भाकृअनुप ICAR

हर कदम, हर डगर किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

वार्षिक प्रतिवेदन
Annual Report
2010 - 11

भारतीय दलहन अनुसंधान संस्थान
कानपुर 208 024

Indian Institute of Pulses Research
Kanpur 208 024

वार्षिक प्रतिवेदन
Annual Report
2010 - 11

भाकृअनुप
ICAR

भारतीय दलहन अनुसंधान संस्थान
कानपुर 208 024
Indian Institute of Pulses Research
Kanpur 208 024

Published by	:	Dr. N. Nadarajan, Director Indian Institute of Pulses Research, Kanpur
Editing, layout and designing	:	Mr. Diwakar Upadhyaya
Proof reading	:	Mr. Kanhaiya Lal
Hindi translation	:	Mr. R.K. Srivastava
Photography	:	Mr. Rajendra Prasad and Mr. Ved Prakash
Typing assistance	:	Mr. Har Govind Rathore
Graphics	:	Mr. D.K. Sharma
Publication committee	:	Dr. N. Nadarajan, Chairman Dr. C. Chattopadhyay Dr. P.S. Basu Dr. M.S. Venkatesh Dr. Jitendra Kumar Mr. Diwakar Upadhyaya, Member Secretary
Correct citation	:	Annual Report 2010-11 Indian Institute of Pulses Research, Kanpur

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

Preface

During the last decade, country has made good progress in ensuring availability of pulses and all time high record of pulses production, 17.29 million tonnes have been achieved during 2010-11. This was possible due to sincere efforts of researchers, developmental agencies, favourable weather and policy support.

The present Annual Report of Indian Institute of Pulses Research for 2010-11 highlights significant achievements made under different research programmes. Concerted efforts of scientists have paid dividends in terms of release and notification of 5 high yielding varieties *viz*., Ujjawal (IPCK 2004-29) of *kabuli* chickpea for central zone, IPM 02-3 of mungbean for spring season in NWPZ, IPM 02-14 for summer season in SZ, IPU 02-43 of urdbean for South zone and IPF 4-9 of fieldpea for U.P. State. In addition, extra large seeded *kabuli* chickpea variety IPCK 02 and lentil variety IPL 315 have been identified for North West plain zone and Central zone, respectively. Under ambit of All India Coordinated Research Projects, many varieties have been released and notified or identified for different agro-ecological zones. Total 8849.67q breeder seed (84 varieties) of chickpea, 1097.95 q of pigeonpea (36 varieties), 1168.65 q of mungbean (62 varieties), 617.15 q of urdbean (44 varieties), 515.96 q of lentil (33 varieties) and 1303.60 q of fieldpea (30 varieties) was produced.

Institute has maintained 2895 germplasm accessions of major pulse crops and many of these have been shared with SAUs. Besides this, 98 accessions of wild *Cicer*, 56 of pigeonpea, 53 of *Vigna* and 153 accessions of lentil were also maintained for their evaluation and utilization in broadening the genetic base.

Molecular marker technology for mapping and tagging of wilt resistant genes in chickpea and pigeonpea has been given priority and parental polymorphism was studied and mapping populations were developed in chickpea and pigeonpea. Remarkable progress has been made in developing regeneration and transformation protocols and efforts are being made to develop transgenic against *Helicoverpa armigera* in chickpea and pigeonpea. Large number of donors exhibiting stable resistance against fusarium wilt in chickpea and MYMV resistance in mungbean have been identified.

For climate resilient agriculture, a network project has been launched recently to mitigate impact of climate change on *kharif* pulses. Efforts on improving heat tolerance in *rabi* crops has given encouraging results. Large scale field and laboratory based screening has resulted in identifying genotypes possessing heat tolerance in chickpea. Massive programme to transfer the genes conferring heat tolerance has been initiated.

