C2	(+)	(-)	(-)	(-)	(+)	(+)	(+)

*(+) Resistance; (-) Sensitive

sensitivity to streptomycin while resistance toward penicillin suggesting that most of these bacteria were gram –ve and it was further confirmed by staining. Reactivity towards tetracycline, kanamycin, chloroamphinicol and different concentrations of rifampicin was, however variable and indicate the differences in the strains of bacteria colonizing the different tissues. Endophytic bacteria present inside the cotyledon on germination migrated to the radical and plumule. Soaking of seeds in the antibiotic mixture consisting of tetracycline and kanamycin with concentrations of 50, 100 and 250 ppm inhibited/ delayed seed germination as compared to the soaking in water. Increased antibiotic from 50 to 250 ppm inhibited germination and delayed emergence of plumule. Tissue developed in treated and untreated seedlings, however showed the presence of bacteria on a nutrient medium. This indicates that seed soaking in antibiotic solution did not eliminate the endophytic bacteria from the pigeonpea seedlings but seed germination was altered due to soaking in antibiotic solution.

M. ciceri from nodules of chickpea

Mesorhizobium ciceri strains isolated from nodules of chickpea genotypes grown on soil with P-deficiency were compared with strains isolated from plants grown with enriched phosphorus. 16S rDNA restriction analysis of Mesorhizobium isolates from high and low fertility soil produced three different restriction patterns. Mesorhizobium isolates with 16S rDNA restriction pattern of Group A (800, 450, 200bp) and Group B (800, 400, 250bp) colonized the chickpea nodules from high and low fertility soils. However, the isolates with restriction pattern of Group C (1150, 300bp) were found to nodulate chickpea plants grown only under high fertility soil. It indicates the possible role of plant genotype and soil fertility on selecting symbiotic nitrogen fixing partner with chickpea.

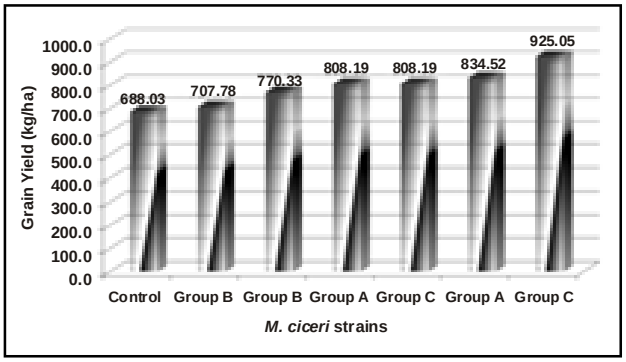
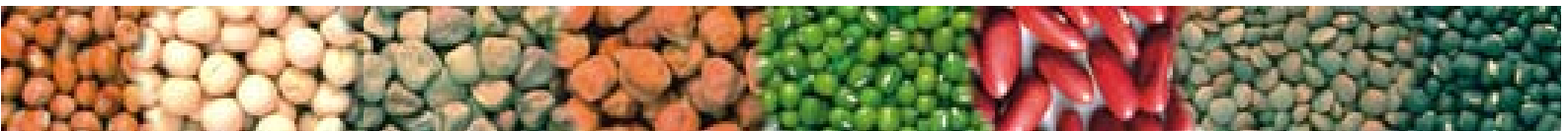


Fig. 20: Effect of inoculation with *M. ciceri* strains on grain yield of chickpea var. RSG 888.

Based on this grouping, representative isolates were used for evaluating growth responsiveness in field inoculation of chickpea genotype RSG 888 (Fig. 20). *M. ciceri* strains belonging to Group C recorded maximum increase in grain yield as compared to others and grain yield increased from 688 kg/ha in un-inoculated control to 925 kg/ha in inoculated with *M. ciceri* strain.

Genotypic differences in P-uptake efficiency

Chickpea genotypes with two checks *viz.*, JG 16 and BG 256 were evaluated on low and high soil P availability to assess their P-uptake and use efficiency for grain yield. At low P availability in soil the P content in shoot after sixty days of plant growth was significantly lower as compared to the shoot P in plants grown at high soil P availability. At harvest stage, the grain yield reduction due to limited P supply in different varieties ranged from 13 to 35 per cent with the exception of no reduction in IPC 2008-92. The reduction in seed yield in JG 16 and BG 256 was, however 15 and 22 per cent, respectively. This year results corroborate the findings of 2012-13 that a large variation in P-uptake and its use efficiency exist in elite genotypes of chickpea.



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

Potential of ACC deaminase producing bacteria for enhancing chickpea root biomass, nodulation and grain yield was assessed under field condition. Inoculation of ACC deaminase producing bacteria enhanced the root biomass in a range of 66.69-119.46% over uninoculated control. ACC deaminase producing bacterial strains showed differential response on shoot biomass development. ACC-10 and ACC-78 helped to increase shoot biomass at 45 DAS. However isolates like ACC-16 and AAC-68 did not promote the shoot biomass at early stages, but recorded highest shoot biomass at 90 DAS. ACC-7, -95, -96, and -16 recorded higher nodule dry weight of > 0.1 g/plant over 0.043 g nodule weight of uninoculated control plant. Out of 26 bacterial isolates, only seven isolates promoted the grain yield both under irrigated as well as rainfed conditions. Five isolates (Isolate No. 10, 16, 78, 107 and 108) that enhanced seed yield above the range of 35% over uninoculated control were selected. Among the ACC deaminase producing bacterial isolates, ACC-68 recorded highest ACC deaminase activity.

Interactive effect of co-inoculation of five ACC deaminase producing bacteria with *Mesorhizobium ciceri* on chickpea growth and nodulation was studied under field condition. Co-inoculation of beneficial bacteria enhanced the shoot biomass up to 89.85%, over uninoculated control (Fig. 21). There was no significant increase in plant biomass during 45 DAS. Based on the potential to confer stress tolerance, compatibility with *Mesorhizobium ciceri* and promote chickpea grain yield, top three isolates *viz*., ACC-10, -16 and -68 with more than 50% higher grain yield over uninoculated control plants were selected and recommended for developing commercial bioinoculants.

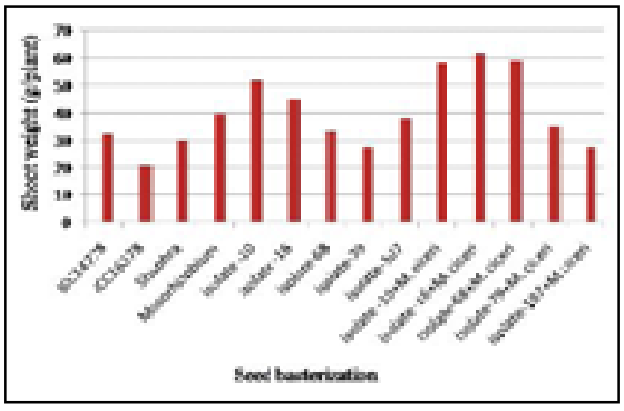
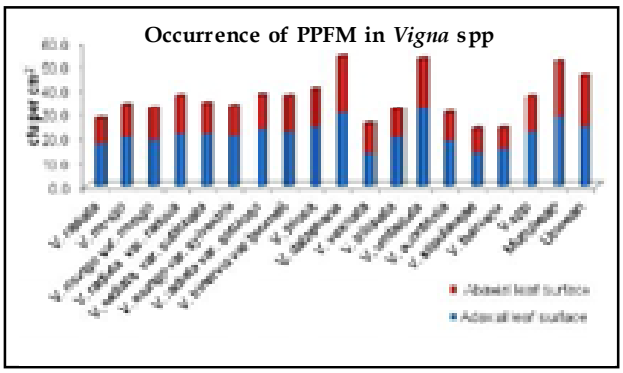


Fig. 21: Effect of co-inoculation of ACC deaminase producing bacteria with *M. ciceri* on soot biomass production

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

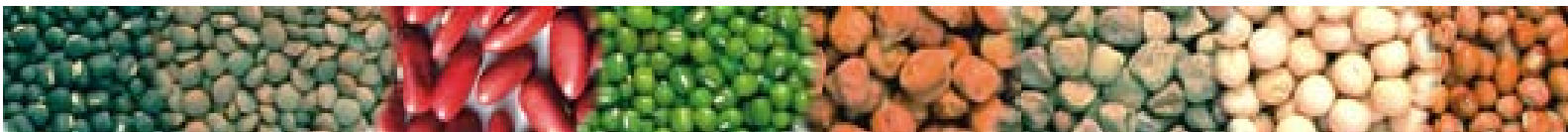
About eighty Pink Pigmented Facultative Methylotrophs (PPFM) were isolated from the wild species including 5 accessions of *Vigna radiata*, 5 of *V. radiata* var. *radiata*, 6 of *V. Radiate* var. *sublobata*, 2 of *V. Radiate* var. *setulosa*, 4 of *V. mungo*, 5 of *V. Mungo* var. *mungo*, 4 of *V. mungo* var. *sylvestris*, 3 of *V. Trinervia* var. *bourneii*, 3 of each from *V. pilosa*, *V. dalzelliana*, *V. hainiana*, 2 of *V. vexillata*, 16 of *V. trilobata*, 12 of *V. umbellata*, 2 of *V. acontifolia*, one of *V. stipulaceae* and from cultivable mungbean varieties (Samrat, Meha, Diksha and IPM 2-14) and urdbean varieties (Uttara and IPU 2-43). From fieldpea about twenty eight PPFM isolates were isolated from the prominent cultivars *viz*., Adarsh, Vikas, Prakash, Aman and IPF 4-9. PPFM abundance was significantly higher on leaves of *Vigna* than fieldpea.



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

Selection of most bioactive molecules

Bioassay results of previous years experiments as given in the Table below revealed that out of all the different categories (polar to non-polar) of extracted fractions and sub fractions only those possessing polarity index in range of 2-4 show promising biological activities against *Fusarium ciceri* race-2 pathogen as well as the *H. armigera*. Therefore all the sub fractions of this range *i.e*,. 5 to 6 sub fractions of dichloromethane and some of the fractions of ethyl acetate soluble materials of all the four chickpea varieties were processed for recovery of compounds. On TLC all the fractions were visualized to contain a huge number of compounds overlapping on almost all the Rt values from bottom to the top of the plate. Since these fractions do not differ much in their polarities,

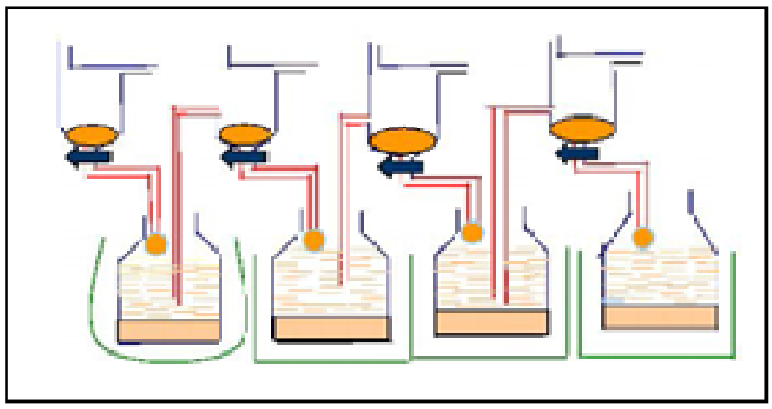


Chickpea varieties	Isolated extracts		Polarity of fractions based on lipophilicity of solvents		Bioassay results		Total No of compounds detected on TLC	
	Fra. (wide solubility)	Sub. Frac. (narrowso lub.)	Polarity index	Eluent strength	Crude fraction µg/ ml	Relatively pure fractionµg/ ml	Common compound	Unique compound
KWR 108, IPC 2004-52, JG 315, and JG 62	Hex	1	0.00-0.2	0.01-0.04	300	200	4	1
	CH_2Cl_2	1-6	0.3-3.5	0.1-0.3	300	200	>30	7
	EtOAc.	1-5	3.5-4.7	0.4-0.5	700	400	>40	3
	acetone	1-3	4.7-5.1	0.5-0.6	1000	700	>50	3
	methanol	2-3	5.1-5.5	0.75-0.95	2000	1500	N A	N A
	water	1	10.2	large	ineffective	ineffective	N A	N A

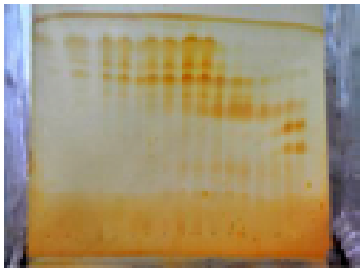
therefore, extraction of individual compounds from this kind of complex mixture was felt much difficult and tedious task. As we know that the solubility of any organic compound largely depends upon the choice of solvents, temperature and pressure therefore to accomplish this task some of the new procedures and chromatographic techniques were developed.

Isolation of unique molecules

The isolated fractions were purified by fractional crystallization of the fractions as shown in Fig. 1. By repeatedly following this procedure the fractions of interest were successfully purified as authentic solubility fraction of very pure form. These pure fractions were again analyzed on TLC and 14 distinct compounds were identified. The targeted compounds were again separated by column chromatography. In this procedure different types *i.e.*, wide and short, wide long, narrow long, *etc.* of columns were employed. Purifed compounds were sent to IIT, Kanpur, and CDRI, Lucknow for chemical structures analysis.



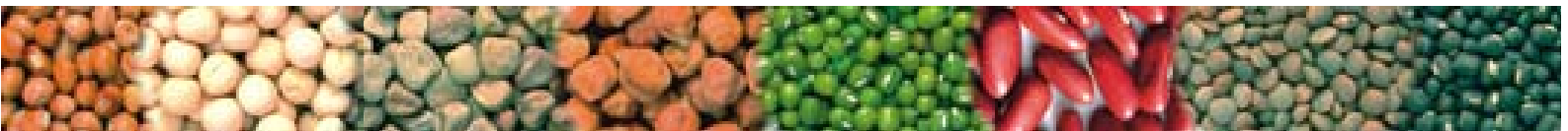
A view of fractional crystallization technique: fractions were systematically crystallized to various sub fractions of close solubility.



TLC of crude fraction

TLC of pure and distinct compound of all the four chickpea varieties

View of pure compounds



Social Science

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

This project is being implemented in tribal dominated 10 districts of M.P. and Chhattisgarh. Total 212 participatory demonstrations were laid out on pigeonpea, urdbean and mungbean during *kharif* 2013 and 1040 technology demonstrations on chickpea, lentil and fieldpea were laid out in Baster, Dantewada, Kanker, Kawardha and Balrampur districts of Chhattisgarh and Jhabua, Shahdol, Badwani, Dindori and Dhar districts of M.P. with active support of KVKs in the concerned district.

Chickpea was grown under a variety of soils and wide range of topography, cropping pattern, temperature, *etc.* Based on the farmers' preferences and existing farming situations, total 650 demonstrations (in one acre area each) were laid out on package technology in chickpea during *rabi* 2013-14 in M.P. and Chhattisgarh. The impact and yield advantage of chickpea demonstrations are given in the following Table:

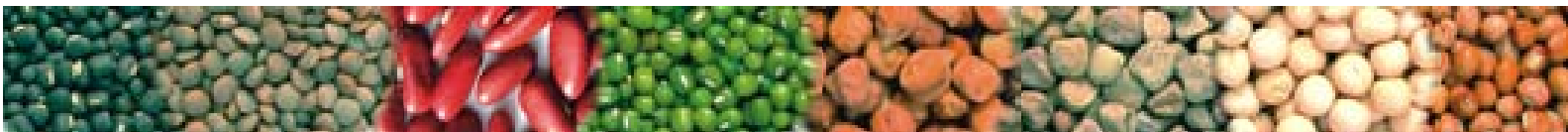
State/District	No. of Demonstrations	Variety(s)	Technology Package Demonstration Yield (q/ha)			Yield (q/ha) Control	% Yield advantage
			Highest	Lowest	Average		
Chhattisgarh							
Kanker	60	JG 130 JAKI 9218	10.13	6.50	8.65	6.40	35.0
Dantewada	60	JAKI 9218	11.80	6.30	6.40	3.70	72.4
Balrampur	60	JG 11, Vijay	15.0	9.00	12.00	8.00	33.0
Baster	100	JG 11, JG 130	10.20	6.80	8.50	6.20	36.0
Kawardha	80	JAKI 9218	12.80	7.50	10.20	7.20	43.0
Madhya Pradesh							
Badwani	50	JG 130	12.60	10.40	11.50	9.40	22.30
Dhar	70	JG 16 JG 130	14.37 16.25	11.87 12.50	13.16 14.06	9.59 9.50	37.28 47.20
Dindori	50	JG 16	15.00	13.50	14.21	11.20	34.30
Jhabua	60	JG 130	15.25	11.25	13.10	9.22	42.77
Shahdol	60	JG 130	14.50	10.63	13.27	10.35	28.22

Besides above, 205 demonstrations on lentil and 185 on fieldpea were also carried out. Farmers obtained maximum net return of Rs. 26055/- under chickpea demonstrations in Dindori district of M.P.

For timely management of diseases and insect pests, 100 KNAP-SACK sprayers were also given to tribal farmer groups as a community input. Convergence pattern of storage steel bins has been assessed. It has been reported that tribal farmers of Chhattisgarh stored 176 q chickpea, 25 q lentil and 11 q fieldpea seed produced during *rabi* 2013-14 for multiplication and farmer to farmer distribution. Farmers of selected districts of M.P. have also kept 46 q chickpea (JG 11, JG 130 and JAKI 9217 varieties) and 12 quintals of lentil (JL 3) as seed. For up gradation of skill on different aspects of management and protection of crops, 36 off campus trainings were organized in which more than 1710 tribal farm families including farm woman actively participated. Besides, 10 field days, 8 diagnostic field visits, 22 farmers' meeting and 12 exposure visits were also organized.

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

Data was collected from three villages *viz.*, Badhapur, Kuitkhera and Sariyapara of Kanpur Dehat district from 50 farmers adopted under the project. The findings indicated that the production and productivity has increased. The major crops grown are wheat, pigeonpea, mungbean, urdbean, chickpea and mustard. It was informed by the farmers that pulses are profitable in comparison to the other crops. Generally, farmers procure the seed from the IIPR, NSC, SAUs, Agril Department and Tarai Beej Vikas Nigam. Inputs are procured from the cooperative societies and Plant Protection Units. The compost is applied ones in three years by the farmers. Seed rate was drastically reduced due to line sowing. Area under pulses has increased, specially under pigeonpea and chickpea. The farmers have adopted the cluster approach for seed

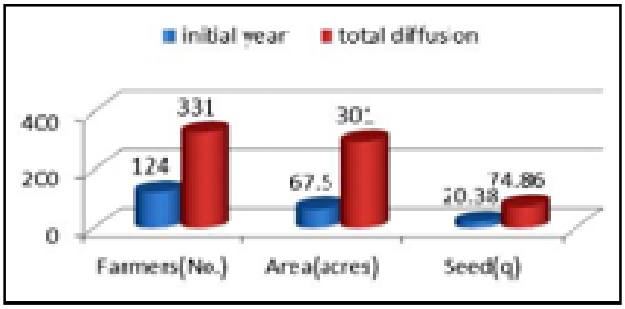


production. The 6:2 ratio of chickpea and mustard technology has been adopted by the farmers. The ridge sowing technology has also been adopted along with weed control technology. Definitely, there is increase in the farm and non- farm assets like tractor, house contraction, education of children, *etc*. Majority (86%) of farmers get information about pulses technology as well as seed production from IIPR & NSC, Kanpur. It was observed that majority of farmers (64%) have developed personality traits like the confidence, leadership quality, communication skill and convincing ability. Majority of farmers (76%) were still continuing the technologies in same fashion for higher profitability. Technologies were also percolated to other farmers of villages through farmers cooperative society. Farmers are actively involved in promotion of formal as well as informal seed procurement and marketing. The society has been formed by the farmers with the active support of IIPR scientists. The linkages of the farmers have been developed with different agencies due to the IIPR project. Overall production and productivity has improved.

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

Farmer to farmer informal diffusion assumes significant importance in spread of profit enhancing technologies in the farming communities. During *rabi* 2013-14, 37 key farmers were provided improved seeds of recommenced varieties of chickpea (Ujjawal, DCP 92-3 and Shubhra) for half acre area each, along with technical knowhow related to chickpea production. The participating farmers gained as additional 0.5 q yield per hectare in comparison to the control plots.

The overall varietal diffusion recorded from the 124 key farmers identified under the project for 2010-11 to 2012-13 is presented below. From the initial quantity of about 20.38 q of seed of improved pulse varieties that was introduced in the project villages during year 2010-11, about 74.80 q of produce was spread as seed among 331 additional farmers, covering about 300 acres of area through farmers to farmer



Overall varietal diffusion from key farmers through farmer to farmer networks (2010-13)

informal diffusion. Thus, about 2.7, 4.4 and 3.7 fold increase is recorded in the number of farmers covered, area sown and quantity of seed made accessible among farmers, respectively through the farmer to farmers diffusion approach in the project villages.