In long-term trials on cereal based cropping, maize-wheat-mungbean system was found most efficient in enhancing system productivity in upland, whereas rice-wheat-mungbean recorded highest system productivity under lowland condition. Among resource conservation technology, incorporation of crop residue led to enhanced soil organic carbon, whereas raised bed planting led to 20-32% increase in chickpea and urdbean grain yield. Similarly, drip-fertigation either only at branching or at both branching and podding produced significantly higher pigeonpea grain yield. Post-emergence application of imazethapyr controlled most of the rainy season weeds in mungbean.

The Institute is successfully harnessing national and international collaborations and has developed strong linkages with ICRISAT, ICARDA, DAC, DBT, DST, Indo-US AKI, Bill & Melinda Gates Foundation/Generation Challenge Programme (GCP) and SAUs and ICAR Institutes. Institute is also collaborating in large number of network projects. Institute has established good linkages with states and organized training courses to develop trained man power to boost pulses production and productivity.

Institute has developed improved agricultural machineries including pigeonpea stripper, thresher and suction winnower. An expert system for pulses (PulsExpert) has been developed to provide online help to pulse growers and extension workers of the country. Online information retrieval system for AICRP on chickpea has been developed and separate website has been launched. Efforts have been diverted to develop similar system for other pulse crops.

Human resources development is on top of the agenda of the Institute**.** Number of students and research fellows are pursuing their Ph.D. research in frontier areas, besides short and long term attachment trainings for post-graduate students.

Technology demonstrations have clearly indicated the potential of high yielding varieties and production and protection technologies. Under technology demonstrations, about 34 - 46% increase in grain yield was recorded in *kharif* pulses. I am sure that with technologies emanating from the Institute research projects will go a long way in augmenting pulse production in the country. The Institute has identified major R&D issues as per the recommendations of the Research Advisory Committee which are being tackled through integration of conventional approaches with cutting edge technologies such as genomics, transgenics, molecular breeding, molecular approaches for stress management, high input use efficiency, quality improvement, forecasting and forewarning and resource conservation technologies in the recently formulated research project.

The overall 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 gratitude and respect. I am extremely thankful to Dr. B.B. Singh, Assistant Director General (Oilseeds & Pulses) for his involvement, active support and inspiration in carrying out various activities.

I appreciate the efforts made by Drs. N.D. Mazumder, N.P. Singh, C. Chattopadhyay, P.K. Ghosh, S.K. Chaturvedi, Jagdish Singh, G.P. Dixit, S.K. Singh, Mr. Prasoon Verma and Mr. Devraj in compiling the report of their respective divisions and sections meticulously. I am thankful to the members of the Publication Committee- Drs. P.S. Basu, M.S. Venkatesh, Jitendra Kumar and Editor Shri Diwakar Upadhyaya for their efforts in bringing out the report in time.

(N. Nadarajan)
Director

Contents

कार्यकारी सारांश

संस्थान में प्रतिवेदित वर्ष में चल रहे अनुसंधान कार्यक्रमों के अन्तर्गत प्रमुख दलहनी फसलों पर मौलिक, प्रयुक्त तथा नीतिपरक शोध परिणामों का संक्षिप्त सार निम्नवत है :

फसल सुधार

- दलहनी फसलों की उच्च उत्पादकतायुक्त तीन प्रजातियाँ, काबुली चना की उज्जवल (आई.पी.सी. 2004-29) मध्य क्षेत्र हेतु, मूँग की आई.पी.एम. 02-3 उत्तर परिश्चमी मैदानी क्षेत्र में बसन्त ऋतु हेतु तथा आई.पी.एम. 02-14 दक्षिणी क्षेत्र में ग्रीष्मऋतु हेतु एवं मटर की आई.पी.एफ. 4-9 उत्तर प्रदेश में खेती हेतु अनुमोदित एवं अधिसूचित की गयीं।
- मसूर की प्रजाति आई.पी.एल. 315 तथा उर्द की प्रजाति आई.पी.यू. 2-43 क्रमशः मध्य क्षेत्र तथा उत्तर परिश्चमी मैदानी क्षेत्र हेतु चिन्हित की गई।
- संस्थान द्वारा विकसित कई जीनप्रारुपों ने अखिल भारतीय समन्वित दलहन सुधार परियोजनाओं के अन्तर्गत उत्कृष्ट परिणाम दर्शाए हैं। इनमें से कुछ जैसे चना में आई.पी.सी.के. 113 तथा आई.पी.सी.के. 491, अरहर में आई.पी.ए. 203, मूँग में आई.पी.एम. 06-5, आई.पी.एम. 9901-6 तथा आई.पी.एम. 05-2-8, उर्द में आई.पी.यू. 07-3 तथा आई.पी.यू. 09-16 तथा मसूर में आई.पी.एल. 316 एवं आई.पी.एल. 215 उच्चतर प्रजनन परीक्षणों में मूल्यांकित किए जा रहें है।
- देसी चना के कुल 374, काबुली चना के 98, दीर्घकालीन अरहर के 760, अगेती अरहर के 429, मूँग के 250, मसूर के 764 तथा मटर के 220 जननद्रव्यों का मूल्याकंन किया गया तथा बाह्य-दैहिकी एवं पुष्पन गुणों के आधार पर चिन्हित किया गया। इनके अतिरिक्त, चना की 98 वन्य प्रजातियाँ, अरहर की 56, मूँग व उर्द की 53 तथा मसूर की 153 वन्य प्रजातियाँ भी संचयित की गयीं।
- पौलीमॉरफिज्म अध्ययन में, कुल 132 संसूचकों (68 ए.एफ.एल.पी., 30 एस.आर.ए.पी, 14 एस.आर.ए.पी.-आर.जी.ए. तथा 20 ए.फ.एल.पी. - आर.जी.ए.) ने अरहर के आई.सी.पी. 8893 तथा टाइप 7 जीनप्रारूपों पर मूल्यांकित करने पर बहुरूपता दशाई जिनमें से 125 प्रबल तथा 7 सह-प्रबल प्रकृति के थे।
- चना में फयूजेरियम उकठा प्रभेद 2 के रोधी जीनों से संलग्न आणविक संसूचकों की पहचान हेतु, कुल 460 संसूचक मूल्यांकित किए गए जिनमें से जे.जी. 62 तथा डब्लू.आर. 315 जनकों के मध्य 32 ससूंचक बहुरूपी पाए गए। के 850 तथा आई.पी.सी. 2004-52 जनकों के लिए, 50 एस.एस.आर. तथा 25 आर.ए.पी.डी. संसूचकों में से केवल दो एस.एस.आर. संसूचक बहुरूपी पाए गए।