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

To promote pulse enterprises in Kanpur Dehat district, following modules were identified and explored:

Module 1: The basket making of pigeonpea sticks is an impotent activity. Dozens of basket making hubs in Kanpur city and out-skirt area are available. Baskets are mostly used in earth work, flowers, fruits and vegetables, footwear industry, festivals, *etc*. The major constraints are bruchid attack in stored sticks, storage space, introduction of plastic and iron made baskets, use of machinery in earth work, reduction in pigeonpea area, middle men, lack of government support. The innovation in basket size, shape, design will be helpful in promotion of this activity.

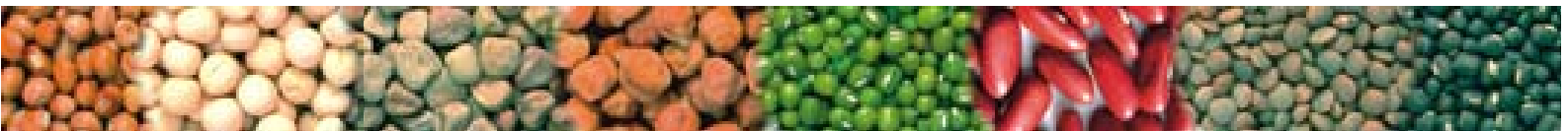
Module 2: Entrepreneurship through neem seed kernel collection and marketing can be promoted, as neem extract/oil is beneficial to plant protection measures in pulses. Raw kernel costs Rs. 3-4/kg, where as neem oil costs Rs. 85/kg and neem cake 15/kg. It was noticed that traditional local expeller gives 3-4% neem oil only, where as efficient machine gives 10-12%. Thus there is need to promote small entrepreneurship at local level.

Module 3: Fieldpea production is quite high in Jalaun and this can be processed and supplied to poor people mostly labour on brick mills, factories and slums as they always look for cheap pulses and buy from daily *haat*. These efforts will reduce malnutrition in children and women.

Module 4: Urdbean in summer season is sown in the first fortnight of April, after wheat harvest. The innovation shows that farmers irrigate wheat just before a week of harvesting and subsequently, harvest the wheat at optimum moisture in one time throughout day and night engaging more number of labours. After wheat harvest, urdbean is broadcasted in early morning/cockcrow and ploughed twice with final plunking before the sun rise.

Development of Appropriate Training Modules on Pulses Production Technologies

The analysis of training needs of farmers in Jalaun district showed that out of 19 practices for fieldpea, 9



were most needed, 7 needed, 4 not needed category. Most needed category includes improved varieties, grading of produce, marketing of produce, seed treatment, insect and disease management, irrigation and sprinkler, seed replacement rate, sowing method and value addition. Further, training needs of farmers for lentil showed that out of 21 practices, 7 were most needed, 8 needed and 4 not needed category. Most needed category includes disease management, improved varieties, seed treatment, irrigation and sprinkler, sowing method, insect management and seed replacement rate. Whereas training needs of farmers for chickpea showed that out of 20 practices, 8 were most needed, 8 needed and 4 not needed category. Most needed category includes improved varieties, insect pest management, disease management, irrigation and sprinkler, sowing method, seed treatment, seed replacement rate and marketing of produce.

Training needs of farmers in Kanpur Dehat district under spring/summer pulses showed that out of 21 practices, 10 were most needed, 8 needed and 3 not needed category. Most needed category included improved varieties, plant population, weed management, insect management, irrigation schedule, seed replacement rate, marketing of produce and value addition.

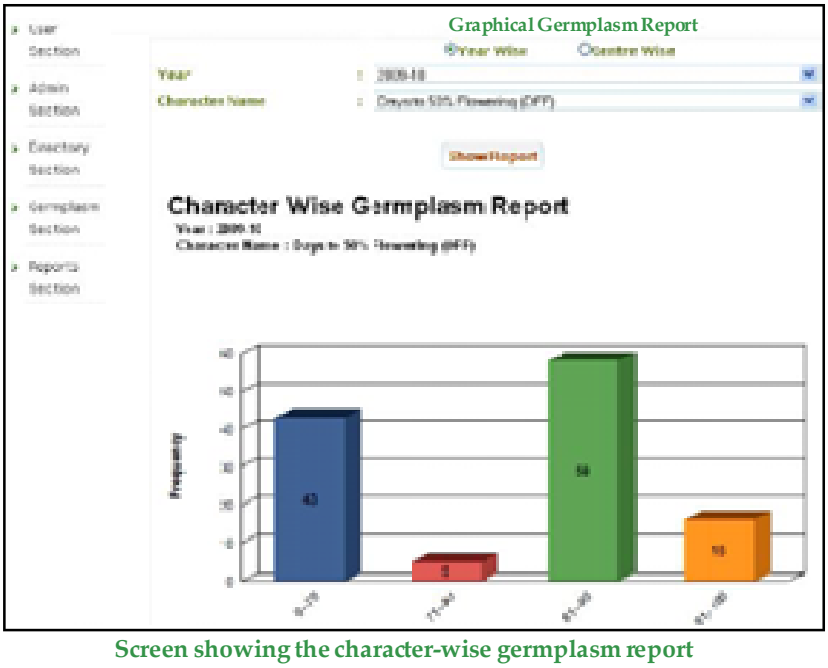
Development of Database and Information Retrieval System for Pulses Genetic Resources

Online Database and Information System for pulses germplasm addresses the data management need by producing a user-friendly menu driven system that generates data entry forms, queries and reports and maintains a comprehensive database on chickpea and pigeonpea for statistical analysis and interpretations. System has two components one for data management and other for generating queries and reports. Germplasm data management module has been designed for data entry, data updation and data submission. Germplasm report generation module has been developed to retrieve/search germplasm accessions based on single character or combination of more than one character. A user-friendly interface for data entry has been designed and developed for entering the basic information related to each accession of pigeonpea germplasm. Statistical analysis of the data was done on the variable with continuous variation to determine the mean, range, variance standard deviation, skewners and kurtosis. User customized reports have been designed in PDF format to generate the information on various parameters of interest for pigeonpea germplasm (Fig. 1). Total 4 main reports have been designed to enable quick and accurate retrieval of data *viz.*, qualitative report, quantitative report, query-based report and details report. The database provides secure data storage that can be shared over Intranet of Indian Institute of Pulses Research, Kanpur and linking with the Institute's website (http://www.iipr.res.in) for access by genetic resource specialists, breeders and planners to differentiate genetic materials from possible duplications.

Analysis of Consumption Pattern and Prices of Major Pulses in India

Fluctuations in market arrivals largely contribute to the price instability of the produce. To device suitable ways and means for reducing price fluctuations of pulses, thorough understanding of price behavior over time and over space is needed. It has been observed that when major portion of the produce reaches the market during the peak seasons, the prices generally are low which depress the farmer's income to a great extent. Understanding the behavior of prices over time helps in suggesting proper marketing strategies.

To understand the market structure and situations it is very important to study the consumption pattern, seasonality and variability in wholesale prices, relationship between arrivals and prices in major pulses and dynamics of export and import of major pulses.



Screen showing the character-wise germplasm report

Wholesale Price Index of chickpea and pigeonpea reached their peak during August and September, 2012 and declined thereafter. Farmer is not assured of procurement of his produce when the market price is lower than the Government's minimum support price (MSP). Hence the announcement of MSP for pulses is not serving its purpose. In many markets, prices of pulses are lower than the MSP. Government should implement its policy for procurement of farmers' produce at MSP.

The central government has allowed NAFED, Central Warehousing Corporation (CWC), National Cooperative Consumers' Federation (NCCF), Small Farmers' Agribusiness Consortium (SFAC) to procure pulses at MSP from the farmers under Price Support Scheme (PSS).

Analysis of Growth and Instability in Major Pulses of India

It very important to study the growth pattern and stability in the production and area of pulses as these affect food management, food security, price stability and macro policies. This project is undertaken to study the growth in area, production and productivity, estimate the instability and decomposition analysis of major pulses.

In case of total pulses there was increase in instability in production in 2000-10 as compared to previous decade, but the instability in yield kept on fluctuating with time, however come up to constant at 0.04 in the last two decades *i.e.*, 1990-2000 and 2000-10. It gives an idea that the yield stood still for the last two decades. So it is needed to shift the concern in increasing the productivity of pulses because to sustain the growing demand the yield should have some significant contribution in the production.

Bi-decade wise analysis of pulses shows that the instability in yield has decreased from 0.06 in 1950-70 to 0.04 in 1990-2010 though it was constant in area and production. So it infers that there had been some significant scientific, technological and innovative changes which led to bring stability in the yield component, which in turn had a positive impact on the market as it brings some stability in the price volatility.

From cross sectional data by tri-decade wise analysis of total pulses, it is observed that although the instability in the production and yield has decreased, but in area it increased which brings the inference that still today the farmers decision to grow the pulses is significantly affected by climate or the market led factors which is bringing the high instability in area component.

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

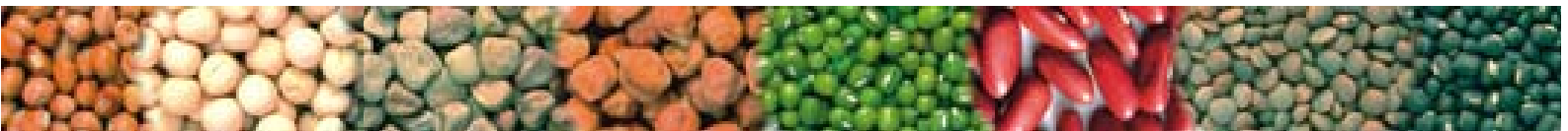
Incomplete block design is recommended for accommodation of large number of treatments and it is cumbersome to get the data analyzed in convenient way from the incomplete block designs. A user-friendly analytical modules has been initiated to get the data analyzed in simplified and convenient way from some incomplete block designs. A page has been designed for user-friendly analytical module for some In-complete Block Design in which a data entry user interface has been created for augmented block design using the hyper text markup language, active server page and visual basic as back end coding. The entered data is saved in a database from which data can be retrieved for further use in text or excel or CSV format. The sequential query language is used for database and a separate SAS program has been written for the analysis of augmented design.

EXTERNALLY FUNDED PROJECTS

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

This project on "Enhancing lentil production" is being implemented in Hamirpur district of Bundelkhand region of U.P. Total 30 villages involving 500 farmers from two blocks (Maudaha 250 and Sumerpur 250 farmers) have been selected. In-depth base line survey of all the identified farm families was done with the help of structured interview questionnaire and participatory rural appraisal techniques. Participatory Rural Appraisal tools were mainly used to ascertain existing resources, aspiration and constraints responsible for adoption of different technological packages as well as low yield of lentil under deferent farming situations. Eighty per cent farmers of both blocks viewed that lentil is cultivated under monocropped (*Kharif* fallow) rainfed farming situations. Majority (78%) farmers opined that sowing of lentil is mainly done by tractor drawn seed drill in line with intercropping of linseed (9:1). Farmers preferred large seed of lentil. Duration of small seeded lentil varieties is 15-20 days more and market price is Rs. 150-200 is lower as compared to large seeded lentil. Due to unavailability of quality seeds of preferred variety, productivity of lentil is less as they desire.

Kharif fallow lentil/chickpea intercropped or mixed with linseed/mustared is prevalent cropping system under monocropped, rainfed clay/clay loam soils, Til-chickpea and urdbean-chickpea cropping pattern are found under partial irrigation facility. Long duration pigeonpea + sorgham as fodder as well as



grain is also followed by majority of farmers under rainfed farming situation, Urdbean-wheat, til-wheat, mungbean-wheat, sorgham (fodder)-wheat are most common cropping patterns under double cropped irrigated farming situations. Sixty five per cent farmers of Maudaha and 58% of Sumerpur viewed that use of old, deteriorated seeds and incidence of diseases reduced the yield of lentil. Only 16% of Maudaha and 22% farmers of Sumerpur blocks opined that seed of lentil is changed every three years. Twenty three per cent farmers cultivate lentil since last six year continuously in same fields in Maudaha. Majority of farmers of all selected villages of both blocks stated that lentil area has been shifted under wheat due to enhancement of irrigation facilities mainly due to deep bore tube wells and yield of lentil is adversely affected in every alternate three or four year due to severe attack of aphids. Weed management is very difficult operation as non-availability of hired laborers and lack of post-emergence herbicide in lentil. Every alternate week heavy rains from January to Ist fortnight of March affected overall production of lentil. Farmers viewed that harvesting of lentil generally start in last week of February, but due to rains crop duration increased (15-20 days) and water stagnation also damaged growth of lentil in clay and clay loam soils. Lentil yield varied between 9-13 q/ha in selected villages of Hamirpur.

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

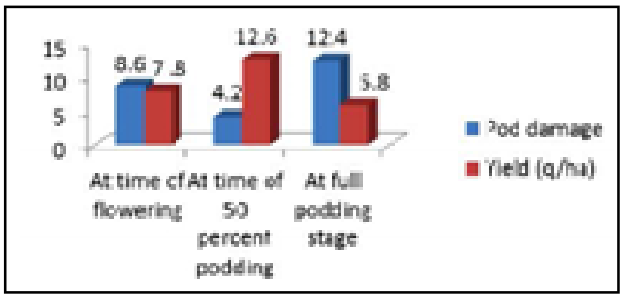
This project is being implemented with the objective to demonstrate plant nutrient and plant protection centric technologies and management of practices for pigeonpea and chickpea in Bahuwa block of Fatehpur district. Total 526 farmers covering 384.16 ha area of 16 villages have been covered under participatory demonstrations on integrated pest management in pigeonpea during *kharif*, 2013. Continous rains from mid June to July, 2013 affected coverage of pigeonpea. Some farmers did not sow short as well as long duration pigeonpea due to rains and water stagnation in fields. Integrated pest management on short duration pigeonpea was undertaken at 160 farmers' fields in 125.60 ha. Various critical inputs *viz*., seed of short duration pigeonpea, Rhizobium culture, Trichoderma, pheromone traps, bio- as well as pesticides were used as IPM modules at 35 farmers' fields of five villages in short duration pigeonpea. The additional net return (profitability) due to application of insecticide (bio- as well as chemical) for management of pod borer in short duration pigeonpea is given in Table below:

No. of Farmers-35

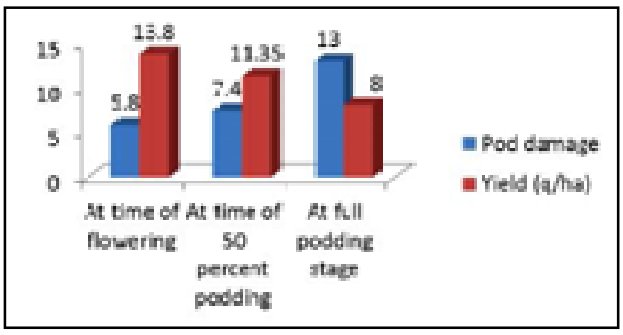
Particular	Yield (q/ha)	Additional yield (q/ha)	Additional cost (Rs./ha)	Additional benefit (Rs./ha)
Control	10.50	-	-	-
HaNPV 250 LE	12.30	1.80	1140	7000
Dimethoate 1.5 liter	12.80	2.30	1670	9400
Indoxacarb 14.5 SC 500 ml	14.60	4.10	2600	16000
HaNPV + Indoxacarb	15.40	4.90	3000	20000

For intensive application of integrated pest management components in chickpea, total 15 villages in cluster were selected involving 465 farmers in 450 ha. Seeds of two wilt resistant varieties *viz*., RSG 888 and DCP 92-3 were used at majority of farmers fields. 5.0 q breeder seed of *kabuli* (Subhra) was also used in Nandlalpur village.

Chickpea sowing was done in monocropped situation in October, 2013 and after harvest of paddy under double cropped situations in IInd fortnight of November, 2013. Efficacy and spraying schedule in management of pod borer is presented in Fig. 22.



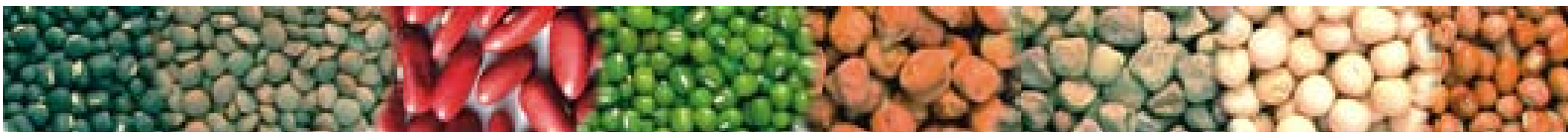
Chickpea sown under monocropped situations (October 2013)



Chickpea sown after harvest of pady under double cropped (IInd fortnight of Nov. 2013)

Fig. 22: Effect of spraying schedule in management of pod borer in chickpea

Farmers were trained on proper application of insecticides. Continuous and heavy rains on every week interval in January to mid March, 2014 affected flower initiation, pod formation, plant growth, *etc*., in



chickpea. Spraying of insecticide (Indoxacarb) at 50% podding stage was effective in October sown chickpea for management of pod borer. Farmers perceived that management of pod borer could be done at flowering stage in late sown chickpea and only 5.8% damage was noticed, whereas maximum 13% pod damage was recorded at full podding stage. Farmers were convinced with spraying schedule in managing of pod borer in chickpea and have committed to follow spraying schedule in large scale in coming season.

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

To popularize the use of environment friendly biorationals for management of *Helicoverpa armigera* in chickpea ecosystem, demonstrations on use of biorationals were laid in 27 acres area with participation of 30 farmers in three villages. Total 9.20 q seed of improved chickpea varieties (Shubhra, Ujjawal and DCP 92-3) was provided to the participating farmers. About 32.5 acres area was covered under demonstrations on use of pheromone traps in the project villages. Awareness campaign, on-farm training and on-campus trainings were conducted for participating farmers for enhancing their skills in production and utilization of biorationals module. The pod damage due to *Helicoverpa* was recorded to be 18% in the demonstration plots and 23% in control plots.

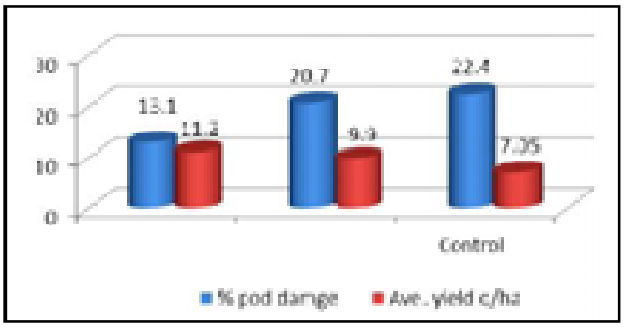


Fig. 23: Effect of biorationals treatments on pod damage and yield (2010-11 to 2013-14)

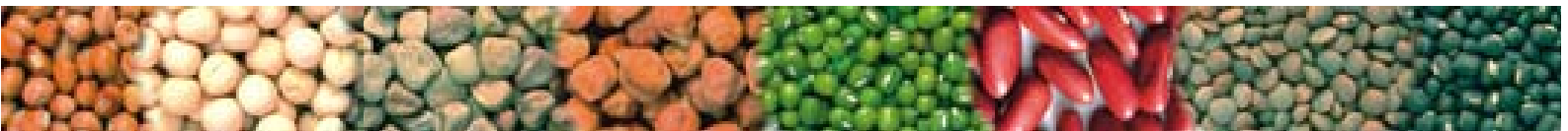
The overall effect of biorationals treatments on pod damage and yield of chickpea crop for 2010-11 to 2013-14 is presented in Fig. 23. The yield of demonstration plots where biorational module was utilized with improved chickpea variety gave higher yield in comparison to plots wherein biorational module was used with local variety as well as from the control plots. In addition, the pod damage due to *Helicoverpa* was reported to be low in the demonstration plots where biorational module was utilized with improved varieties.

Network Project on Market Intelligence

Month-wise data on arrivals and prices of major pulse *mandis viz.*, Kanpur Nagar, Lucknow, Allahabad, Kannauj, Farrukhabad, Aligarh and Lalitpur have been collected. Crop calendars of the selected pulses have been compiled. Crop profiles for chickpea and lentil have been prepared. Farmers' and trade's survey was carried out for the pre-harvest forecast of the pulses.

The price forecast has been prepared on the basis of the price trends, opinion survey among traders and market officials, expected harvest of the crop in the state and analysis of the prices for the past nine years. The prices of lentil are expected to range between Rs. 3900 - 4400 per quintal in April. The prices will further increase in the month of May, 2014 and may vary from Rs. 4100 to Rs. 4600. The farmers are advised to hold their produce and sell it during the month of May, since the average prices remain high during this month in case of lentil.

For chickpea, hail storm and continuous rain in January, February and first fortnight of March, 2014 that wreaked havoc in Madhya Pradesh, Maharashtra and Uttar Pradesh have adversely affected the pulse production in the region. The arrivals in the market will be low in the months of April and May, 2014 as compared to the last year. With this, the prices are expected to go up for chickpea as compared to previous year. The prices are expected to range between Rs. 2600 to Rs. 3400 in April, 2014 and there are chances that the prices will go up in the month of May, 2014.