फसल उत्पादन

- दीर्घकालीन परीक्षणों में अरहर समतुल्य उपज की दृष्टि से सर्वाधिक प्रणाली उत्पादकता (5244 कि.ग्रा./हे.) मक्का-गेहूँ-मूंग फसल प्रणाली द्वारा प्राप्त हुई जबकि अरहर-गेहूँ फसल प्रणाली (4334 कि.ग्रा./हे.) का दूसरा तथा मक्का-गेहूँ प्रणाली (3125 कि.ग्रा./हे) का अन्तिम स्थान रहा। इस प्रकार मक्का-गेहूँ-मूंग फसल प्रणाली से ऊंचे खेतों में सर्वाधिक उत्पादकता प्राप्त हुई। इसी प्रकार, धान-गेहूँ-मूंग से निचले खेतों में सर्वाधिक उत्पादकता प्राप्त हुई।
- अकार्बनिक उर्वरकों के प्रयोग से सर्वाधिक अरहर समतुल्य उपज (4872 कि.ग्रा./हे.) प्राप्त हुई जबकि कार्बनिक उपचार से 4090 कि.ग्रा./हे. उपज प्राप्त हुई जो नियन्त्रण की तुलना में क्रमशः 41.2% तथा 18.6% अधिक थी।
- मक्का-गेहूँ-मूंग तथा धान-गेहूँ-मूंग प्रणालियों में सर्वाधिक मृदा जीवांश पाया गया।
- उठी हुए बीज शैय्या (75 से.मी.) पर बुवाई करने से उर्द तथा चना की उत्पादकता में क्रमशः 32.2 तथा 20.2% वृद्धि दर्ज की गई।
- धान से खाली क्षेत्रों में, शून्याकर्षण बुवाई तथा पलवार के प्रयोग से चना की उत्पादकता में 23-28% की वृद्धि हुई।
- अकुंरण के उपरान्त इमाजेथापर खरपतवारनाशी रसायन के प्रयोग से वर्षाकाल के अधिकांश खरपतवारों पर नियन्त्रण प्राप्त हुआ तथा मूंग की उत्पादकता में 68% की वृद्धि भी हुई।
- ऊंचे खेतों में धान-मसूर फसल प्रणाली के अन्तर्गत दोनों फसलों के अवशेषों के समावेश से धान तथा मसूर की उपज में क्रमशः 37.42% तथा 17.64% वृद्धि हुई। इसी प्रकार धान (रोपाई) - गेहूँ-मूंग फसल प्रणाली में तीनों फसलों के अवशेषों के समावेश से धान तथा गेहूँ की उपज में क्रमशः 42.5% तथा 33.2% वृद्धि हुई।
- मक्का की फसल में गोबर की खाद के प्रयोग से मक्का तथा चना की उत्पादकता में क्रमशः 13.9 तथा 9.5% वृद्धि दर्ज की गई। फास्फोरस के प्रयोग तथा फास्फेट घुलनशील जीवाणु के उपचार से भी मक्का तथा चना की उत्पादकता में सार्थक वृद्धि दर्ज की गयी। गोबर की खाद तथा 40 कि.ग्रा. फास्फोरस + पी.एस बी. के प्रयोग से फास्फोरस की सस्य दक्षता (कि.ग्रा. उपज/कि.ग्रा. $पी_2ओ_5$ प्रयुक्त) 5.08 से 9.21 तथा 5.33 से 8.42 की वृद्धि हुई।

फसल सुरक्षा

- चना के 205 जननद्रव्य (10% से कम उकठा से प्रभावित) उकठा रोग के प्रति अवरोधी पाए गऐ। आठ जीनप्रारूप उकठा के सभी छहों प्रभेदों जैसे प्रभेद 1,2,3,4,5 व 6 के प्रति रोगरोधी पाए गए।
- मसूर के 51 जीनप्रारूपों जिनका उकठा रोगाणु, *फ्यूजेरियम ऑक्सीस्पोरम एफ.स्पे. लैन्टिस* के विरुद्ध मूल्यांकन करने पर पाँच जीनप्रारूपों जैसे पी.एल. 4147, पी.एल. 02, जी.पी.

3278, जी.पी. 4076 तथा जे.एल. 3 में 30% से कम पौधों की मृत्यु हुई।

- अरहर की प्रजाति यू.पी.ए.एस. 120 में फाइटोफ्थोरा अंगमारी का केवल 13% प्रभाव देखा गया। रोग का प्रभाव मुख्यतः 0.0 से 20% की सीमा में रहा। आई.सी.पी. 8859, आई.पी.ए., पी.बी. 55-2, के.ए.डब्लू.आर. 45, आई.पी.ए. 8-1, बी.डी.एन. 2, आई.सी.पी. 7119, के.ए. 09-01, आई.पी.ए.पी.बी. 8-1-8 तथा शरन 1 वंशानुक्रमों में रोग की उच्च तीव्रता पाई गई।
- कानपुर में उर्द पत्र संकुचन रोग धब्बेदार भृंग (*एपीलाचना डोडेकॅस्टिग्म*) तथा श्वेत मक्खी (*बेमीसिया टबाकी*) द्वारा नहीं फैलता है।
- कानपुर व आस-पास के क्षेत्रों में ग्रीष्मकालीन मूँग एवं उर्द फसलों पर पत्र मोड़क रोग का प्रभाव 1-2% रहा, जबकि खरीफ फसलों में इसका प्रकोप 10% तक पाया गया। सामान्यतया, उर्द की अपेक्षा मूँग में पत्र मोड़क रोग का प्रकोप अधिक होता है।
- दलहनी फसलों के सभी दस नमूनों (मूँग व उर्द दोनों के पाँच-पाँच) के परिवर्द्धित उत्पादों ने जी.बी.एन.वी. के एन.एस.एम. जीनों तथा एन.पी. जीनों के सापेक्ष क्रमशः 900 बी.पी. तथा 800 बीपी के डी.एन.ए अंश दर्शाये, जबकि स्वस्थ नमूनों में नकारात्मक परिणाम आए। इससे कानपुर में मूँग व उर्द के पत्र मोड़क रोग के मूँगफली बड नैक्रोसिस विषाणु द्वारा फैलने की पुष्टि होती है।
- कानपुर में उगाई गई मूँग व उर्द की वन्य प्रजातियों/उप-प्रजातियों में पीत चितेरी रोग, मूँग पीत चितेरी इण्डिया विषाणु द्वारा फैलता है। *विग्ना हॅनियाना, वी. ट्राइलोबेरा* तथा *वी. रैडिएटा वैराइटी रैडिएटा* में पीत चितेरी रोग के कारक विषाणु के रूप में एम.वाई.एम.आई.वी. के नाभिकीय अम्ल आधारित पहचान की प्रथम रिपोर्ट है।
- कानपुर, लुधियाना, नवसारी तथा ढोली में मूँग व उर्द में पीत चितेरी रोग *मूंगबीन यैलो मोजेक इण्डिया वायरस* (एम.वाई.एम.आई.वी.) द्वारा फैलता है जबकि वम्बन तथा कोयम्बटूर में मूँग व उर्द में पीत चितेरी रोग *मूंगबीन यैलो मोज़ेक वाइरस* (एम.वाई.एम.वी.) द्वारा फैलता है।
- चना के वंशानुक्रमों में *बोट्राइटिस ग्रे मोल्ड* रोग की तीव्रता 0-9 के पैमाने पर नापी गई। वशांनुक्रम आई.पी.सी. 2010 199 पूर्णतया रोगमुक्त रहा। तीस वंशानुक्रमों में रोग 1.1, 11 वशांनुक्रमों में 1.5, 25 वंशानुक्रमों में 2-4, 10 वंशानुक्रमों में 4.5-7 तथा शेष 39 वंशानुक्रमों में 7.5-9 के पैमाने पर रहा।
- चना में फली भेदक कीट का प्रकोप मार्च के प्रथम पखवाड़े अर्थात् नवे मानक मौसम सप्ताह से आरम्भ हुआ। प्रजाति जे.के. जी. 1, में लार्वा की सर्वाधिक जनसंख्या (2 लार्वा/24 वर्ग मीटर का प्लॉट) पाई गई। प्रजाति के.डब्लू.आर. 108 का 1 लार्वा/प्लॉट की लार्वा की जनसंख्या के साथ दूसरे स्थान पर रहा। लार्वा की जनसंख्या मार्च के द्वितीय पखवाड़े (12वें मानक मौसम सप्ताह) तक धीर-धीरे बढ़ी। प्रजाति जे.के.जी.1 में लार्वा की सर्वाधिक जनसंख्या (3 लार्वा/प्लॉट) तथा प्रजाति के.डब्लू.आर. 108 में 2 लार्वा/प्लॉट तक पहुंच गई। तत्पश्चात इनकी जनसंख्या घटने लगी तथा अप्रैल के प्रथम सप्ताह तक पूर्णतया अदृश्य हो गई है।