Regional Station *cum* Off-season Nursery, Dharwad

Generation of breeding material

In chickpea, 4 crosses *viz*., BGD 9971 × Shubhra, BGD 9971 × Ujjwala, BGD 9971 × JG 11 and BGD 9971 × JG 16 were attempted. Three F_1 crosses *viz*., IPA 7-10 × TS 3, IPA 203 × Obovate mutant and IPA 203 × Protruded stigma mutant of pigeonpea were advanced to F_2 generation through selfing of individual plants. Besides, backcrosses (BC_1 and BC_2) of the heterozygote with respective parents for obovate leaf shape and protruded stigma were also attempted. Three crosses (IPM-2-14 × DGGV-2, DGGV-2 × *V. trilobata* and IPM-2-14 × *V. trilobata*) and two crosses (DU-1 × IPU-94-1 and DBGV-5 × DU-1) were attempted in mungbean and urdbean, respectively. More than 200 SPS were made in *kabuli* and *desi* chickpea.

Entries in AICRP trial

IPA 7-10, a genotype of long-duration pigeonpea was submitted to AICRP on pigeonpea for assessment of its performance in the North East plain zone.

Maintenance of mungbean and urdbean germplasm

Total 100 accessions of mungbean and urdbean germplasm were rejuvenated during *Kharif* 2013. Wild *Vigna* species such as *V. trilobata* (LRM-13-24 and LRM-13-30), *V. stipulacea* (LRM-13-33) and *V. aconitifolia* (LRM-13-11) were also rejuvenated during *Kharif* 2013.

Off-season advancement of chickpea and lentil

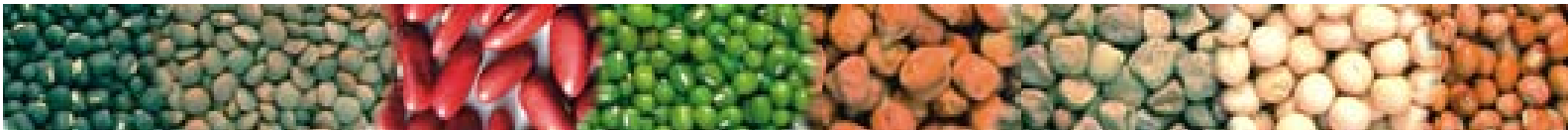
F_1 and segregating materials (F_2, F_3, F_4 and F_5 generations) received from 6 centres of AICRP on chickpea (PDKV, Akola; ARS, Sriganganagar; ARS, Kota; RAK College of Agriculture, Sehore; GAU, Junagarh and HAU, Hisar) as well as from IIPR, Kanpur were advanced to the next filial generation.

Seed multiplication

Seed of two varieties of *kabuli* chickpea (IPCK 2002-29 and IPCK 2004-29) and one variety of *desi* chickpea (JG 11) was multiplied and 800 kg seed was produced.

Seed multiplication of 3 varieties of mungbean (IPM 2-14, DGGV 2 and DGGS 1), one variety of urdbean (DU 1) and urdbean variety Uttara was also taken up and ~525 kg seed was produced.

Seed production of pigeonpea varieties IPA 203 and IPA 7-10 was undertaken in isolation and > 40 kg seed was produced. IPA 7-10 was grown in isolation and 5.0 kg genetically pure seed was obtained.



All India Coordinated Research Projects

Chickpea

Varieties Identified

GJG 0809: This variety has been developed from the cross GJG 9707 x IPC 97-7 and identified for NHZ comprising of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and NEH region. Its average yield is 15-16 q/ha. It matures in 157 to 160 days in NHZ. It has attractive brown colour medium size seed and semi-erect growth habit. It is moderately resistant to wilt, stunt and root rot and tolerant to Ascochyta blight diseases.

CSJ 515: This variety has been developed from the cross FG 712 x CSJ 146 and identified for rainfed areas of NWPZ comprising of North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi. It is semi-erect in nature with profuse branching. Its average yield is 24.0 q/ha and matures in 135 days. It is moderately resistant to wilt, dry root rot, collar rot and tolerant to BGM and Ascochyta blight diseases.

GLK 28127: This variety has been developed from the cross GLK 88016 x FLIP 88-34C and identified for NWPZ comprising of North-West Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi. Its foliage colour is light green. Seeds are large (34-40 g/100 seeds) and of light yellow or creamy colour with irregular owls head. Its average yield is 21.0 q/ha and matures in 149 days.

Pre-breeding

One hundred twenty exotic germplasm lines, 165 exotic landraces and 124 accessions of 7 wild *Cicer* species *viz*., *Cicer reticulatum, C. echinospermum, C. pinnatifidum, C. bijugum, C. judaicum, C. cuneatum* and *C. chorassanicum* were maintained. Total 709 germplasm accessions were also rejuvenated and characterized for 21 qualitative and quantitative traits. Molecular diversity analysis in 221 chickpea genotypes including wild (46 acc.), land races (89 acc.) and cultivated genotypes (86 acc.) was also performed with 25 simple sequence repeats (SSR) markers and 22 SSR markers exhibited polymorphism.

Total 124 accessions belonging to 7 wild *Cicer* species *viz*., *C. reticulatum, C. echinospermum, C. pinnatifidum, C. chorassanicum, C. judaicum, C. bijugum* and *C. cuneatum* were evaluated for various yield attributes. Large amount of variability was observed for number of primary branches/plant, pods/plant and seeds/pod. Number of primary branches/plant ranged from 3 (*C. cuneatum*) to 28 (*C. reticulatum* and *C. echinospermum*), whereas number of secondary branches/plant varied from 13 (*C. cuneatum*) to 49 (*C. pinnatifidum*). Variability for pods/plant ranged from 31 (*C. chorassanicum*) to 89 pods (*C. judaicum* and *C. pinnatifidum*). Similarly, accessions of 6 wild *Cicer* species had 1 to 2 seeds/pod, whereas accessions belonging to *C. cuneatum* (EC 600098, EC 600100 and EC 600098) had 5-6 seeds/pod though seeds size was very small.

Six interspecific crosses *viz*., IPCK 2004-29 x ILWC 179, IPCK 2002-29 x ILWC 21, IPCK 2004-29 x ILWC 21, IPC 2006-11 x ILWC 49, KWR 108 x ILWC 148 and IPCK 2002-29 x ILWC 148 (*C. reticulatum, C. echinospermum*) and three crosses *viz*., ILWC 3279 x IPCK 2004-40, IPCK 2002-29 x ILC 593 and IPCK 2002-29 x ILC 593 utilizing landraces were made to develop suitable genotypes.

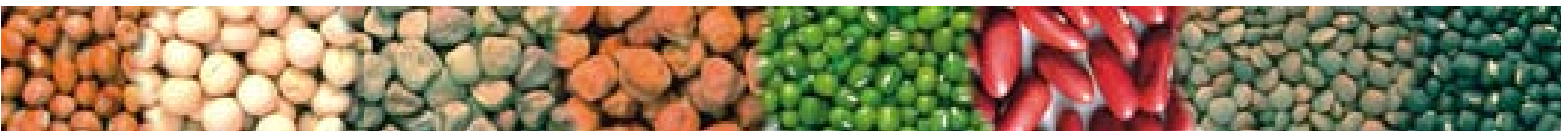
National Crossing Programme

To develop pool of segregating material, various centres *viz*., MPKV, Rahuri (5), ARS, Durgapura (20), JAU, Junagadh (6), RARS, Nandyal (6), ARS, Kota (3), CCSHAU, Hisar (4), ARS, Sriganganagar (4), PAU, Ludhiana (4), NDUAT, Faizabad (7), JNKVV, Jabalpur (4), COA, Sehore (17), IARI, New Delhi (4), BAU, Ranchi (2), IGKVV, Raipur (2) attempted crosses as per need of the region under national crossing programme. Seeds of these crosses will be advanced and segregating material will be shared among various centres for varietal development.

Shuttle Breeding Programme

Shuttle breeding provides an opportunity for flow of breeding material of diverse origin among cooperative centres of AICRP to strengthen the breeding programmes. The material developed through this project also served as input to breeding programme of various ecosystems.

F_2 seeds of five crosses received from Sriganganagar were distributed to Kalyani and Shillongani. F_3 seeds of four crosses received from Ludhiana were supplied to Mokama. Seeds of four wild derivatives received from Ludhiana were supplied to Jabalpur. Eleven accessions of wild spp. of chickpea were supplied to MPKV, Rahuri for multiplication and maintenance. F_4 seeds of eight crosses received from IARI, New Delhi were supplied to Ranchi, Shillongani. Kalyani, Mokama, Faizabad, Dholi, Sriganganagar and Imphal. F_3 seeds of nine crosses received from JAU, Junagadh were distributed to Jabalpur, Raipur, Nandyal and Kota. F_3 seeds of ten *desi* and *kabuli* crosses received from CCSHAU, Hisar were supplied to



Shillongani, Kalyani, Mokama and Ranchi. F_3 seeds of seventeen crosses received from MPKV, Rahuri were distributed to Junagadh and Raipur.

Off-season Nursery

During 2013, facility for growing off season nursery has been created at IIPR Regional Station-cum-Off Season Nursery at Dharwad. Seeds of forty eight crosses from CCSHAU, Hisar were sent for generation advancement.

Genetic Resource Management

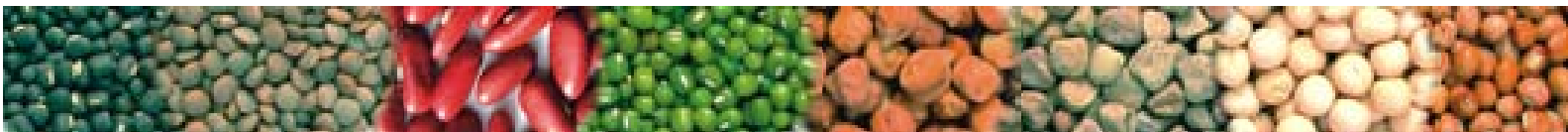
Total 18,172 germplasm accessions were maintained at 16 centres. These accessions were evaluated for morphological traits.

Breeder Seed Production

Total 10,452.06 q of breeder seed of 92 chickpea varieties was produced against DAC indent of 9367.94 q.

Research Achievements

- Sowing of chickpea on BBF with intercropping gave 31.91, 54.0, 33.29 and 25.90 per cent higher yield at Ranchi, Ludhiana, Sehore and Kota, respectively over sowing on flat bed. Two irrigations, one each at branching and pod development stage gave 127, 551, 200, 322, 209, 195 kg/ha more yield at Ranchi, Durgapura, Ludhiana, Rahuri, Sehore and Kota, respectively over one irrigation provided at branching stage.
- Varieties *viz*., GJG 0809 at Samba, GLK 28127 at Ludhiana and Sriganganagar, JGK 1 and CSJ 515 at Durgapura, Pant G 3 and RSG 931 at Pantnagar and RSG 931 (*desi*) at Sriganganagar were highest yielder. Timely sowing at all the centres gave highest yield over late sowing except at Durgapura where large seeded chickpea yield was at par on both the sowing dates.
- Among tillage operation, conventional tillage gave 8.0 and 12.4% higher yield over reduced tillage at Ranchi and Samba centres, respectively. However, at Gulbarga centre, reduced tillage gave 31.67 % higher yield over conventional tillage.
- At Ranchi, Samba and Kota centres, integrated use of fertilizer gave 8.9, 4.83 and 17.25 per cent higher yield, respectively over RDF alone. But at Banglore and Gulbarga centres, RDF was found better over integrated use of fertilizer.
- Twice manual weeding gave 11.44, 5.8, 9.38, 7.58, 11.78, 11.41 per cent higher yield over use of recommended doses of herbicide at Ranchi, Samba, Dholi, Kota, Badanapur and Gulbarga, respectively. However, at Banglore centre use of recommended doses of herbicide was better than manual weeding.
- Application of Imazethapyr @ 15 g/ha POE on 30 DAG at Samba and Kumher, @15 g/ha POE at 10 DAG at Kota , @ 20 g/ha POE at 10 DAG at Badanapur, Rahuri at 20 DAG at Dholi and @ 30 g/ha POE at 10 DAG at Gulbarga gave highest yield among all the doses and time of application of Imazethapyr. However, at Rahuri, Badanapur and Kota, application of pendimethalin (1.0 kg/ha), PE + one hand weeding at 30 DAS was at par in comparison to the best performing dose of Imazethapyr.
- At Dholi, Kota, Junagadh, Rahuri and Gulbarga, application of pendimethalin CS formulation (0.75 – 1.0 kg/ha), PE + one hoeing at 30-35 DAS gave highest yield among all the treatments, while Pantnagar, Ludhiana, Samba, Sehore, Badanapur and Banglore centres reported higher yield due to application of pendimethalin 30 EC formulation + Imazethapyr 2% (Ready mix combination) @ 1.0 kg/ha PE + one hoeing at 30-35 DAS.
- Application of RDF + 1.0 g Ammonium molybdate/kg seed with Rh+PSB was found better at Sriganganagar, Junagadh and Kota with a yield increase of 16.77, 18.79 and 11.81 per cent, respectively over RDF alone.
- At Faizabad and Dholi centers, conventional tillage (two harrowing + planking), followed by line sowing gave highest yield with an yield increase of 34.17% over broadcasting of seed, followed by (27.99%) reduced tillage (one harrowing + planking), while at Jabalpur centre bed planting was found better over rest of the treatments.
- Genotypes RSG 888, RSG 807, JG 11, JG 130, Vishal, Virat, Digvijay and Indira Chana 1 showed higher root depth, dry matter and root to shoot ratio.
- Genotypes like Phule G 96006, L 550, GNG 663, Vaibhav, Annegiri, GPF 2, ICCV 88505 and ICCV 8506 performed better at low temperature.
- Genotypes *viz*., PG 96006, ICCV 92944, Annegiri, JG 74 and BGD 103 were identified heat tolerant on the basis of heat susceptibility index.
- Three new promising PGPR strains from chickpea rhizosphere were identified as PGPR 3 (Ludhiana), LK 786 (Pantnagar) and PSM 15 (Hisar) along with *Mesorhizobium* (CH 1233) which can be utilized for improving productivity in chickpea.



- Strain MPKVR 2 from Rahuri gave an yield increase of 27.9%. Reference strain UASB 835 from Bangalore recorded 26.2% increase in grain yield. With rhizobial inoculation, there is a minimum saving of 40 kg N/ha.
- On the basis of pooled mean (3 yrs), inoculation with all the inoculants (*Piriformospora indica* + *Mesorhizobium* + PSB + PGPR) with 30 kg P_2O_5/ ha could increase the grain yield upto 33.4% over un- inoculated control.
- Following genotypes with stable resistance against major disease can be used as donors in breeding programme:

Wilt	:	JG 2000-04, JSC 40, GJG 0919
Dry root rot	:	IPC 2005-28
Ascochyta blight	:	GLK 24092, GLK 26167, H 03-45

- Following genotypes were identified as resistant against dual and multiple diseases:

Wilt, Dry root rot	:	DKG 972, CSJK 74, JG 24
Wilt, Dry root rot and BGM	:	BG 3004
Collar rot and Ascochyta blight	:	JGK 22
Wilt and Botrytis grey mould	:	CSJK 54, SKUA - C - 23311, GJG 0906, Phule G 0818

- Following entries have showen stable resistance for two or more years (no. of years given in parenthesis) against major diseases:

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

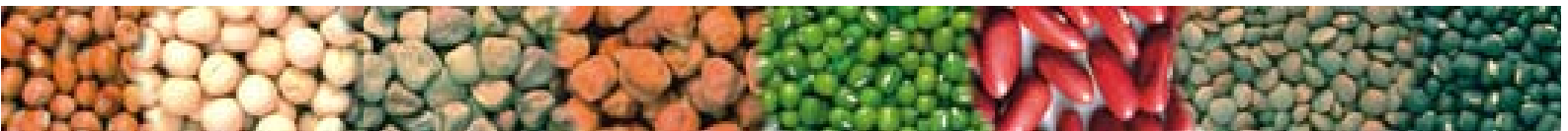
- Following genotypes were found R/MR against races/ pathotypes of Foc. in different zones:

SZ (ICRISAT)	:	GPF 2, DCP 92-3, CPS 1, JG 74, BG 212, JG 315, KWR 108
NWPZ (New Delhi)	:	JG 74, BG 212
CZ		
Junagadh	:	CPS 1, JG-315, C 104, KWR 108
Jabalpur	:	GPF 2, DCP 92-3, CPS 1, JG 315, C 104
Rahuri	:	DCP 92-3, CPS1, JG 315, C 104, KWR 108
Sehore	:	JG 315

- Seed treatment with *Trichoderma harzianum* strain Pusa 5SD in combination with vitavax power @ 1g/kg proved highly effective in reducing wilt and root rot incidence and increasing the yield on the basis of three years multi-locations evaluation.
- The commercial lure was the best as compared to other blends at Ludhiana and Jabalpur. However, the number of moths trapped did not show any difference at Sriganganagar and Bangalore for different blends.

Front Line Demonstrations

- One hundred thirty nine demonstrations were conducted on production potential of high yielding varieties. The overall mean grain yield of high yielding varieties was 1601 kg/ha against 1336 kg/ha of old/local varieties. The per cent increase in grain yield was 20.4.
- One hundred thirty six demonstrations were conducted on package technology. In package technology, 1546 kg/ha yield was obtained against 1154 kg/ha by farmers' practice. Increase in grain yield was 23.4%.
- Two hundred forty five demonstrations on production and protection technologies were conducted in tribal areas of 5 states *viz.*, Madhya Pradesh, Rajasthan, Jharkhand, Chhattisgarh and Maharashtra. Average yield in



demonstrations was 1337 kg/ha, which was 26.3% higher than the local practice (1039 kg/ha).

Pigeonpea

Promising Genotypes

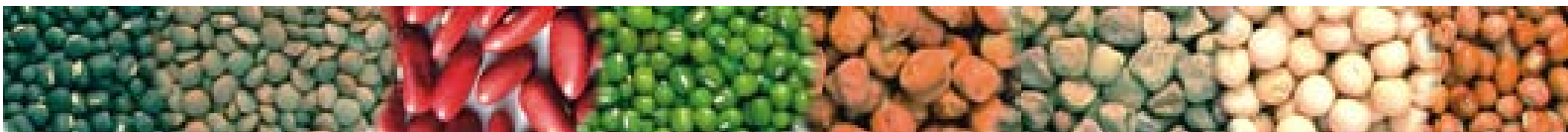
Genotypes *viz.*, WRGE 97, SKNP 1005, TDRGE 5, BDN 2011-1, AKTE 11-3, PT 257, PT 3071 (CZ) and WRGE 97, BDN 2011-1, PT 257, PT 307-1 (SZ) in IVT (Mid early); CRG 333, NTL 900, AKTE 11-1 (CZ) and NTL 900, AKTE 11-1, PT 04-307 (SZ) in AVT 1 (Mid early) and RVKT 260, BRG 10-02, RVKT 261 and BRG 11-01 (SZ) in AVT 2 (Mid early) were found promising.

Breeder Seed Production

Total 673.80 q breeder seed (41varieties) was produced against the DAC indent of 390.94 q.

Research Achievements

- Optimum plant spacing ranges between 90 cm (Badnapur, Junagadh, Gulbarga) and 120 cm (Coimbatore).
- In NEHZ, the optimum time of sowing for *kharif* season is between June 1st (Nagaland) and June 15th (Tripura).
- Early *i.e.*, 18th September sowing registered significantly higher yield in *rabi*.
- Conventional pre-emergence herbicide pendimethalin @ 0.75 kg a.i./ha + early post emergence application of imazethapyr @ 100 g a.i./ha at 10-15 DAS (2-3 leaf stage of weed) + one hand weeding at 50 DAS gave relatively more weed control and increased the grain yield.
- Presence of soil moisture at the time of herbicide application enhanced the weed control efficiency.
- Pigeonpea was found suitable for drip irrigation.
- Lateral spacing of 120 cm and dripper spacing of 60 cm was found optimum for increased productivity.
- Irrigation at 75% CPE was found beneficial.
- Adoption of all the management practices together (INM + IWM+ IPM) increased the grain yield of pigeonpea.
- BRG 2 and thermo-tolerant line TTB 7 (TIR 10) were found superior showing less reduction in yield under terminal moisture stress.
- Genotype Pant A 402, ICPL 20330, MH 5 and P 992 had highest root surface area and root dry mass.
- Reconfirmation studies indicated ICP 3226 to be high P uptake type with higher specific activity of acid phosphatase out of the identified genotypes under P deficient condition.
- Genotypes AL 1747 and AL 1790 were found promising against pod borer. Similarly, BRG 10-2, BRG 11-01, WRG 29 and WRG 161 were promising against insect/pests.
- Among the new insecticides tested, rynaxipyr 18.5 SC @ 30 g a.i./ha. was effective in management of *Maruca vitrata* and podfly.
- Application of neem soap or Pongamia soap or NSKE, followed by two applications of indoxacarb was as effective as three applications of indoxacarb for control of pod borers.
- In validation and promotion of IPM, there was an overall increase of 42.70% grain yield of pigeonpea over farmers' practice in Khargone.
- Entries *viz.*, BRG 3, BSMR 2, BSMR 243, BSMR 571, BSMR 579, BSMR 736, BSMR 853, BWR 133, GRG 333, GRG 811, GRG 2009, IPAC 68, IPA 8F, IPA 204, KPL 44, TS 3R and WRI 1 were found promising and exhibited R to MR reaction to wilt. One hybrid SKNPCH 0923 showed moderately resistant reaction. ICRISAT genotypes *viz.*, ICPL 12728, ICPL12739, ICPL 12752, ICPL 20124, ICPL 20136, ICPL 96053, ICPL99055, ICPL 99095 and ICPL99098 showed R to MR reaction to wilt.
- Entries BRG 3 and MA 6 showed resistant reaction against sterility mosaic. Whereas, Bahar, BRG 1, BRG 2, ICPL 87119, IPA 8F, IPA 204, MAL 13 KPL 43, ICPL 96053, ICPL 990044, and ICPL 99091 were found promising and exhibited resistant reaction at majorty of the locations tested.
- Three entries *viz.*, BSMR 571, BSMR 853 and RVSA 07-10 showed MR reaction against Phytophthora stem blight at Ludhiana and GT 101, BSMR 736 and IPA 8F exhibited MR reaction at Sehore.
- Entries *viz.*, GRG 333, IPA 8F, IPA 15F and UPAS 120 recorded resistant reaction against Macrophomina stem blight at one location out of 2 locations.
- Entries RVSA 07-31, RVSA 07-10 and RVSA 07-29 were found moderately resistant against *Meloidogyne incognita* at three locations out of five in preliminary screening. Similarly, varieties BDN 2 and BRG 2 were found moderately resistant against *M. incognita* at three locations out of five in preliminary screening.