- मक्का आधारित भोजन पर पाले गये *कोरसाइरा* लार्वा से *ब्रेकान हिबैटर* का विकास लार्वा, प्यूपा एवं वयस्कों की संख्या की दृष्टि से अच्छा हुआ। मक्का पर पाले गऐ *कोरसाइरा* लार्वा पर पाले गए *ब्रेकॉन हिबैटर* से 16 लार्वा तथा 12 प्यूपा निकले। जबकि गेहूँ व चावल आधारित भोजन पर पाले गए *कोरइसारा* को *ब्रेकॉन हिबैटर* के लिए प्रयोग करने पर औसतन क्रमशः 11.6 व 11.5 लार्वा तथा 10.2 व 9.5 प्यूपा निकले।
- परपोषी *ब्रेकॉन हिबैटर* पर साइपरमेथरिन तथा स्पाइनोसाद के प्रयोग से अण्डों की सर्वोच्च मृत्यु (100% मृत्यु), लार्वा (100 तथा 61.9% मृत्यु), प्यूपा हुई। एमामैक्टिन बैन्जोएट से अण्डा, लार्वा, प्यूपा व वयस्क में क्रमशः 85.5, 62.2, 52.8 तथा 85.0% मृत्यु हुई।
- अरहर में फूल आने की अवस्था में *मारुका* कीट के प्रकोप को मानक 1-9 के पैमाने (1: कोई क्षति नही, 9: > 90%) पर दर्ज किया गया। सबसे कम क्षति जीनप्रारुपों आई.सी.पी. 12890 तथा आई.सी.पी. 12882 (क्षति रेटिंगः 2) में दर्ज की गई। *मारुका* से फलियों की सबसे कम क्षति आई.सी.पी. 12890 (1.9%) तथा आई.सी.पी. 12882 (3.7%) जीनप्रारूपों में दर्ज की गई।
- *मारुका* की लार्वा जनसंख्या में सर्वाधिक प्रतिशत कमी (95.6) डीडीवीपी 76 ईसी + राइनाक्जापर 20 ई.सी. उपचारित अगेती अरहर में दर्ज किया गया लहसुन व नियन्त्रण (दोनों उपचारों के परिणाम एक से रहे) का दूसरा स्थान रहा। डीडीवीपी 76 ईसी + राइनाक्जापर 20 ई.सी. उपचारित प्लॉटों में सबसे कम फली क्षति (34%) दर्ज की गई जबकि लहसुन का सत + राइनाक्जापर 20 ई.सी. (4.6%) का दूसरा स्थान रहा। परन्तु यह भी साख्यिकीय दृष्टि से उपरोक्त के बराबर ही रहा जो अनुपचारित नियन्त्रण की तुलना में 18.8% अच्छा था।
- मूँग के मुक्त अवसर परीक्षण के अन्तर्गत, कोई भी वंशानुक्रम घुन के विरुद्ध प्रतिरोधी नहीं पाया गया। छह वंशानुक्रम मध्यम अवरोधी पाए गए। उर्द में एक वंशानुक्रम के.यू.96.3 (अनुकूलता सूचकांक : 0.049) अवरोधी पाया गया तथा दो वंशानुक्रम मध्यम अवरोधी पाए गए। कोई अवसर नहीं की दशा के अन्तर्गत किए गये परीक्षणों मे, उर्द का कोई वंशानुक्रम अवरोधी नहीं पाया गया, जबकि तीन वंशानुक्रम मध्यम अवरोधी पाए गये।
- मूँग की विभिन्न प्रजातियों पर घुन का प्रक्षेत्र प्रकोप फली क्षति के आधार पर औसतन 2.7% तथा 0.8% (सम्राट) से 5.0% (एन.डी.एम. 1) की सीमा में रहा। मूंग की विभिन्न प्रजातियों के दोनों पर घुन का प्रकोप 0.1% (सम्राट) से 0.8% (एन.डी.एम. 1) की सीमा में तथा औसतन 0.4% रहा। उर्द की प्रजातियों में घुन का प्रकोप फलियों में 2.2% (टाइप 9) से 3.2% (शेखर 1) की सीमा में तथा औसतन 2.8% रहा जबकि दोनो में यह प्रकोप 0.6% (उत्तरा) से 0.9% (शेखर) के मध्य तथा औसतन 0.7% रहा।

- मूँग में घुन से संक्रमित प्रतिशत फली क्षति तथा दाने क्षति तथा फली की चौड़ाई में घनात्मक सह-सम्बन्ध पाया गया। उर्द में धुन से संक्रमित प्रतिशत फली एवं दाने क्षति तथा फली की चौड़ाई, फली का *ट्राइचोम* घनत्व व फली में दोनों की संख्या में घनात्मक सह-सम्बन्ध तथा फली भित्ति की मोटाई से ऋणात्मक सह-सम्बन्ध पाया गया।
- मेड़ों पर एकल अरहर के समेकित कीट प्रबन्धन मॉडयूल में, अरहर + उर्द व अरहर + ज्वार के समेकित कीट प्रबन्धन मॉडयूल जिनमें क्रमशः 37.5 तथा 38.8% फ्यूजेरियम उकठा तथा 2.4 तथा 2.2% फली भेदक के प्रकोप की तुलना में फ्यूजेरियम उकठा (33.3%) तथा फली भेदक (1.6% क्षतिग्रस्त फलियाँ) का प्रकोप कम हुआ।
- अरहर-ज्वार के साथ समेकित कीट प्रबन्धन मॉडयूल (43.6% क्षतिग्रस्त फलियाँ तथा 36% क्षतिग्रस्त दाने) तथा एकल अरहर के साथ समेकित कीट प्रबन्धन मॉडयूल (30.6% क्षतिग्रत फलियाँ तथा 33.4 क्षतिग्रस्त दाने) की अपेक्षाकृत अरहर + उर्द के साथ समेकित कीट प्रबन्धन मॉडयूल में फली मक्खी से कम क्षति (26.4% क्षतिग्रस्त फलियाँ तथा 33.4% क्षतिग्रस्त दाने) हुई।
- *बेसिलस थ्यूरिनजिएनसिस* (6.6% क्षतिग्रस्त फलियाँ) कीटाविकारी सूत्रकृमि का स्पंज फार्मूलेशन (7.1% क्षतिग्रस्त फलियाँ) तथा अनुपचारित नियन्त्रण (10.9% क्षतिग्रस्त फलियाँ) की तुलना में इन्डोसल्फान (2.1% क्षतिग्रस्त फलियाँ) तथा *हैलिकोवर्पा आर्मीजेरा* न्यूक्लियर पॉलीहाइड्रोसिस विषाणु (एच.ए.एन.पी.वी.) (4.5% क्षतिग्रस्त फलियाँ) उपयुक्त पाऐ गऐ। इसी प्रकार, इन्डोसल्फान तथा एच.ए.एन.पी.वी. (250 लार्वा समतुल्य) द्वारा उपचारित प्लॉटो में उपज क्रमशः 15.4 तथा 13.1 कुन्तल/हे. पाई गई। अन्य उपचारों में बेसिलस थ्यूरिनजिएनसिस (12.1 कुन्तल/हे.) से कीट विकारी सूत्रकृमि के स्पंज फार्मूलेशन (11. 9 कुन्तल/हे.) द्वारा मिली उपज अनुपचारित नियन्त्रण में मिली उपज (11.9 कुन्तल/हे.) के बराबर ही रही।
- बुन्देलखण्ड को विभिन्न जनपदों से एकत्रित किए गए नमूनों के चना में *प्रैटीलैन्कस* प्रजाति के सूत्रकृमि ही अधिक पाए गए जबकि अरहर, मूँग, उर्द, मसूर व मटर में *होप्लोलाइमस* प्रजाति के सूत्रकृमि प्रमुख थे।