Front Line Demonstrations

- Intercropping of pigeonpea with soybean (2:4) resulted in 32% more grain yield than farmers' practice (Sole crop) in 30 demonstrations.
- Application of drip irrigation enhanced the yield by 59% than local practice in 10 demonstrations.
- Application of 20 kg S/ha with 100 kg DAP/ha enhanced the productivity by 21.20% in 10 demonstrations.
- Insect (Pod borer) management was found most beneficial and recorded 21.7% higher grain yield with 13.3% higher net return in 10 demonstrations.
- To control weeds in pigeonpea, pre-emergence applications of pendimethalin @ 1.25 kg a.i./ha was found most effective with 21.4% higher grain yield in five demonstrations.
- Planting on ridges recorded 20.8% higher grain yield in five demonstrations.
- Integration of all components of production technology enhanced the productivity of pigeonpea by 29.8% with 27.2% higher net return in 258 demonstrations.

MULLaRP

Varieties Identified

MH 421: This mungbean variety developed from cross Muskan x BDYR 2 has been identified for summer season in Punjab, Haryana, New Delhi and western Uttar Pradesh. It has shown yield superiority of 10.3% over the best check with an average yield of 1157 kg/ha.

IPFD 10-12: This green seeded dwarf fieldpea variety developed from cross IPF 99-25 x EC 384275 has been identified for Madhya Pradesh, Chhatisgarh, Bundelkhand region of U.P., Gujarat and South Rajasthan. Its average yield is 2176 kg/ha and has shown an yield advantage of 17% over the check variety Adarsh. It is resistant to powdery mildew disease and matures in 109 days.

HFP 715: This dwarf fieldpea variety developed from cross DMR 50 x HFP 9948 and has been identified for Himanchal Pradesh, J & K, hills of Uttarakhand and NEH states. Its average yield is 1531 kg/ha and has shown an yield advantage of about 11% over the check variety Prakash. It is resistant to powdery mildew disease.

SRJ 1: This rajmash variety developed from selection from a local land race KRC 8 has been identified for eastern U.P., Bihar, Jharkhand and Assam states. Its average yield is 1286 kg/ha and has shown an yield increase of about 19% over the check PDR 14. The seeds are large and variegated magenta in colour.

Genetic Resource Management

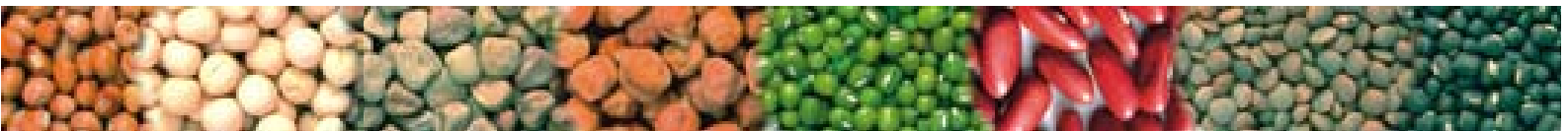
Total 3341 accessions of mungbean, 2007 of urdbean, 1018 of lentil, 753 of fieldpea and 1964 accessions of lathyrus were maintained and evaluated for various attributes at diferent centres. Promising accessions of mungbean for early maturity, seed wt., pod length and synchronous maturity were identified. Two unique germplasm of urdbean, SPS 5 for sympodial bearing and IPU 97-167m for functional male sterility were registered with NBPGR.

Breeder Seed Production

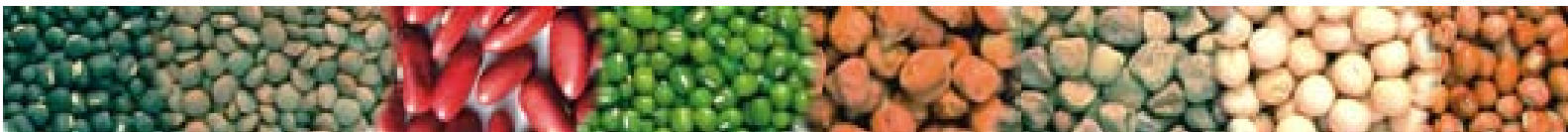
Total 936.69 q breeder seed of mungbean (61 varieties), 941.11 q of urdbean (41 varieties), 916.00 q of lentil (30 varieties) and 863.33 q of fieldpea (23 varieties) was produced against the indent of 1033.49 q, 752.11 q, 561.96 q and 691.85 q, respectively.

Research Achievements

- In IVT, genotypes GM 04-02 (773 kg/ha) and MH 805 (739 kg/ha) were found promising for NHZ and IPM 2K 15-4 (1388 kg/ha) was the highest yielding line in NWPZ.
- AKM 1012 and AKM 09-2 at Akola and MH 565 at Hisar were most suited mungbean genotypes for intercropping with pigeonpea.
- *Kharif* mungbean can be sown upto 20th July. ML 818 (1345 kg/ha) at Ludhiana, Meha (908 kg/ha) at Dholi, RM 03-79 (801 kg/ha) at Raipur, and GM 04 (949 kg/ha) at Badanapur were most promising.
- Pendimethalin 30 EC + Imazethapyr 2 EC @ 1.0 kg/ha (Vallore 32) and Imazethapyr 55 g/ha were most effective herbicides (NWPZ, NEPZ, CZ and SZ).
- Entry ML 1464 showed combined multiple and multilocational resistance to MYMV, leaf curl virus, urdbean leaf crinkle virus and root rot. Genotype IPM 306-6 showed multiple resistance to MYMV and urdbean leaf crinkle virus.
- Among the NGSN entries, genotypes KM 2262, LH 911, ML 1721, ML 1921, ML 1946, ML 2037 and ML 2081 showed multilocational and multiple resistance to MYMV and anthracnose.
- Genotypes ML 1464, ML 2060, ML 2081 and ML 2083 were resistant to MYMV and Cercospora leaf spot.
- The differential reaction to isolates of MYMV on differential cultivars at various locations suggested pathogenic variability.



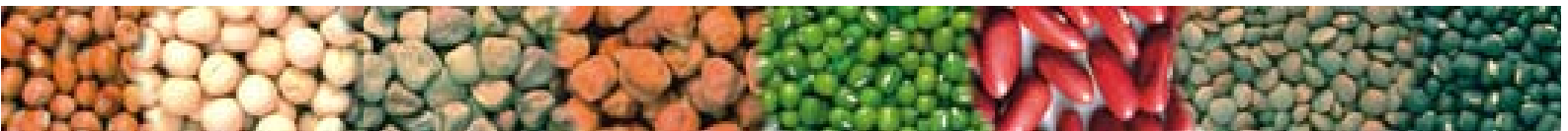
- Seed treatment with carbendazim @ 2 g/kg and two foliar sprays of propiconazole and carbendazim @ 0.1% were effective in reducing the severity of foliar diseases *viz*., Cercospora leaf spot, anthracnose, powdery mildew, macrophomina blight and/or Web blight.
- The promising urdbean genotypes in AVT 2 and AVT 1 for *kharif* season were KUG 503 (841 kg/ha) in NWPZ. In IVT, KUG 586 (886 kg/ha) in NWPZ and UH 07-06 (1195 kg/ha), KU 1006 (1194 kg/ha) in NEPZ were high yielding lines.
- Among *rabi* urdbean, genotypes LBG 787 (1268 kg/ha) and TU 18 (1127 kg/ha) were found promising in SZ.
- Imazethapyr @ 40-55 g/ha managed the weeds in urdbean + ragi (2:1) intercropping at Dholi, Ranchi, Berhampur (O) and Dharwad.
- Pant U31 (Pantnagar), VBN (Bg) 7 (Vamban) and TNAU Co6 (Coimbatore) were most promising urdbean genotypes in intercropping with Maize. AKU 10-1 was most suited with pigeonpea at Akola.
- Application of lime @ 300 kg/ha, 100% RDF and seed treatment with Mo @ 4 g/kg seed + two sprays of 2% urea significantly maximized urdbean yield on acid soils at Ranchi, Berhampur (O) and Vamban.
- Pendimethalin 30 EC+Imazethapyr 2 EC @ 1.0 kg/ha (PE) was most effective herbicide.
- Uttara and IPU 02-43 showed multiple resistance to MYMV, LCV and stem necrosis, and NDU 12-300, VBG 10-24 and KPU 1-10 were resistant to MYMV and stem necrosis. Entries UH 07-06 and KU 11-06 were resistant to MYMV and LCV.
- Seed treatment with carbendazim along with two foliar sprays of propiconazole/cabendazim @ 0.1% were highly effective for the management of foliar diseases of urdbean.
- Web blight caused by *Rhizoctonia solani* is appearing as a threatening disease in Himachal Pradesh and Uttarakhand.
- MYMV populations differed pathogenically in different areas.
- Large seeded lentil genotypes VL 521 (1173 kg/ha), SKUA L2-96 (1298 kg/ha), VL 507 (1278 kg/ha and SKUA L-9 (1365 kg/ha) were found promising in NHZ
- Extra early genotypes RKL 607-01 (1423 kg/ha) and IPL 534 (1268 kg/ha) were found promising.
- Pre-breeding efforts were made in lentil by making 10 fresh crosses using *L. orientalis, L. erviodes* and *L. odemensis*.
- Trait specific mapping populations were developed for earliness and seed weight in lentil.
- Ten crosses were made in lentil for identification of QTLs for Fe and Zn concentration.
- Pendimethalin 30 EC+Imazethapyr 2 EC at 0.75 to 1.0 kg/ha (PE) consistently and effectively managed the weeds with higher lentil yield in all the zones. Alternatively, pendimethalin 1.0 kg/ha as PE+Imazethapyr 37.5 g/ha at 30 DAS or pendimethalin 1.0 kg/ha as PE+quizalofop ethyl 50 g/ha at 30 DAS were equally effective at Ludhiana, Pantnagar and Dholi.
- Spray of 500 ppm thiourea at pre flowering and pod filling stages proved better than 2% urea spray for higher lentil yield under rainfed and limited irrigation conditions.
- *Rhizobium* strain, LR 63-01 significantly increased the nodulation (16.1/plant) and grain yield (13.9 q/ha) in lentil variety PL 5 when co-inoculated with KRB 1. The performance of this treatment was at par with LR 35B-01 (check). Among the *Rhizobium* strains, DL 1 in Durgapura, LLR 12 in Ludhiana and LR 63-01 in Pantnagar were superior in increasing the nodulation and grain yield of lentil when co-inoculated with KRB 1.
- Entries VL 521, IPL 321 and DPL 15 showed multiple resistance to wilt, rust and Ascochyta blight. Entries IPL 326, LL 1114, RKL 606-09, EC 1, IPL 81, L 4711, IPL 222 and SKUL 9-96 were resistant to rust and Ascochyta blight.
- Seed treatment with carbendazim+Thiram- (1:2) @ 3 g/kg, followed by seed treatment with *Trichoderma viride/harzianum*+ Vitavax power (6:1) @ 3 g/kg were highly effective for management of wilt in lentil.
- VL 521, L 4147 and L 4076 were observed as resistant and IPL 224 and LL 1255 as moderately resistant against *Meloidogyne incognita* at ARS Durgapura. Entries IPL 224, RLG 157, DPL 62, IPL 406, IPL 215, PL 135, RKL 604-01, VL 145 and RKL 607-01 were observed as resistant against *M. javanica* at IIPR, Kanpur
- Tall fieldpea genotype IPF 11-15 (1516 kg/ha) was found promising in CZ. Among dwarf genotypes, IPFD 11-15 (2085 kg/ha) and IPFD 10-12 (2068 kg/ha) were high yielding genotypes in CZ.
- Pendimethalin 30 EC+Imazethapyr 2 EC 0.75-1.0 kg/ha (Pre-emergence) effectively managed broad leaved as well as grassy weeds and produced higher yield of fieldpea across the zones. Post-emergence herbicide imazethapyr 50-75 g/ha applied at 30 DAS was also found effective for controlling weeds and gave higher yield of fieldpea in NEPZ, CZ, NHZ and NWPZ.



- Paired planting of value added maize (baby corn) with fieldpea in 2:2 ratio recorded maximum fieldpea equivalent yield in intercropping (Pantnagar and Dholi).
- HUDP 15, KPF 1028, IPFD 10-12, IPFD 12-8, HUDP 1211, HUDP 1200, HUDP 954, RFP 2009-1, ICPF 1024, Ambika, RFP 2009-2, VL 58, RFP 72 and HFP 919 showed promise, registering PSR 2 against pod borer at Shillongani.
- Biorational pest management in fieldpea revealed indoxacarb @ 60 g a.i./ha as best treatment, which was at par with Emamectin benzoate (10 g a.i./ha), Rynoxypyr (25 g a.i./ha) and NSEK 5% on larvae reduction with higher crop yield at Shillongani.
- Fieldpea entry HUDP 954 was found resistant/moderately resistant against *Meloidogyne incognita* at three centres. Entries NDP 12-11, IPFD 12-2, UL 58, KPMR 925(D) and HUDP 954 were found resistant against *M. incognita* at two centres. IPFD 11-10 and IPFD 99-13 were found resistant against *M. javanica* at IIPR in micro plot screening.
- Lathyrus genotype RLS 3004-2 (926 kg/ha) was found promising in NEPZ.
- Pre-emergence application of pendimethalin 30 EC+Imazethapyr 2 EC 0.75-1.0 kg/ha effectively managed broad leaved as well as grassy weeds and produced higher yield of rajmash (Varanasi, Kota, Raipur and S.K. Nagar).
- Rajmash genotype 194 A and HUR 203 exhibited cipher damage due to pod borer at Varanasi. PKR 1033 recorded merely 0.67% pod damage due to pod borer, which was at par with PKR 1033, SRJ 612, HUR 137 and SKUAR 132.

Front Line Demonstrations

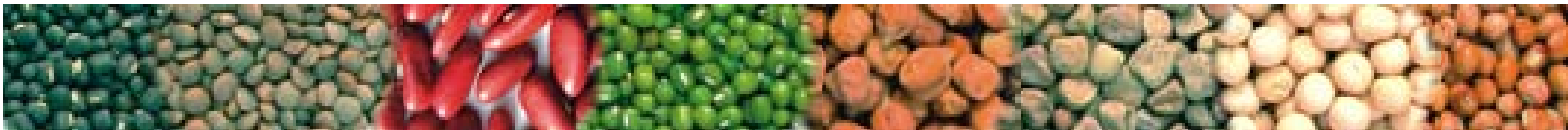
- During *kharif* mungbean, 285 demonstrations were conducted on full package technology. This recorded 19.56% higher grain yield and 23.61% increase in net returns over local varieties. During *rabi* mungbean, 89 demonstrations were conducted on full package. This recorded 17.81% higher grain yield and 26.72% increase in net returns over local varieties. In rice-fallow mungbean, package technology depicted 14.21% higher grain yield and 38.57% increase in terms of net returns over local varieties.
- During *kharif* urdbean, 317 demonstrations were conducted on package technology. This recorded 22.50% higher grain yield and 25.92% increase in net returns over local varieties. During *rabi* urdbean, 90 demonstrations were conducted on package technology. This recorded 12.65% higher grain yield and 21.98% increase in net returns over local varieties. In rice-fallow urdbean, package technology depicted 15.61% higher grain yield and 74.72% increase in terms of net return over local varieties.
- Total 60 demonstrations (30 each in lentil and fieldpea) were conducted under Tribal Sub-Plan with emphasis on full package technology. With the adoption of improved technologies, 31% and 33% increase in yield was observed in lentil and fieldpea, respectively.



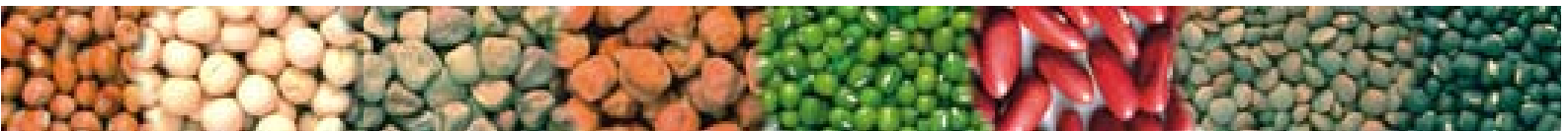
Transfer of Technology

Following training and extension activities were organized during 2013-14:

Activity	Date	No. of participants	Background of participants	Venue/Place
Model Training Course	21-28 October, 2013	16	Joint Director (Agriculture) Deputy Director (Agriculture) Distt. Agril. Officers of different states	IIPR, Kanpur
State level Training	22-26 February, 2014	25	Deputy Director (Training) State Consultants (NFSM), B.T.Ms of five districts of Kanpur Division	
Training of farmers				
From other states	24 August, 2013	32	Farmers of M.P.	IIPR, Kanpur
	10-12 September, 2013	32	Farmers of Almora, Uttarakahnd	
	18-22 September, 2013	28	Farmers of M.P.	
	8-10 October, 2013	29	Farmers of Almora, Uttarakhand	
	6-10 November, 2013	25	Farmers of Hazaribagh, Jharkhand	
	18-22 December, 2013	22	Farmers of Latehar, Jharkhand	
	26-28 December, 2013	18	Farmers of Nawada, Bihar	
	20-22 January, 2014	24	Farmers of Ranchi, Jharkhand	
	27-31 January, 2014	35	Farmers of Satna (M.P.)	
	17-21 February, 2014	25	Farmers of Latehar, Jharkhand	
	3-7 March, 2014	23	Farmers of Latehar, Jharkhand	
From Uttar Pradesh	30 September, 2013	62	Farmers of Fatehpur	
	25 October, 2013	60	Farmers of Kanpur Dehat	
	4 October, 2013	18	Farmers of Fatehpur	
	11-12 February, 2014	50	Farmers of Jaloun	
	18 February, 2014	74	Farmers of Kanpur Dehat and Fatehpur, U.P.	
	14 March, 2014	16	Farmers of Jhansi, U.P.	
Field days	24 December, 2013	54	Farmers of Fatehpur	Fatehpur
	24 January, 2014	88	Farmers of Hamirpur	Hamirpur
	14 March, 2014	86	Farmers of Jalaun	Jalaun
Farmer's day	30 September, 2013	137	Farmers of Kanpur Dehat and Fatehpur	IIPR Kanpur
	18 February, 2014	162	Farmers of Kanpur Dehat and Fatehpur	
Participation in Kisan Mela	25-27 February, 2014	-	Farmers, Extension Personnel, Scientists, Students, *etc.*	CSAU&T, Kanpur
Participation in Krishi Basant 2014	9-13 February, 2014	-	National and International dignitaries, Farmers, Extension Personnel, Scientists, Students, *etc.*	Central Institute for Cotton Research, Nagpur, (MS)



Exposure Visits	3May, 2013	20	Farmers of Satna, M. P.	IIPR, Kanpur
	1 August, 2013	50	Farmers of Hardoi,U.P.	
	4 August, 2013	30	Farmers of Shyopur, M.P.	
	2 September, 2013	30	Farmers of Anoopur M.P.	
	27 September, 2013	35	Farmers of Shahdol (M.P.)	
	27 September, 2013	30	Farmers of Jabalpur (M.P.)	
	4 December, 2013	10	Farmers of Kanpur, U.P.	
	18 December, 2013	42	Farmers of Bhind (M.P.)	
	25 January, 2014	34	Farmers of Kodarma, Jharkhand	
	1 March, 2014	60	Farmers of Anoop Pur, M.P.	
TV Talk	13 (Nine Live telecast)		Doordarshan Kendra, Lucknow	
Radio Talk	01		AIR Lucknow	



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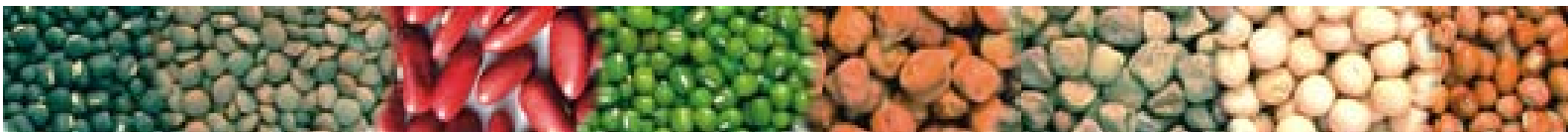

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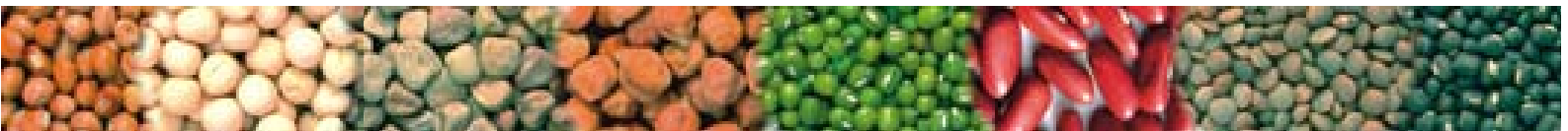

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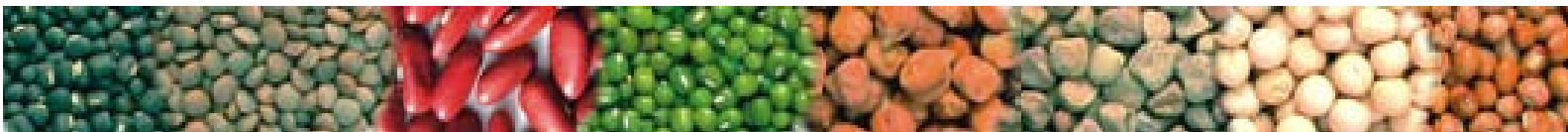

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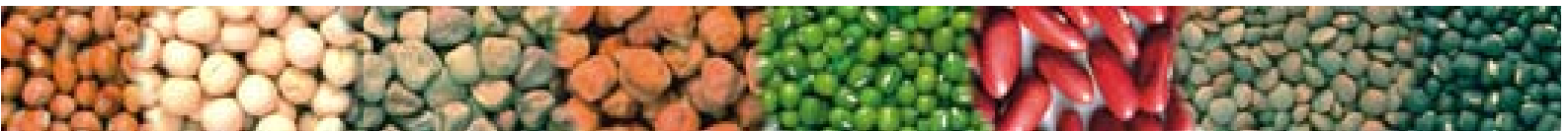

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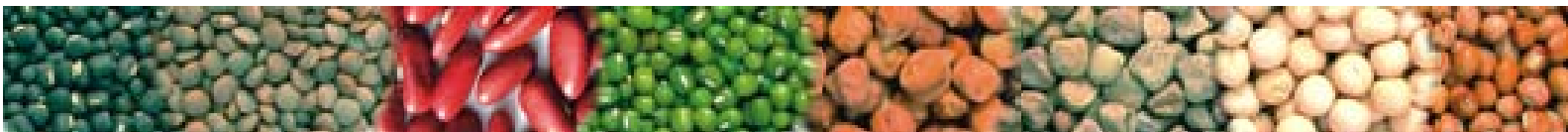

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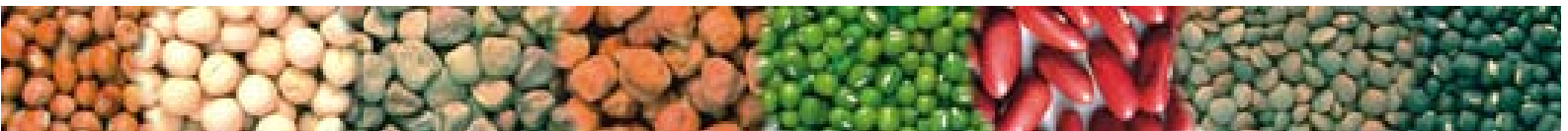

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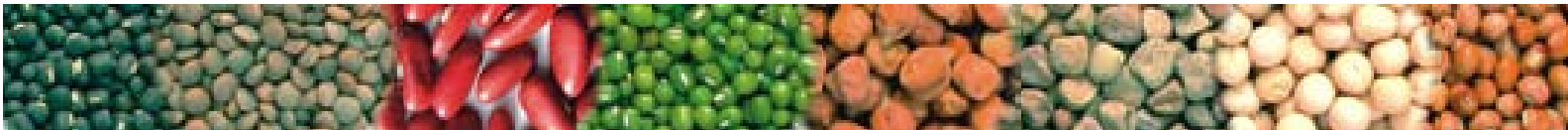
- *Masoor Utpadan Taknik*. [Kumar, Narendra, Singh, S.K., Akram, Mohd., Dixit, G.P. and Kumar, Jitendra]
- Souvenir & Programme : ICAR Zonal Tournament.



Human Resource Development

Deputation Abroad

Drs. Jagdish Singh, HoD, Basic Science and Jitendra Kumar, Senior Scientist were deputed to attend the Review and Planning Meeting of ICARDA South Asia and China Regional Programme under HarvestPlus Challenge Programme on Lentil Biofortification held on September 23-25, 2013 at Kathmandu, Nepal. Dr. Singh delivered a lecture on 'Nutritional quality traits in pulses: Potential for biofortification'.

Dr. C.S. Praharaj, Principal Scientist (Agronomy), was deputed to visit Cairo, Egypt for participating in International Conference on Policies for Water and Food Security in Dry Areas held on June 24-26, 2013. The Conference was organized jointly by ICARDA, FAO, IFAD, IDRC, CRDI and ARC.

Dr. Aditya Pratap, Senior Scientist, was deputed to visit Nairobi, Kenya to attend a training course on "Application of biometrics and bioinformatics tools in crop improvement research" organized and sponsored by ICRISAT, Hyderabad on November 4-9, 2013. Hands-on training on crop improvement related softwares such as GenStat, genotypic data management system, Integrated Breeding Platform, *etc*. were also organized during this training.

Dr. M.S. Venkatesh, Principal Scientist was deputed to attend international training on Carbon Sequestration during September 23 to December 21, 2013 at Carbon Management and Sequestration Center (C-MASC), School of Environment and Natural Resources (SENR), Ohio State University, Columbus, USA. The training was sponsored by National Agricultural Innovation Project (NAIP) of Indian Council of Agricultural Research.

Dr. Mohd. Akram, Senior Scientist was deputed to attend the 10th International Congress of Plant Pathology on "Bio-security,food safety and plant pathology: the role of plant pathology in globalized economy" held at Beijing International Convention Center, Beijing, China on August 20-30, 2013. Dr. Akram presented a paper 'Genetic diversity in *Groundnut bud necrosis virus* isolates infecting legumes in India'.

Participation in Training/Meeting, etc.

Dr. Aditya Pratap attended 1st U.P. Agricultural Science Congress, held at ND University of Agriculture and Technology, Kumarganj, Faizabad, U.P. on August 16-17, 2013.

Drs. S.K. Chaturvedi and Aditya Pratap attended 4th International Workshop on 'Next generation genomics and integrated breeding for crop improvement' held on February 19-21, 2014 at ICRISAT, Patancheru (India).

Dr. S.K. Chaturvedi attended VIII National Conference on 'Biotechnology, biodiversity and environment on recent advances in biodiversity conservation, biotechnology and environmental management research' held at Govt. M.S. Golwalkar College, Rewa (M.P.) on 19-20 April 2013.

Dr. Revanappa participated in the Training-cum Awareness Programme on PPV&FRA 2001, held at University of Agriculture Sciences, Dharwad on March 27, 2014.

Dr. Bansa Singh, attended National Conference on 'Crop improvement and adaptive strategies to meet challenges of climate', held at UAS, Bangalore on 22-24 February, 2013.

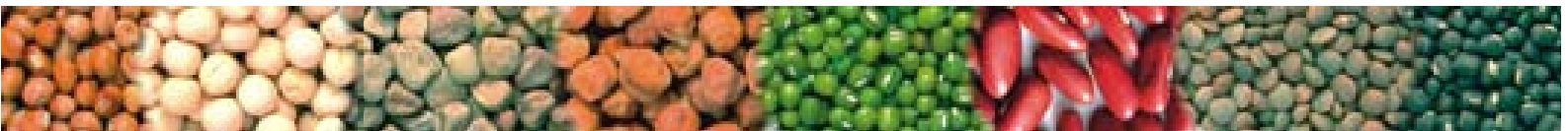
Dr. Bansa Singh attended Workshop on Technology Management organized by ZTM & BPD Unit IVRI, Bareilly on 16 March, 2013.

Dr. R. Jagdishwaran participated in 21 days CAFT programme on "Computational and statistical advances in bioinformatics for 'omics' data" held at IASRI, New Delhi on January 21 - February 10, 2014.

Dr. R. Jagdishwaran participated in SAS Sensitization Training of NAIP Project "Strengthening Statistical Computing for NARS" held at IIPR, Kanpur on 14 March, 2014.

Dr. S.K. Singh attended Steering committee meeting of CROPSAP for pigeonpea and chickpea in Maharashtra held on December 6, 2013 at Commissionerate of Agric., Pune (M.S.)

Dr. Senthilkumar attended MDP workshop on "PME of agricultural research projects" held at National Academy of Agricultural Research Management, Hyderabad on November 19-23, 2013.



Dr. Senthilkumar attended a short term training course on "Multi-omics approaches to alleviate abiotic stress in post genomic era: Methods and applications in microbiological research" held at National Institute of Abiotic Stress Management, Pune on January 24 – February 6, 2014.

Dr. Paulraj attended a training programme on "Food quality and safety management systems" held at Tamil Nadu Agricultural University, Coimbatore on December 4 – 24, 2013.

Dr. Alagupalamuthirsolai attended a training programme on "Physiological and molecular approaches to improve drought adaptation of crops" held at UAS, Bangalore on February 24 – March 10, 2014.

Dr. Devraj attended one-day "Sensitization workshop on internet protocol Version 6 (IPV6)" held at NASC, New Delhi on February 27, 2014.

Dr. K.R. Soren attended Winter School on 'Advances in statistical genetics' held at ISARI, New Delhi on 2-22, July 2013.

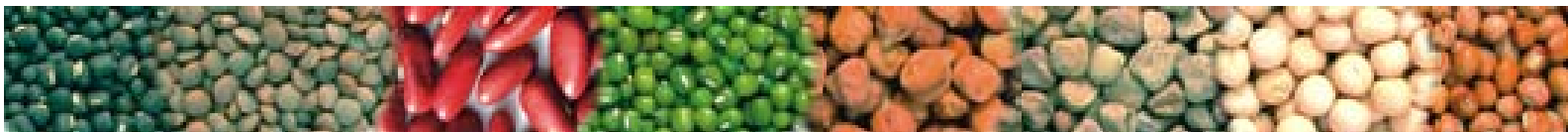
Dr. Narendra Kumar attended Biennial Conference of ISWS on 'Emerging challenges in weed management", held at DWSR, Jabalpur on February 15-17, 2014.

Dr. M.S. Venkatesh attended International Symposium on 'Potassium nutrition and crop quality', held at Ranchi, Jharkhand on 4-5 March, 2014.

Dr. C.S. Praharaj attended Training Course on 'Management development programme on consultancy projects management (MDPCPM)' held at NAARM, Hyderabad on August 1-7, 2013.

Award and Recognition

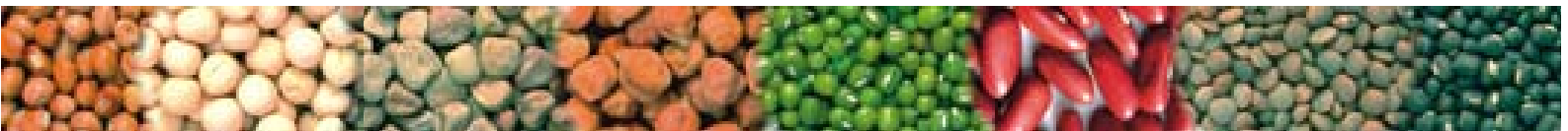
Dr. Ummed Singh, Senior Scientist was honoured with IMPHOS-FAI Award 2013, instituted by the World Phosphate Institute (IMPHOS), Casablanca, Morocco and administered by The Fertiliser Association of India, New Delhi. Dr. Singh was honoured in FAI Annual Seminar 2013 (Fertiliser Sector at Crossroads) held at New Delhi during December 11-13, 2013, for his outstanding research work done on role of phosphorus on yield and quality of crops.



On-going Research Projects

CROP IMPROVEMENT

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



BIOTECHNOLOGY

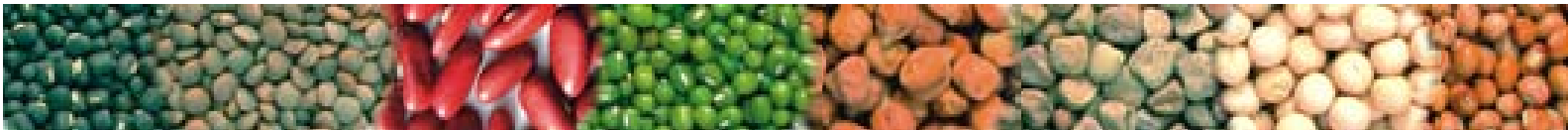
S.N.	Title of the Project	Principal Investigator	Associate
1.	Identification of molecular markers linked to Fusarium wilt race 2 resistance genes in chickpea chickpea (*Cicer arietinum* L)	Dr. K.R. Soren	Dr. P.R. Saabale
2.	Development of chickpea (*Cicer arietinum* L) transgenic for drought tolerance	Dr. Alok Das	Dr. S. Datta Dr. P.S. Basu
3.	Prospecting alleles for enhanced drought tolerance in chickpea and pigeonpea	Dr. Alok Das	Dr. Alagu P.S. Dr. K.R. Soren

CROP PRODUCTION

S.N.	Title of the Project	Principal Investigator	Associate
1.	Efficient management of water for higher productivity in pulses	Dr. C.S. Praharaj	Dr. Ummed Singh
2.	Demonstration of IIPR technologies at farmers' fields	Dr. C. S. Praharaj	Dr. Rajesh Kumar Dr. Mohd. Akram Mr. U.C. Jha
3.	Long term effect of pulses in cropping systems on soil health and crop productivity	Dr. M.S.Venkatesh	Dr. Bansa Singh Dr. C.S. Praharaj Dr. K.K. Hazra Dr. Narendra Kumar Dr. Senthil Kumar Dr. Naimuddin
4.	Sulphur management in pulse based cropping system	Dr. M.S. Venkatesh	Dr. Ummed Singh
5.	Resource conservation technology in pulse based cropping system	Dr. Narendra Kumar	Dr. S. Paulraj
6.	Development of weed management strategies for enhancing pulse productivity	Dr. Narendra Kumar	Dr. K.K. Hazra
7.	Development and evaluation of suitable sowing equipment for pulses	Dr. Narendra Kumar	Mr. S.K. Garg
8.	Carry-over effect of pulse intercrop on nutrient and moisture conservation in chickpea	Dr. Ummed Singh	Dr. Narendra Kumar
9.	Yield maximization and resource use efficiency enhancement in pigeonpea-wheat system	Dr. Ummed Singh	--
10.	Standardization of agro-techniques in summer mungbean	Mr. K.K. Hazra	Dr. Ummed Singh
11.	Improvement in IIPR mini Dal Mill and development of allied milling machinery	--	Mr. S.K. Garg

CROP PROTECTION

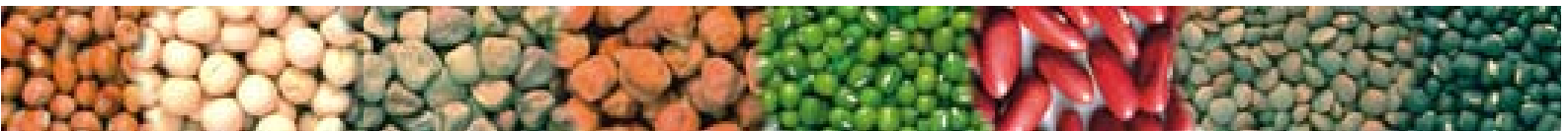
S.N.	Title of the Project	Principal Investigator	Associate
1.	Development of management strategies against thrips infesting mungbean	Dr. Hem Saxena	Dr. Mohd. Akram
2.	Bioprospecting of botanicals for their insecticidal property against major insect pests of pulses	Dr. Hem Saxena	Dr. G.K. Sujayanand Dr. Lalit Kumar



3.	Identification of sources of resistance/tolerance against root knot nematodes in pulses	Dr. Bansa Singh	Dr. R. Jagdeeswaran
4.	Bio-ecological studies of lesion nematode *Pratylenchus* spp. in chickpea and their management	Dr. Bansa Singh	Dr. R. Jagdeeswaran
5.	Bio-ecological studies of *Heterodera cajani* and its eco-friendly management in *Vigna* crops.	Dr. Bansa Singh	Dr. R. Jagdeeswaran
6.	Bioecology of borer complex and sucking pests infesting long duration pigeonpea and their management	Dr. S.K. Singh	Dr. Hem Saxena
7.	Management of viral diseases of mungbean	Dr. Mohd. Akram	Dr. Naimuddin
8.	Variability among geographical isolates of *Fusarium oxysporum* f. sp. *lentis* and management of lentil wilt	Dr. Naimuddin	Dr. Mohd. Akram
9.	Biological control of *Meloidogyne javanica* and *Hetrodera cajani* by *Paecilomyces ilacinus* in *Vigna* crops and chickpea	Dr. R. Jagdeeswaran	Dr. Bansa Singh
10.	Diversity analysis, identification of resistant donors and management of *Rhizoctonia bataticola* causing dry root rot in chickpea	Dr. P.R. Saabale	Dr. Naimuddin
11.	Eco-friendly management of spotted pod borer *Maruca vitrata* Fabricius in short duration pigeonpea	Dr. Sujayanand, G.K.	Dr. Hem Saxena

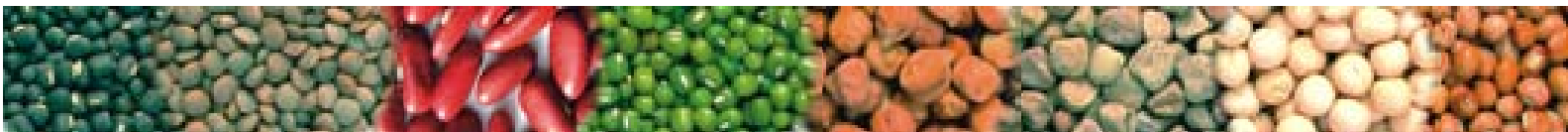
BASIC SCIENCE

S.N.	Title of the Project	Principal Investigator	Associate
1.	Quantification of biologically active components in pulses having potential impact in human health	Dr. Jagdish Singh	Dr. Jitendra Kumar Dr. R.P. Srivastava
2.	Anti-nutritional components of lathyrus and their removal by processing	Dr. R.P. Srivastava	Dr. Jagdish Singh
3.	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 Palamuthir Solai
4.	Physiological response of mungbean to photo-thermoperiods and identification of insensitive genotypes for different photo-thermal regimes	Dr. Vijay Laxmi	--
5.	Screening of lentil genotypes for improved tolerance to drought under rainfed condition	Dr. Vijay Laxmi	--
6.	Identification and characterization of biochemical compounds imparting resistance to fungal pathogens and *Helicoverpa armigera* in chickpea	Dr. Lalit Kumar	Dr. Jagdish Singh
7.	Exploring the genetic diversity of ACC deaminase producing bacteria for moisture stress management in chickpea	Dr. M. Senthil Kumar	Dr. Mohan Singh
8.	Studies on the diversity of PPFM (*Methylobacterium*) in *Vigna* and fieldpea and their potential on plant growth promotion	Dr. S. Paulraj	Dr. M. Senthil Kumar
9.	Identification of source of tolerance to temperature extremities in long duration pigeonpea (*Cajanus cajan*) and analysis of physiological traits conferring tolerance	Dr. Alagu Palamuthir Solai	Dr. D. Datta



SOCIAL SCIENCE

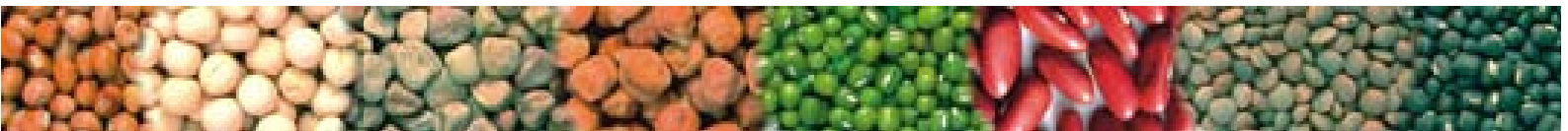
S.N.	Title of the Project	Principal Investigator	Associate
1.	Enhancing pulses production for food, nutritional security and livelihoods of tribal farming community through demonstration and training	Dr. S.K. Singh	Dr. Rajesh Kumar Dr. Uma Sha
2.	Impact analysis of transfer of technology projects implemented by IIPR in Uttar Pradesh	Dr. Rajesh Kumar	Mr. Deepak Singh
3.	Entrepreneurship development through pulses production and processing technologies among rural youths for income and employment generation	Dr. Purushottam	Dr. Rajesh Kumar
4.	Development of appropriate training modules on pulses production technologies	Dr. Purushottam	Dr. Rajesh Kumar
5.	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
6.	Development of database and information system for pulses genetic resources	Dr. Dev Raj	Mr. Deepak Singh
7.	Development of user-friendly analytical module for some in-complete block designs	Mr. Hemant Kumar	Dr. Dev Raj
8.	Analysis of growth and instability in major pulses of India	Mr. Deepak Singh	-
9.	Analysis of consumption pattern and prices of major pulses in India	Mr. Deepak Singh	-



Externally Funded Projects

CROP IMPROVEMENT

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Development of lentil cultivar with high concentration of iron and zinc	ICARDA	Dr. N.P. Singh	Dr. Jitendra Kumar
2.	Evaluation of lentil germplasm for heat tolerance and herbicide tolerance	ICARDA	**Focal Person :** Dr. N.P. Singh **PI:** Dr. Jitendra Kumar	---
3.	Conducting replicated trials on two heat tolerant RIL populations (about 500 lines) in normal and late conditions of chickpea	ICRISAT	**Focal Person :** Dr. N.P. Singh **PI:** Dr. S.K. Chaturvedi	---
4.	Generation advancement and development of new genotypes through pre-breeding in lentil and *kabuli* chickpea	DAC-ICARDA-ICAR	**Coordinator :** Dr. N.P. Singh **PI (Lentil) :** Dr. Jitendra Kumar **PI (*Kabuli* chickpea) :** Dr. S.K. Chaturvedi	Mr. Udai Chand Jha
5.	National initiative on climate resilient agriculture (NICRA)	ICAR	**Institute Coordinator:** Dr. N.P. Singh **PI:** Dr. Sanjeev Gupta	Dr. P.S. Basu Dr. Aditya Pratap Dr. Dibendu Datta Mr. Alagupalamuthir Solai Dr. G.P.Dixit
6.	Implementation of PVP legislation of chickpea (DUS)	PPV & FRA	Dr. N.P. Singh	Dr. Shiv Sewak
7.	Implementation of PVP legislation of MULLaRP (DUS)	PPV & FRA	Dr. Sanjeev Gupta	Dr. G.P. Dixit (*Rabi*) Dr. A.K. Parihar (*Kharif*)
8..	Implementation of PVP legislation of pigeonpea (DUS)	PPV & FRA	Dr. I.P. Singh	Dr. Farindra Singh
9.	Developing chickpea cultivars suited to mechanical harvesting and tolerant to herbicides	NFSM	Dr. S.K. Chaturvedi	---
10.	Seed production in agricultural crops	DAC	Dr. P.K. Katiyar	---
11.	ICAR (NSP) crops	DAC	Dr. P.K. Katiyar	---
12.	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. P.R. Saabale



BIOTECHNOLOGY

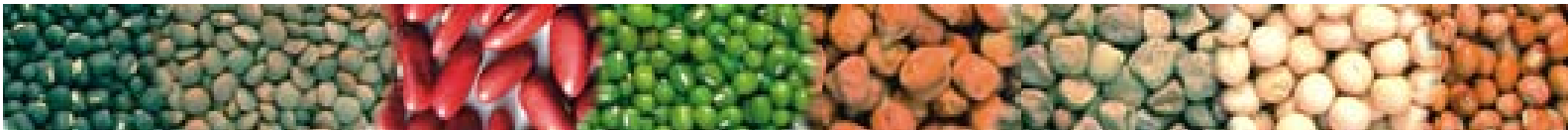
S. No.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Development of pod borer resistant transgenic in pigeonpea and chickpea (Core Group 1) (Phase-I)	NFBSFARA (ICAR)	Dr. S. Datta	Dr. S.K. Chaturvedi Dr. K.R. Soren Dr. Alok Das Dr. Sujayanand G.K.
2.	Transgenic in chickpea and pigeonpea for pod borer resistance	NPTC (ICAR)	Dr. S. Datta	Dr. Alok Das Dr. Sujayanand G.K.
3.	Centre of excellence for highthruput allele determination for molecular breeding	DBT	Dr. S. Datta	Dr. S. K. Chaturvedi Dr. K.R. Soren Dr. A. Bohra Dr. P.R. Saabale
4.	Functional genomics in chickpea	NPTC (ICAR)	Dr. S. Datta	Dr. S.K. Chaturvedi Dr. K.R. Soren

CROP PRODUCTION

S. No.	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. S.S. Singh	Dr. C.S. Praharaj Dr. Narendra Kumar Dr. P.S. Basu Dr. Senthil Kumar Dr. M.S. Venkatesh Dr. K.K. Hazra

CROP PROTECTION

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Crop pest surveillance and advisory project (CROPSAP)	RKVY, Maharashtra	Dr. Shiva Kant Singh	---
2.	Development and validation of PCR based diagnoistic for major viral diseases of some important pulses crops	Council of Science & Technology, UP	Dr. Mohd. Akram	Dr. Naimuddin
3.	Outreach programme on "*Phytophthora*, *Fusarium* and *Ralstonia* diseases of horticultural and field crops"– *Fusarium* wilt of pigeonpea and chickpea	ICAR (through IISR Calicut)	Dr. Naimuddin	Dr. K.R. Soren Dr. P.R. Saabale
4..	Outreach programme on diagnosis and management of leaf spot diseases of field and horticultural crops – Cercospora leaf spot of mungbean and urdbean	ICAR	Dr. Naimuddin	Dr. Mohd. Akram



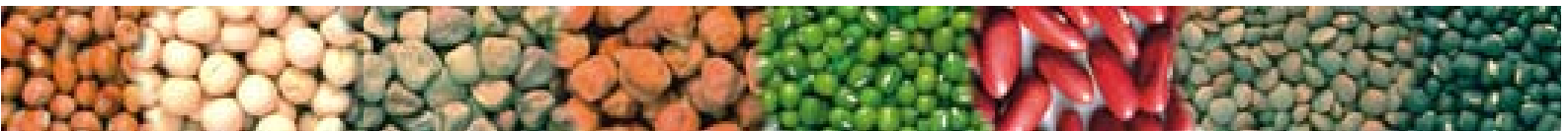
5.	Entopathogenic nematodes and its use as biopesticide	DST (SERB) (Users Project)	Dr. S.S. Ali	--
6.	Developing strategic and holistic pest management modules in legume based cropping system and its authentication	DST (SERB) (Fast track young scientist project)	Dr. Jewesh Kumar	**Mentor :** Dr. S.K. Singh

BASIC SCIENCE

S. No.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Plant growth promoting rhizobacteria (PGPR) for chickpea and pigeonpea	ICAR	Dr. Mohan Singh	---

SOCIAL SCIENCE

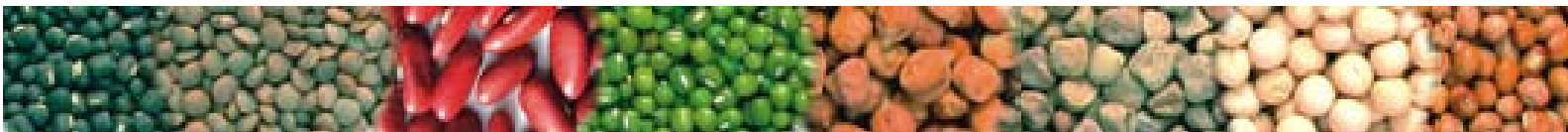
S. No.	Name of the project	Funding Agency	Principal Investigator	Associate
1.	Increasing chickpea and pigeonpea production through intensive application of integrated pest management (A3P project)	DAC	Dr. S.K. Singh	---
2.	Enhancing lentil production in eastern and North-eastern states for nutritional security and sustainable rice based production system in India	DAC-ICARDA-ICAR	Dr. S.K. Singh	---
3.	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
4.	Network project on market intelligence	NCAP, ICAR	Mr. Deepak Singh	---



Institute Management Committee

As on 31.3.2014

Dr. N.P. Singh 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 Ex- 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

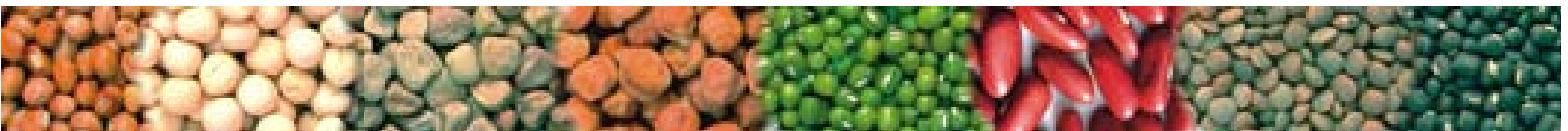
As on 31.3.2014

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

Institute Research Council

As on 31.3.2014

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



Important Committees of the Institute

1. Monthly Review Committee

Chairman: Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. Naimuddin
All Project Coordinators
All Heads of Divisions
All Scientists
Editor
Finance & Accounts Officer
Administrative Officer
Asstt. Admin. Officer (Admin.)
Asstt. Admin. Officer (Stores)
Chairmen of Various Committees
Architect
Secretary, IJSC
I/Cs of Various Activities

2. Farm Advisory Committee

Chairman : Dr. S.K. Chaturvedi
Member Secretary : Dr. C.S. Praharaj
All Heads of Divisions
Farm Manager
I/c Security

3. Estate Managamant Committee

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

4. Publication Committee

Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Mr. Diwakar Upadhyaya
Dr. P.S. Basu
Dr. M.S. Venkatesh
Dr. Jitendra Kumar
Dr. Naimuddin

5. Purchase Committee

Chairman : Dr. Jagdish Singh
Member Secretary : Administrative Officer
Dr. Bansa Singh
Dr. Narendra Kumar
Dr. Jitendra Kumar
Dr. M. Senthil Kumar
Finance & Accounts Officer

6. Institute Technology Management Committee

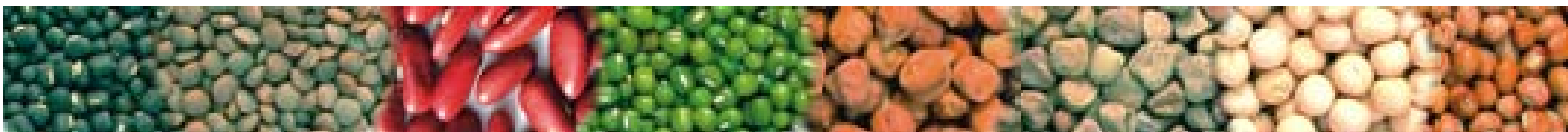
Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. Bansa Singh
Dr. Aditya Pratap
Dr. M.S. Venkatesh
Dr. Lalit Kumar

7. Resource Generation and Farm Produce Price Fixation Committee

Chairman : Dr. G.P. Dixit
Member Secretary : Dr. Narendra Kumar
Dr. Ummed Singh
Dr. Jitendra Kumar
Finance & Accounts Officer
Administrative Officer
I/c Library

8. Prioritization, Monitoring and Evaluation Cell

Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. Aditya Pratap
Dr. M.S. Venkatesh
Dr. M. Senthil Kumar
Dr. Mohd. Akram
Mr. Sripad Bhat
Mr. Diwakar Upadhyaya
Mr. D.K. Sharma
Dr. R.K. Srivastav
Mr. Kanhaiya Lal
Mr. Hasmat Ali



9. Library Committee

Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. Basudeb Sarkar
All Heads of Divisions
Finance & Accounts Officer
Administrative Officer

10. Institute Biosafety Committee

Chairman: Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. S. Datta
Dr. S.K. Chaturvedi
Dr. Mohd. Akaram
Dr. S.K. Goyal (IITR, Lucknow)
Dr. P.K. Singh (GSVM Medical College, Kanpur)

11. Academic Committee

Chairman: Dr. Naimuddin
Member Secretary : Mr. Alok Das
Dr. Basudeb Sarkar
Dr. M. Senthil Kumar

12. Germplasm Identification Committee

Chairman: Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Dr. Jitendra Kumar
Dr. S.K. Chaturvedi
Dr. Shiv Sewak
Dr. S.K. Singh (Ento.)
Dr. Mohd. Akram
Dr. Basudeb Sarkar

13. HRD Cell

Chairman : Dr. P.S. Basu
Member Secretary : Dr. Mohd. Akram
Dr. Rajesh Kumar
Dr. Ummed Singh

14. Consultancy Processing Cell

Chairman : Dr. C.S. Praharaj
Member Secretary : Dr. M.K. Singh (Upto 2.7.2013)
Dr. Rajesh Kumar
Dr. Farindra Singh

15. Institute Joint Staff Council

Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)
Dr. N.P. Singh, Director (From 1.1.2014)
Member Secretary : Administrative Officer
Dr. S.K. Chaturvedi
Dr. Jagdish Singh
Dr. S.K. Singh (Extn.)
Finanance & Accounts Officer
Mr. Yashwant Singh (Secretary, IJSC)
Mr. Rakesh Kumar (Member, CJSC)
Mr. Rajesh Kumar (Upto 5.5.2013)
Mr. K.A. Chaturvedi
Mr. Bachoo Singh

16. Grievance Cell

Chairman : Dr. S.K. Singh (Ento.)
Member Secretary : Administrative Officer
Dr. Jitendra Kumar
Mr. Kanhaiya Lal
Mrs. Rita Mishra
Mr. Satish Chandra

17. Vehicle Maintenance Committee

Chairman : Dr. Bansa Singh
Member Secretary : Mr. D.K. Sharma
Dr. Naimuddin
Dr. M.K. Singh (Upto 4.7.2013)
Finanance & Accounts Officer
Administrative Officer

18. Computer/ARIS Cell & Instrumentation Committee

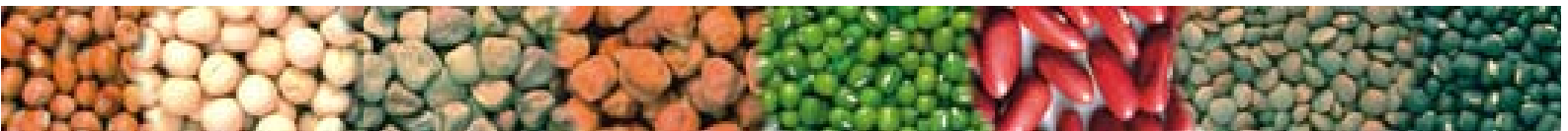
Chairman : Dr. Bansa Singh
Member Secretary (Computer) : Dr. Devraj
Member Secretary (Instrumentation): Mr. G.S. Pandey
Dr. M.S. Venkatesh
Dr. Muraleedhar S. Aski (Upto 31.10.2013)
Mr. Sripad Bhat

19. Guest House Management Committee

Chairman : Dr. Shiv Sewak
Member Secretary : Administrative Officer
Dr. (Mrs.) Uma Sah
Dr. Alagu P. Solai
Dr. Murleedhar S. Aski (Upto 31.10.2013)

20. Sports Committee

Chairman : Dr. Rajesh Kumar
Member Secretary : Dr. K.R. Soren
Dr. R. Jagdeeswaran
Dr. M.P. Singh
Mr. Yashwant Singh, Secretary, IJSC



21. *Rajbhasha* Implementation Committee

Chairman : Dr. N. Nadarajan, Director (Upto 31.12.2013)

Dr. N.P. Singh, Director (From 1.1.2014)

Member Secretary : Mr. Diwakar Upadhyaya

All Heads of Divisions

Dr. R.K. Srivastava

22. Women's Cell & Sexual Harassment Committee

Chairperson : Dr. (Mrs.) Hem Saxena

Member Secretary : Dr. (Mrs.) Uma Sah

Dr. (Mrs.) Vijay Laxmi

Dr. P.K. Katiyar

23. Technical and Proprietery Item Committee

Chairman : Dr. I.P. Singh

Dr. Mohd. Akram

Dr. Lalit Kumar

Dr. M.K. Singh (Upto 4.7.2013)

Dr. K. R. Soren

24. Incharges

Dr. Aditya Pratap, Convener, Seminars

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

Dr. C.S. Praharaj, I/c Farms (Main Farm)

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

Dr. I.P. Singh, I/c Seeds

Dr. Basudeb Sarkar, I/c Cold Module

Dr. M.K. Singh, I/c Farm Machinary & Seed Processing Machines (Upto 4.7.2013)

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

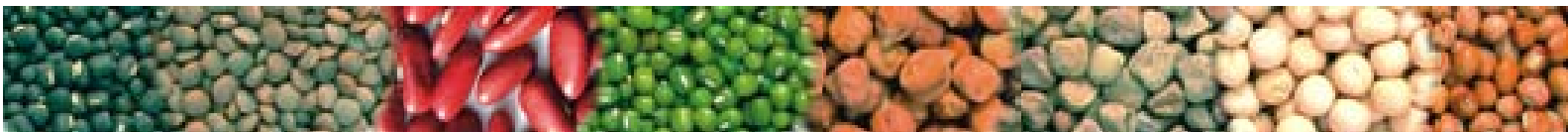
Mr. D.K. Sharma, I/c Vehicles

Dr. Omkar Nath, I/c Security

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

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

Mr. R.P. Singh, Farm Manager, New Research Farm (Upto 30.6.2013)



Panorama

Institute Foundation Day Celebrated

Indian Institute of Pulses Research (IIPR) celebrated its 21st Foundation Day on September 5, 2013. Prof. Ashok Kumar, Vice-Chancellor, CSJM University, Kanpur was the Chief Guest for the occasion and Director, National Sugar Institute, Kanpur, Mr. Narendra Mohan was the Guest of Honour. Dr. N.P. Singh, Project Coordinator (Chickpea) welcomed the honorable guests.

Prof. Ashok Kumar in his inaugural speech expressed his concern over the declining per capita availability of pulses. He added that if quality seeds and matching production techniques are made available to the farmers, the production can be enhanced by 25-30%. He urged the scientists to develop technologies that can help farmers to overcome production constraints. Mr. Narendra Mohan expressed concern over non-availability of high quality seeds and advanced production techniques to farmers. He suggested that farmers should be a part of various research based programmes for getting good results.

Dr. N. Nadarajan, Director, highlighted the achievements and various on-going activities of the Institute including national and international programmes. He stated that besides release of three high yielding varieties of pulses *viz.*, IPL 316 of lentil, IPFD 6-3 of fieldpea and IPA 203 of pigeonpea developed at IIPR this year, scientists at the Institute have also identified much needed heat tolerant variety of chickpea that will be shortly available for cultivation. The online "PulsExpert" system developed by IIPR to identify diseases in pulse crops and their remedies is benefiting the farmers. The Institute organized an International Training Programme wherein 30 Afghanistan officials were trained on various pulse production technologies in dry areas, he added.

On this occasion, four new publications *viz.*, Pulses for Human Health and Nutrition, *Rabi* Pulses Production in Central India, Weed Management Technology in Pulse Crops and Chickpea Cultivation in Dryland of India were released.

During the function, Dr. Narendra Kumar was awarded the Best Scientist Award 2013. Dr. M.P. Singh was awarded as Best Worker in Technical Category. Sh. Sukadeo Mahto and Sh. Akhil Kumar were awarded as Best Worker in the Administrative and Supporting Categories, respectively. Vote of thanks was proposed by Dr. Sanjeev Gupta. Later in the evening, a cultural programme was held, where in children of staff members performed dances and songs, which were appreciated by one and all.

Minister of State for Agriculture, GoI Applauded the Institute

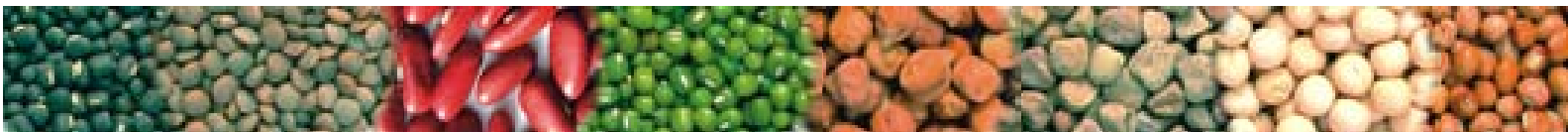
Dr. Charan Das Mahant, Hon'ble Minister of State for Agriculture and Food Processing Industries, Government of India, visited the Institute on September 22, 2013. On this occasion, Dr. N. Nadarajan, Director briefed him about the significant achievements of the Institute towards increasing pulses production and productivity in the country. Hon'ble Minister, while

addressing the scientists and staff of IIPR exhorted to work harder for fulfilling the goals in achieving nutritional security in the years to come. Hon'ble Minister visited the museum as well as field experiments, besides Technology Park of the Institute. He expressed happiness after visiting the Institute and said that IIPR is playing a significant role in increasing production of pulses in the country.

Dr. M.S. Swaminathan Visited the Institute

Dr. M.S. Swaminathan, popularly known as the 'Father of Green Revolution in India', a globally acclaimed scientist and Founder Chairman, M.S. Swaminathan Research Foundation, Chennai visited the Institute on September 2, 2013. Dr. Swapan K. Datta, Deputy Director General (Crop Science), ICAR, New Delhi, was also present on the occasion. Dr.

Swaminathan addressed the scientists and staff of the Institute and visited the field experiments as well as Institute Museum. He expressed happiness over the development in pulses research and appreciated the efforts of the Institute to eradicate protein hunger in the country. He conveyed his best wishes to the Director, scientists and scholars of the Institute to get success in their efforts to make India self reliant in pulses production.



Director General, CIMMYT, Mexico Visited IIPR

Dr. Thomas A. Lumpkin, DG, CIMMYT, Dr Etienne Duveiller, Director Research, Borlaug Institute for South Asia and Dr M. L. Jat, CIMMYT visited IIPR on September 2, 2013. Dr. N. Nadarajan, Director, IIPR appraised them about on-going research programmes of the Institute especially the progress in genomics, transgenics and development of pulse varieties. They also visited the biotechnology lab and appreciated the excellent infrastructure facilities and their efforts in development of transgenics. They also visited the soil chemistry, agronomy and water management labs and experimental fields. Dr. Jagdish Singh briefed them on conservation agriculture, resource conservation technologies, pulse based cropping systems and drip fertigation scheduling. Dr. Jat suggested the use of green seeker based fertilizer application and

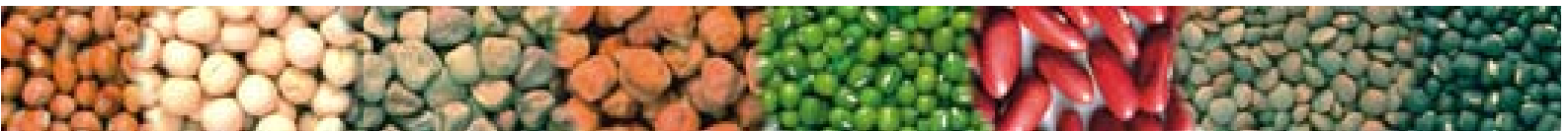
introduction of zero tillage as a precursor technology in the pulse based cropping system to minimise cost of cultivation. Dr. Lumpkin expressed his appreciation on the research work at IIPR and showed interest to have collaboration with the Institute.

Chairman, UP Seed Development Corporation Visited IIPR

Mr. Ujjawal Raman Singh, Chairman, Uttar Pradesh Seed Development Corporation visited IIPR along with Mr. Mukesh Gautam, Managing Director and other officials of the Corporation on April 11, 2013. The objective of this visit was to know about the latest technological advancements as well as newly developed varieties of pulse crops which could be beneficial for the state. The dignitaries had a long meeting with Dr. N. Nadarajan, Director, IIPR as well as Nodal Officer (Seeds) of the Institute and discussed about different pulse varieties developed by the Institute which specifically suit the agro-climatic conditions of Uttar Pradesh. Dr. Nadarajan appraised the visitors about the major research activities of the Institute such as genomics, transgenics, cropping systems research, *etc*. They also discussed about the package of practices of various pulses, plant protection measures, resource conservation technology and the areas where IIPR could be of help to the Seed Corporation as well as U.P. State. Mr. Singh expressed happiness over the research work carried out by the scientists and desired to have an active collaboration between the Corporation and IIPR.

NICRA Review Meeting at IIPR

The on-going project on National Initiative on Climate Resilient Agriculture (NICRA) was reviewed by the National Coordinator of the Project Dr. B. Venkateswarlu and Principal Investigator Dr. M. Maheswari from CRIDA, Hyderabad on September 25, 2013 at IIPR, Kanpur. Dr. Venkateswarlu highlighted the need of climate resilient agriculture under Indian scenario and focused on specific objectives. The overview of project and salient achievements were presented by Dr. N. Nadarajan, Director and Coordinator of the NICRA from IIPR. All CCPI's from coordinating centres, Co-PIs and research fellows participated in this meeting. The salient achievements of the IIPR component of NICRA was presented in the meeting with highlights of two extra early mungbean accessions for summer and other promising heat and drought tolerant lines of urdbean and pigeonpea identified in the project. The experiments carried out under controlled greenhouse, rainout shelter and wild garden of *Vigna* were visited and appreciated by the National Coordinator.



Annual Group Meets of AICRPs

❖ The Annual Group Meet of AICRP on pigeonpea, mungbean and urdbean was held on May 13-15, 2013 at TNAU, Coimbatore. About 200 delegates from cooperating centres, SAUs and State Departments of Agriculture participated in the meet. The group meet was inaugurated by Dr. B.B. Singh, ADG (O&P), ICAR, New Delhi. Dr. K. Ramasamy, Vice-Chancellor, TNAU presided over the inaugural function. Dr. B.B. Singh, in his inaugural address emphasized on use of molecular breeding in *Vigna* and pigeonpea. He stressed upon the need of developing new sources of CMS for production of commercial hybrids in pigeonpea. Dr. Ramasamy, in his presidential address explained the improving situation of pulses cultivation in Tamil Nadu. He exhorted the scientists to concentrate on basic research such as plant genetics, physiological processes, harvesting soil moisture, *etc*.

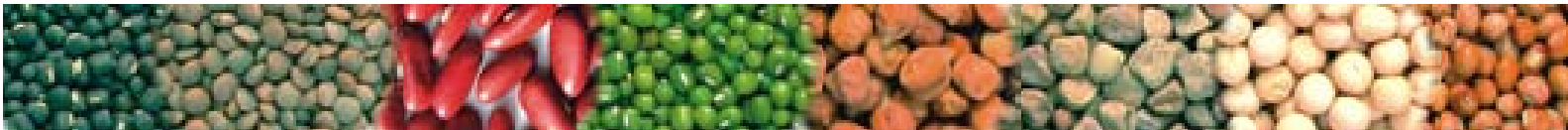
Dr. N. Nadarajan, Director IIPR and Acting Project Coordinator (Pigeonpea) elaborated R&D activities in mungbean, urdbean and pigeonpea in the country. He stressed upon the need of increasing genetic variability through distant hybridization and pre-breeding in *Vigna* and pigeonpea and development of transgenics for pod borer resistance and drought tolerance in pigeonpea, tailoring suitable plant types for different seasons and systems and devising micro-irrigation systems. He also presented the Project Coordinator's report on pigeonpea.

Dr. Sanjeev Gupta, PC, MULLaRP presented the Project Coordinator's report. He applauded the increase in production of urdbean and mungbean. He informed the house that mungbean and urdbean are finding place in newer niches and this year 2 lakh ha additional area came under cultivation in these two crops. After thorough discussion, the technical programmes for 2013-14 were finalized for each discipline.

❖ The Annual Group Meet of AICRP on Chickpea was held on August 24-26, 2013 at Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur. About 130 delegates from cooperating centres of SAU's, ICAR Institutes, State Department of Agriculture, Seed Agencies, Farm Cooperations attended the group meet. Dr. Ram Krishna Kusmaria, Hon'ble Minister, Farmer Welfare and Agriculture Development, Govt. of Madhya Pradesh chaired the inaugural session. In his remarks, he emphasized the importance of pulses specially chickpea for Madhya Pradesh. The Chief Guest, Shri Ishwar Das Rohani, Hon'ble Speaker,

Vidhan Sabha (M.P.) mentioned the importance of pulses in human health. The Guest of Honor at the occasion, Dr. Swapan K. Datta, Dy. Director General (Crop Science), ICAR, raised certain researchable issues. Dr. V.S. Tomar, Vice-Chancellor, JNKKV, Jabalpur recalled the significant contribution of the University in developing high yielding varieties and technologies. Dr. B.B. Singh, Asstt. Director General (O&P), ICAR, emphasized the role of short duration varieties in increasing the pulse production. Dr. N. Nadarajan, Director, IIPR, emphasized the role of research and development activities in increasing the pulses production. Dr. N. P. Singh, Project Coordinator (Chickpea) presented the research highlights of the project. Two publications *viz*., Souvenir and *Jaiv Urvarkon Evam Molybdenum Dwara Chana Utpadakta Vridhi Taknik* were also released on this occasion. Later in the technical sessions, programmes of various disciplines were discussed and finalized.

❖ The *Rabi* Group Meet of AICRP on MULLaRP was held at IGKV, Raipur on September 17-18, 2013. The meeting was inaugurated by His Excellency the Governor of Chhattisgarh, Shri Shekhar Dutt, in presence of Hon'ble Minister, Govt. of Chhattisgarh for Agriculture, Animal Husbandry, Fisheries and Labour, Shri Chandra Shekhar Sahu, Dr. B.B. Singh, ADG (O&P), ICAR, New Delhi, Dr. N. Nadarajan, Director IIPR, Dr. S.K. Patil, Vice- Chancellor, IGKV, Raipur and Dr. Sanjeev Gupta, Project Coordinator, MULLaRP. About 80 scientists attended the Group Meet.



Expressing his concern over low per capita availability of pulses, Hon'ble Governor of Chhattisgarh emphasized on increasing the production of pulses and oilseeds in the country. He suggested that along with the agriculture departments, all the 52 SAUs should also take up targeted responsibility for enhancing pulse area and production in the areas under their jurisdiction. Shri Chandra Shekhar Sahu expressed that lathyrus is a natural choice of Chhattisgarh farmers and the state should make perspective plan for increasing productivity and production of this crop.

In his address, Dr. Patil, stated that India occupies 32% of global area under pulse crops, however, accounts for only 22% of global pulse production. Due to this mismatch in area and production in India, per person availability of pulses has come down to 20-30 g, which used to be 50 g in the fifties. He said that lathyrus is the second most important *rabi* crop in the state and the IGKV has made significant contribution by releasing Prateek and Mahateora varieties of lathyrus which are very low in ODAP content.

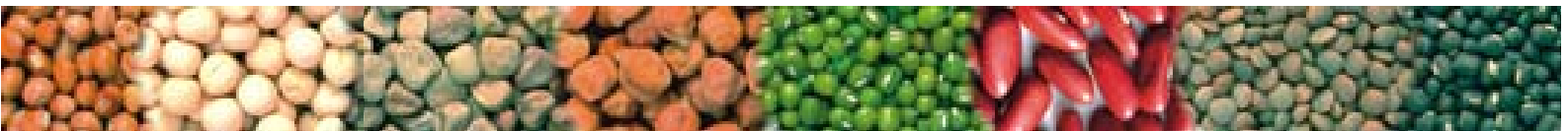
Dr. N. Nadarajan gave a brief scenario of pulse production in India. He pointed out that despite several production related issues, India could register record pulse production recently, which clearly indicates that efforts by pulse scientists and different agencies involved with pulse seed production and farmers are bearing fruits. Two publications prepared by the IGKV scientists were released in the meeting. Later, the technical programmes of different disciplines were discussed and finalized.

❖ Annual Group Meet on "Mungbean and urdbean for spring, summer and rice fallow cultivation" was held at Central Agricultural Research Institute (CARI), Port Blair, Andaman & Nicobar Islands on October 25-26, 2013. The group meet was inaugurated by Dr. N. Nadarajan, Director, IIPR and Dr. S. Dam Roy, Director, CARI, Port Blair presided over the function. About 38 scientists from the different Institutes and Universities participated the meet including Joint Director, Department of Agriculture, A&N Administration, Dy. General Manager and Asstt. General Manager of NABARAD, officers from different line departments, development personals from A&N Administration, Programme Coordinator and SMSs of KVK, Port Blair.

Dr. G.P. Dixit, Principal Scientist and Project Coordinator (I/c), AICRP on MULLaRP briefly explained the research activities undertaken during last year and the future plan of research like gene pyramiding, interspecific hybridization, IPM modules for threatening diseases and pests, and conservation agricultural techniques like rice fallow pulses, minimum tillage or no tillage agronomic practices, *etc*.

Dr. N. Nadarajan discussed in detail about the pulse scenario in the country. He elaborated that the total requirement of pulses in India is about 21 million tons, whereas our present production is about 18 million tons. He also explained because of last three years of research efforts, our production raised to 18.5 million tons and thereby we could reduce the import from five to less than three million tons. He also briefed the future research priorities in pulses.

Dr. Dam Roy, Director, CARI in his presidential address explained about the scope and importance of pulses in vegetarian food and nutritional security. He mentioned about the status of area, production and productivity of pulses in Andaman & Nicobar Islands. He also stressed upon the importance of A&N island biodiversity and explained that these islands are the store houses of a number of land races like beachpea, mungan, ranmung, *etc*., which could be effectively utilized in future breeding programmes. He also stressed on the need of a MULLaRP Centre at CARI, Port Blair for sustainable development and enhancement of pulse production in this fragile agro-ecosystem. Later, the technical programmes of various disciplines for next season were discussed and finalized.



Rabi Pulses Scientists' Meet

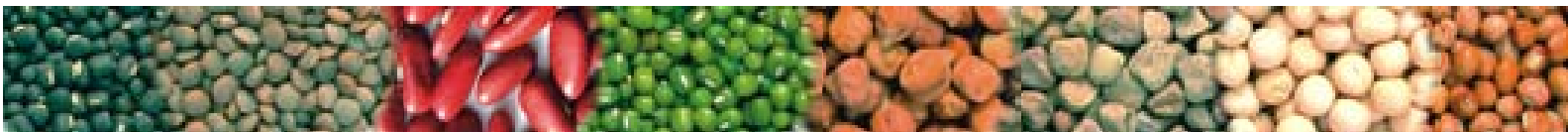
Rabi Pulses Scientists' Meet was organized at the Institute on February 28 to March 1, 2014 to share improved germplasm, segregating material and elite breeding lines with its partners. Total 40 scientists from different AICRP centres, IARI, ICRISAT, ICARDA and IIPR participated in the Meet. While chairing the inaugural session, Dr. N.P. Singh, Director emphasized the need of reducing duplication of efforts by way of sharing breeding and improved germplasm and further suggested that feedback should be provided on the material received to facilitate and continue sharing of the breeding material and genetic resources. Extending warm welcome to the delegates, Dr. S.K. Chaturvedi, Head (Crop Improvement) highlighted the purpose of the Meet and delivered a lecture on "Resetting priorities of research for development of *rabi* pulses in India". At the end of the inaugural session,

Dr. Sanjeev Gupta, Project Coordinator (MULLaRP) proposed a vote of thanks. Dr. P.M. Gaur, Assistant Director Research & Principal Chickpea Breeder at ICRISAT shared his views and information on activities relating to international efforts on pulses research through lecture on "CRP- Grain Legumes for pulses improvement" and emphasized the need for strong collaborative research so that improved techniques and genetic resources can be utilized in better way for pulses improvement in general, and for chickpea and lentil in particular. Dr. A. Sarker of ICARDA delivered his talk on "Legumes research programs at ICARDA and its relevance to India". During field visits, participants selected genetic resources and breeding material of their interest. Most of the breeders showed interest in wild species and requested to share some the accessions of wild *Cicer* and *Lens* for utilization in their breeding programmes.

National Science Day Celebrated

National Science Day with a theme of 'Fostering Scientific Temper' was celebrated in the Institute on February 28, 2014 with great fervor and enthusiasm. The event was chaired by Dr. N.P. Singh, Director of the Institute, while Dr. Pooran Gaur, Principal Scientist, ICRISAT, Hyderabad and Dr. Ashutosh Sarker, Coordinator, South Asia and China Regional Programme, ICARDA were the invited speakers. The programme was attended by all scientists and staff of the Institute and several other scientists from different parts of the country who had came to participate in *Rabi* Pulses Meet. The chairman exhorted the audience to develop a thorough professional approach in scientific research and development and urged to create a scientific atmosphere and make science simple so as to help common man of the country. Dr. Sarker in his lecture cited the examples of past discoveries which had great impact on mankind. Dr. Pooran Gaur

reviewed the scientific developments in the field of agriculture which are able to meet the increasing demands of food, feed and fodder for the ever-growing population of the world. The programme was conducted by Dr. Aditya Pratap along with Dr. Mohd. Akram and ended with vote of thanks by Dr. Bansa Singh.



Institute Participated in *Krishi Vasant 2014*

Department of Agriculture and Cooperation, Ministry of Agriculture, GoI, New Delhi and Government of Maharastra jointly organized Krishi Vasant 2014 at Central Institute of Cotton Research, Nagpur during February 9-13, 2014. This mega event was inaugurated by Hon'ble President Sri Pranab Mukherajee on February 9, 2014. Hon'ble Minister of Agriculture, GoI, Shri Sharad Panwar presided the Inaugural Session. Total 68 ICAR institutes participated in this event. IIPR took active part by displaying various exhibits in form of poster,charts, photographs, *etc*. Display of seeds of improved varieties of chickpea, pigeonpea, urdbean, mungbean,lentil, field pea and rajmash was main attraction of IIPR stall. Secretary DARE and Director General, ICAR Dr. S.

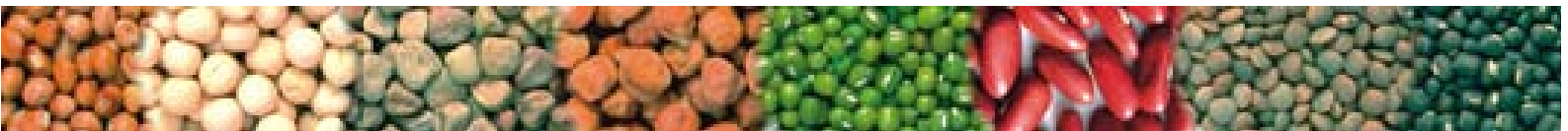
Ayyappan visited IIPR stall and suggested for more scientific and client oriented display of exhibits. DDG (CS) and DDG (A.E.) also visited the Institute stall along with various Directors of ICAR Institutes. Live demonstration gallery was another important and attractive forum where all the dignitaries, visitors, farmers got first hand information on various crops. Several SAUs, KVKs, State departments of Agriculture, banks, private sectors, NGOs, innovative and progressive farmers displayed their exhibits. In a special session, Dr. N.P. Singh, Director IIPR delivered a talk on 'Region specific proven technology of pulses suitable under different cropping system(s)' on February 12, 2014. Farmers' friendly literature was distributed amongst large number of visiting farmers at the Institute stall.

IIPR Hosted ICAR Zonal Sports Tournament

Indian Institute of Pulses Research organised ICAR Zonal Sports Tournament on March 20-23, 2014. Total 781 participants from 23 ICAR Institutes represented six states *viz*., Jammu & Kashmir,

Himachal Pradesh, Uttarakhand, Punjab, Haryana and Uttar Pradesh. The tournament was inaugurated by the Chief Guest Prof. Indranil Manna, Director, IIT Kanpur, in the presence of the Guest of Honour Sri Narendra Mohan, Director, National Sugar Institute, Kanpur. In inaugural session Dr. N.P. Singh, Director IIPR, Kanpur welcomed all the participants and guests. Mr. K.N. Gupta, F&AO was the *Chief de Mission* and Dr. Mohd. Akram was Team Manager of IIPR contingent. NDRI Karnal bagged highest number of gold and silver medals and won 'Overall Championship'. From IIPR, Dr. K R Soren won gold medal in 100m race and Mrs. Rashmi Yadav won silver medal in chess.

Prof. Munna Singh, Vice-Chancellor, CSA University of Agriculture & Technology, Kanpur and Dr N.P. Singh, Director, IIPR honoured the winners with medals and certificates and declared the tournament closed. Dr Rajesh Kumar, Chairman, Games Organising Committee proposed the vote of thanks.



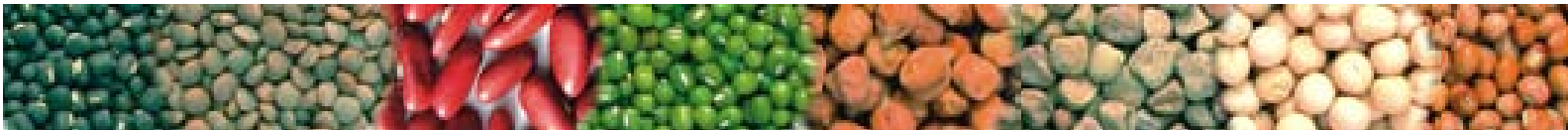
RAC Meeting Held

The Institute Research Advisory Committee meeting was held under the chairmanship of Dr. J.H. Kulkarni, Former Vice-Chancellor, UAS, Dharwad, Karnataka on March 11-12, 2014 at IIPR, Kanpur. The other members present were, Dr. U.P. Singh, Former Head, Division of Genetics & Plant Breeding, Institute of Agricultural Sciences, BHU, Varanasi, Dr. V.V. Ramamurthy, Principal Scientist, IARI, New Delhi, Dr. N.P. Singh, Director, IIPR and Dr. Mohan Singh, Member Secretary. All Project Coordinators, Heads of Divisions and In-charge, Biotechnology Unit also attended the meeting.

At the outset, Dr. N.P. Singh welcomed the chairman and members of RAC and apprised the house about the progress of research at IIPR and AICRP centres. The Institute R&D is successfully reflecting upon increasing productivity and production of pulses in India. Recent estimates of Agril. Ministry projected total pulse production of more than 19.85 million tons for 2013-14. Development of improved varieties of pulses along with improved production and protection technologies have contributed immensely towards increased pulse production. In pigeonpea, IPA 203 and in lentil, a high yielding and large seeded variety IPL 316 have been notified for cultivation in NEPZ and central zone of India, respectively. A high yielding green seeded dwarf fieldpea variety IPFD 10-12 has been identified for cultivation in central zone. In chickpea, three varieties *viz*., IPC 2004-98 (large seeded), IPC 2004-1(medium large seeded) and IPC 2005-62 (suitable for late sown conditions) have been released for cultivation in Uttar Pradesh. In Biotechnology, significant progress has been made in the development of pod borer resistant transgenic pigeonpea and chickpea. Insect bioassay indicated 80% insect mortality in pigeonpea.

For raising productivity of pulses, number of production technologies such as integrated nutrient management, water management, water conservation, reduced tillage and residues management, *etc*., have been developed, evaluated and are being recommended to the farmers. Low cost integrated modules have been developed for disease and pest management. Nutritional quality of chickpea and other pulses have been assessed.

Chairman, RAC and other members appreciated the on-going research programmes and also congratulated the scientists for achievements made during the last year. Number of recommendations were made for improving the on-going R&D efforts.

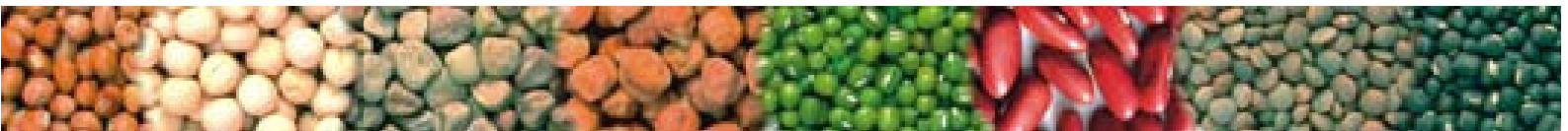


हिन्दी दिवस का आयोजन

भारतीय दलहन अनुसंधान संस्थान में दिनांक 26 सितम्बर, 2013 को हिन्दी दिवस समारोह पूर्वक मनाया गया। डा. (श्रीमती) प्रभा दीक्षित, प्राचार्या, प्राचार्या श्री स्वामी नागा जी बालिका महाविद्यालय, भरूआ सुमेरपुर, हमीरपुर इस समारोह की मुख्य अतिथि थी। समारोह की अध्यक्षता संस्थान के निदेशक डा. ना. नडराजन ने की। समारोह में संस्थान के सभी वैज्ञानिक, तकनीकी, प्रषासनिक एवं सहायक वर्ग के कर्मचारियों ने भाग लिया। अतिथियों का स्वागत डा. नरेन्द्र प्रताप सिंह, परियोजना समन्वयक (चना) ने किया। अपने उद्बोधन में डा. दीक्षित ने कहा कि प्रतिभाओं के मुखर होने में निज भाषा का प्रबल योगदान होता है। जितना अधिक हम अपनी भाषा में सोचकर अपनी भाषा में व्यक्त करेंगे, उतना ही अधिक स्पष्ट एवं प्रभावी ढंग से हम अपने विचार एवं विषय को प्रकट कर सकते हैं। यही हमारी उन्नति का संवाहक होगा। अतः हमें अपनी राजभाषा हिन्दी का अधिक से अधिक प्रयोग करना होगा निजी कार्यों में और सरकारी कामकाज में भी।

अध्यक्षीय उद्बोधन में निदेशक डा. नडराजन 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। उन्होंने वैज्ञानिकों का अवाहन किया कि नई तकनीकी जानकारी किसानों तक उन्ही की भाषा में पहुँचाने के लिए सतत प्रयास करें और हिन्दी के नये प्रकाशनों पर बल दिया। संस्थान की राजभाषा समिति के सचिव श्री दिवाकर उपाध्याय ने संस्थान में राजभाषा की प्रगति आख्या प्रस्तुत की। इस अवसर पर मुख्य अतिथि ने संस्थान की राजभाषा पत्रिका दलहन आलोक 2013 तथा हिन्दी के अन्य नये प्रकाशनों यथा संस्थान का वार्षिक प्रतिवेदन, एलीलोरसायन एवं आधुनिक खेती में उनकी उपयोगिता तथा चना फली भेदक कीट का समेकित प्रबंधन का विमोचन किया।

हिन्दी पखवाड़े में आयोजित विभिन्न प्रतियोगिताओं के विजयी प्रतिभागियों कु. कीर्ति त्रिपाठी, श्री कन्हैया लाल, श्रीमती रश्मि यादव, सर्वश्री आलोक कुमार सक्सेना, रामबाबू, मो. शब्बीर, राजेन्द्र कुमार, श्रीमती मीनाक्षी वार्ष्णेय, डा. नईमउद्दीन, डा. मो. अकरम, डा. सुभोजित दत्ता, डा. गोविन्द कान्त श्रीवास्तव एवं डा. जी.के. सुजयानन्द तथा कार्यालयीन कामकाज में हिन्दी का उत्कृष्ट प्रयोग करने के लिए सर्वश्री शिवशरण सिंह, श्रीमती रीता मिश्रा, श्रीमती मीनाक्षी वार्ष्णेय, सर्वश्री गुलाब चन्द्र शर्मा, आलोक कुमार सक्सेना, राजेन्द्र कुमार एवं श्री राजेन्द्र निगम को मुख्य अतिथि ने पुरस्कार और प्रमाण पत्र प्रदान किए। कार्यक्रम के अन्त में डा. आई.पी. सिंह परियोजना समन्वयक (अरहर) ने धन्यवाद ज्ञापित किया। कार्यक्रम का संचालन डा. (श्रीमती) उमा साह ने किया।



Personnel

A. Research Management

1.	Dr. N. Nadarajan	Director (Upto 31.12.2013)
2.	Dr. N.P. Singh	Director (From 1.1.2014)

B. Scientific

Crop Improvement

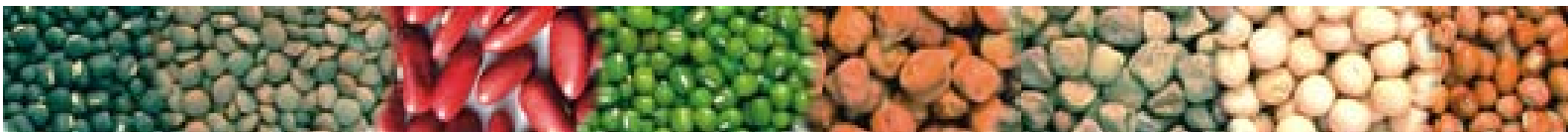
3.	Dr. S.K. Chaturvedi	Plant Breeding	Head of the Division
4.	Dr. N.D. Majumdar	Plant Breeding	Principal Scientist
5.	Dr. I.P. Singh	Plant Breeding	Principal Scientist (Upto 2.7.2013)
6.	Dr. P.K. Katiyar	Plant Breeding	Principal Scientist
7.	Dr. Dibendu Datta	Plant Breeding	Principal Scientist
8.	Dr. Aditya Pratap	Plant Breeding	Senior Scientist
9.	Dr. Jitendra Kumar	Plant Breeding	Senior Scientist
10.	Dr. Basudeb Sarkar	Plant Breeding	Senior Scientist (Upto 5.3.2014)
11.	Mr. Udai Chand Jha	Plant Breeding	Scientist
12.	Mr. Debjyoti Sen Gupta	Plant Breeding	Scientist
13.	Dr. Murleedhar Aski	Plant Breeding	Scientist (Upto 31.10.2013)
14.	Dr. Ashok Kumar Parihar	Plant Breeding	Scientist
15.	Mr. Abhishek Bohra	Plant Breeding	Scientist

Crop Production

16.	Dr. S.S. Singh	Agronomy	Head of the Division
17.	Dr. C.S. Praharaj	Agronomy	Principal Scientist
18.	Dr. M.S. Venkatesh	Soil Science	Principal Scientist
19.	Dr. Narendra Kumar	Agronomy	Senior Scientist
20.	Dr. Ummed Singh	Agronomy	Senior Scientist
21.	Mr. Kali Krishna Hajara	Agronomy	Scientist
22.	Dr. M.K. Singh	Agril. Engineering	Scientist (Sr. Scale) (Upto 4.7.2013)

Crop Protection

23.	Dr. (Mrs.) Hem Saxena	Entomology	Principal Scientist & Acting Head
24.	Dr. R.G. Chaudhary	Plant Pathology	Principal Scientist (Upto 30.4.2013)
25.	Dr. Bansa Singh	Nematology	Principal Scientist
26.	Dr. Shiva Kant Singh	Entomology	Principal Scientist
27.	Dr. Mohd. Akram	Plant Pathology	Senior Scientist
28.	Dr. Naimuddin	Plant Pathology	Senior Scientist
29.	Dr. R. Jagdeeswaran	Nematology	Scientist



30.	Mr. P.R. Saabale	Plant Pathology	Scientist
31.	Dr. G.K. Sujayanand	Entomology Entomology	Scientist

Basic Science

32.	Dr. Jagdish Singh	Plant Physiology	Head of the Division
33.	Dr. Mohan Singh	Microbiology	Principal Scientist
34.	Dr. R.P. Srivastava	Biochemistry	Principal Scientist
35.	Dr. P.S. Basu	Plant Physiology	Principal Scientist
36.	Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
37.	Dr. Lalit Kumar	Agril. Chemistry	Senior Scientist
38.	Dr. M. Senthilkumar	Microbiology	Senior Scientist
39.	Mr. S. Paul Raj	Microbiology	Scientist
40.	Mr. Alagupalamuthir Solai	Plant Physiology	Scientist
41.	Mr. Nand Lal Meena	Biochemistry	Scientist

Social Science

42.	Dr. S.K. Singh	Agril. Extension	Principal Scientist & Acting Head
43.	Dr. Rajesh Kumar	Agril. Extension	Principal Scientist
44.	Dr. (Mrs.) Uma Sah	Agril. Extension	Senior Scientist
45.	Dr. Purushottam	Agril. Extension	Senior Scientist
46.	Mr. Devraj	Computer Application	Senior Scientist
47.	Mr. Hemant Kumar	Agril. Statistics	Scientist (Sr. Scale)
48.	Mr. Deepak Singh	Agril. Statistics	Scientist
49.	Mr. Shripad Bhat	Agril. Economics	Scientist (On study leave)

Biotechnology

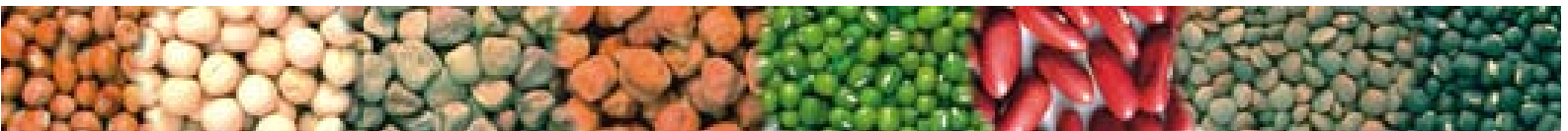
50.	Dr. S. Datta	Biotechnology	Senior Scientist
51.	Mr. P. Nandeesha	Biotechnology	Scientist (Upto 29.10.2013)
52.	Mr. Prakash G. Patil	Biotechnology	Scientist (On study leave)
53.	Dr. Khela Ram Soren	Biotechnology	Scientist
54.	Dr. Alok Das	Biotechnology	Scientist

C. AICRP on Pigeonpea

55.	Dr. N. Nadarajan	Acting Project Coordinator (Upto 1.7.2013)
56.	Dr. I.P. Singh	Project Coordinator (From 2.7.2013)
57.	Dr. Farindra Singh	Principal Scientist

D. AICRP on Chickpea

58.	Dr. N.P. Singh	Project Coordinator (Upto 27.1.2014) Acting Project Coordinator (From 28.1.2014)
59.	Dr. Shiv Sewak	Principal Scientist

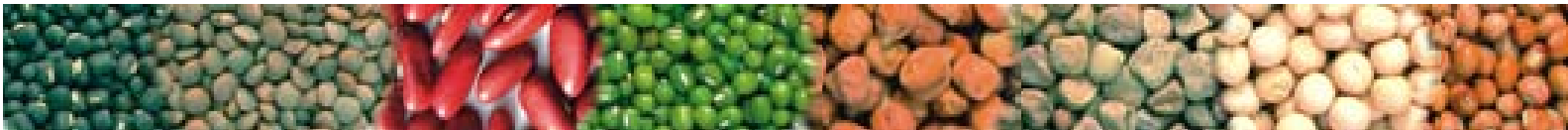


E. AICRP on MULLaRP

60.	Dr. Sanjeev Gupta	Project Coordinator
61.	Dr. G.P. Dixit	Principal Scientist

F. Technical

62.	Mr. Diwakar Upadhyaya	Chief Editor (T-9)
63.	Mr. D.N. Awasthi	Chief Architect (T-9)
64.	Dr. T.N. Tiwari	Chief Technical Officer (T-9)
65.	Mr. D.K. Sharma	Chief Technical Officer (T-9)
66.	Mr. Desh Raj	Chief Technical Officer (T-9)
67.	Dr. M.P. Singh	Assistant Chief Technical Officer (T-7/8)
68.	Mr. Vijendra Singh	Assistant Chief Technical Officer (T-7/8)
69.	Mr. S.P.S. Chauhan	Assistant Chief Technical Officer (T-7/8)
70.	Mr. R.S. Mathur	Assistant Chief Technical Officer (T-7/8)
71.	Dr. G.K. Srivastava	Assistant Chief Technical Officer (T-7/8)
72.	Dr. Omkar Nath	Assistant Chief Technical Officer (T-7/8)
73.	Mr. Radha Krishan	Assistant Chief Technical Officer (T-7/8)
74.	Dr. Ved Ram	Assistant Chief Technical Officer (T-7/8)
75.	Mr. A.B. Singh	Assistant Chief Technical Officer (T-7/8)
76.	Dr. Aditya Prakash	Assistant Chief Technical Officer (T-7/8)
77.	Mr. S.K. Garg	Assistant Chief Technical Officer (T-7/8)
78.	Mr. Ramesh Chandra	Assistant Chief Technical Officer (T-7/8)
79.	Mr. Ved Prakash	Senior Technical Officer (T-6)
80.	Mr. A.P. Singh	Senior Technical Officer (T-6)
81.	Mrs. Rashmi Yadav	Senior Technical Officer (T-6)
82.	Mr. Rajendra Prasad	Technical Officer (T-5)
83.	Mr. V.B. Choube	Technical Officer (T-5) (Upto 31.12.2013)
84.	Mr. R.P. Singh	Technical Officer (T-5) (Upto 30.6.2013)
85.	Mr. R.K.S. Yadav	Technical Officer (T-5)
86.	Mr. Krishna Autar	Technical Officer (T-5)
87.	Mr. G.S. Pandey	Technical Officer (T-5)
88.	Mr. Kailash Chandra	Technical Officer (T-5)
89.	Mr. S.K. Dwivedi	Technical Officer (T-5)
90.	Mr. Lakhan	Technical Officer (T-5)
91.	Mr. R.K. Singh	Technical Officer (T-5)
92.	Mr. Rakesh	Technical Officer (T-5)
93.	Mr. Malkhan Singh	Technical Officer (T-5)
94.	Mr. Ashraf Khan	Technical Officer (T-5)



95.	Mr. Arvind Singh Yadav	Technical Officer (T-5)
96.	Mr. R.M. Pal	Technical Officer (T-5)

G. Administrative

97.	Mr. K.N. Gupta	Finance & Accounts Officer
98.	Mr. Panchoo Lal	Administrative Officer
99.	Mr. A.K. Saxena	Assistant Administrative Officer (Upto 31.7.2013)
100.	Mrs. A. Abraham	Assistant Administrative Officer
101.	Mr. Shukdeo Mehto	Assistant Administrative Officer
102.	Mr. B.K.Verma	P.S. to Director

H. Regional Station-cum Off-season Nursery, Dharwad

103.	Dr. A.K. Choudhary	Plant Breeding	Principal Scientist & Station In-charge
104.	Dr. Revanappa	Plant Breeding	Scientist

I. Regional Station, Bhopal

105.	Dr. K.K. Singh	Agronomy	Principal Scientist
106.	Dr. D.N. Gawande	Plant Breeding	Scientist

Appointments, Promotions, Transfers, etc.

Appointment

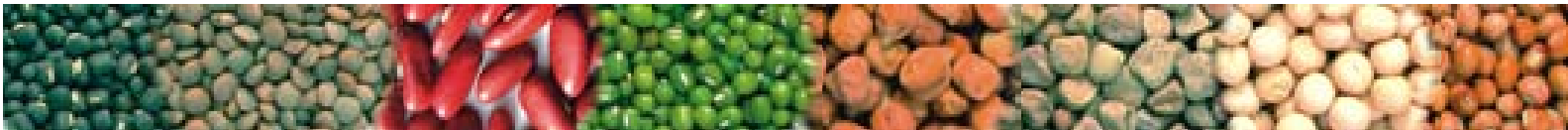
Name	Post	Date of joining
Dr. N.P. Singh	Director	28.1.2014
Dr. S.S. Singh	Head, Division of Crop Production	22.1.2014
Mr. Nand Lal Meena	Scientist (Biochemistry)	10.4.2013
Mr. Mayank Mishra	Jr. Clerk	19.9.2013

Promotions

Name	Promoted to	*W.e.f.*
Mr. Desh Raj	Chief Technical Officer (T-9)	1.7.2012
Mr. S.K. Garg	Asstt.Chief Technical Officer (T-7/8)	24.2.2011
Mr. Ramesh Chandra	Asstt.Chief Technical Officer (T-7/8)	1.7.2012
Mr. Jokhu Ram	Asstt.Chief Technical Officer (T-7/8)	3.2.2010
Dr. Aditya Prakash	Asstt.Chief Technical Officer (T-7/8)	3.2.2010
Smt. Rashmi Yadav	Sr. Technichal Officer (T-6)	7.1.2013
Mr. Shukdeo Mehto	Asstt. Administrative Officer	11.12.2013
Mr. Arvind Kumar	Sr. Technical Assistant	12.2.2013
Mr. Indra Bahadur	T-1	28.5.2013
Mr. Amar Nath	T-1	10.6.2013
Mr. Babu Lal	T-1	17.6.2013
Mr. S.G. Kushwaha	Tech. Assistant	16.1.2013

Transfers

Name	Post	From	To	*W.e.f.*
Dr. M.K. Singh	Scientist (Sr. Scale)	IIPR, Kanpur	IARI, New Delhi	4.7.2013
Dr. P. Nandisha	Scientist	IIPR, Kanpur	IIHR, Bangalore	29.10.2013
Dr. Muraleedhar S. Aski	Scientist	IIPR, Kanpur	IARI, New Delhi	31.10.2013
Mr. Deen Dayal Kumar	Technical Information	IIPR, Kanpur	NDRI, Karnal	31.7.2013
Dr. Basudeb Sarkar	Senior Scientist	IIPR, Kanpur	CRIDA, Hyderabad	5.3.2014



Retirements

Name	Post held	Date of Retirement
Dr. N. Nadarajan	Director	31.12.2013
Dr. R.G. Chaudhary	Principal Scientist (Plant Pathology)	30.4.2013
Mr. R.P. Singh	Technical Officer (T-5)	30.6.2013
Mr. Anil Kumar Saxena	Asstt. Administrative Officer	31.7.2013
Mr. V.B. Choubey	Technical Officer (T-5)	31.12.2013
Mr. Raja Ram	Technical Assistant (T-3)	31.1.2014
Dr. N.D. Majumdar	Principal Scientist (Plant Breeding)	31.3.2014

Obituary

- Mr. Rajesh Kumar, Jr. Clerk, left for heavenly abode on May 5, 2013. May his soul rest in Peace.
- Mr. Balaram Singh, Sr. Technical Assistant, left for heavenly abode on September 6, 2013. May his soul rest in Peace.
- Mr. Satish Kumar Lal, Skilled Supporting Staff, left for heavenly abode on January 7, 2014. May his soul rest in Peace.
- Mr. Jiya Lal, Sr. Technical Assistant (Driver), left for heavenly abode on March 8, 2014. May his soul rest in Peace.

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