फसल दैहिकी, जैवरसायन एवं सूक्ष्म जीव विज्ञान

- चना में उष्मा सहनशीलता की पहचान व चयन के लिए, पर्णहरित *फलुओरेसेन्स* छाया आधारित तकनीक तथा वर्तिकाग्र पटल पर परागकणों का अकुरण तकनीक प्रयुक्त की गयी।
- देर से बुवाई की दशा में मूल्यांकन तकनीक तथा उपज पर आधारित पाँच उष्मा सहनशील जननद्रव्य (जे.जी. 74, आई.सी.सी. 637, आई.सी.सी. 8950, अवरोधी तथा अन्नेगिरी) तथा तीन उष्मा संवेदनशील (आई.सी.सी. 8522, आई.सी.सी. 1194 तथा आई.सी.सी. 3230) चिहिन्त किये गए।
- मटर में कुल 55 मूल्यांकित किए गए जीनप्रारूपों में से सात जीनप्रारूप (आई.पी.एफ. 523, आई.पी.एफ. 99-26, आई.पी.एफ. 19, के.पी.एम.आर. 11-1, के.पी.एफ. 103, डी.एम.आर. 15 तथा पन्त मटर 5) उष्मा सहनशील पाए गए।
- मसूर के देर से फूल आने वाले जीनप्रारूपों जैसे वी.एल. 4, बी. 77, रंजन, डब्लू.बी.एल.58, आई.पी.एल. 203, आई.पी.एल. 403, आई.पी. एल 404, आई.पी.एल. 517 तथा पी 2016 ने सिंचित अवस्था में बेहतर प्रदर्शन किया।
- परॉक्सीडेज (पी ओ), पॉलीफीनोल ऑक्सीडेज (पी पी ओ) तथा फिनाएल अलानीन अमोनिया लाएज (पी ए एल) एसिड डिटर्जेन्ट फाइबर तथा लिग्निन बनाने में सहायक होते है जो अरहर में उकठा के विरुद्ध अवरोधिता का गुण उत्पन्न करता है।
- मृदा गुणवत्ता के कारक जैसे जीवांश, फैटॅशियम परमैगनेट - ऑक्सी-डाइजेबिल-कार्बन, सूक्ष्मजीवाणु जैवभार-कार्बन तथा अन्य सूक्ष्म-जीवाणुओं की अन्य क्रियाएं जैसे मृदा एन्जाइम के क्रिया-कलाप तथा आधारीय श्वसन दर रासायनिक प्रणाली की तुलना में जैविक व समेकित उत्पादन प्रणाली में सार्थक सुधार हुआ।
- मृदा में कम नमी की दशा में चना की प्रजाति आर.एस.जी. 888 को *एम. साइसेरी* के दो प्रभावी प्रभेदों से उपचारित करने पर अनुपचारित नियन्त्रण की तुलना में जड़ों में अधिक गांठे बनी तथा उपज में भी 20% की वृद्धि दर्ज की गई।
- चना में पी.जी.पी.आर. प्रभेद द्वारा प्रक्षेत्र उपचारित परीक्षणों में यह पुष्टि हुई कि उपचार का वृद्धि पर प्रभाव मृदा में कम जैविक कार्बन के स्तर (0.2%) की तुलना में मृदा में अधिक जैविक कार्बन स्तर (0.35%) में अधिक था। चना के लिए अधिकांश पी.जी.पी.आर. प्रभेद *बेसिलस* प्रजाति के थे।

कृषि प्रसार

- शिक्षाप्रद यात्रायें, बैठक तथा प्रशिक्षण दलहन उत्पादन प्रौद्योगिकी को हस्तान्तरण करने के प्रमुख माध्यम थे। समय पर गुणवत्तापूर्ण बीज की अनुपलब्धता, रोग एवं कीटों का प्रकोप तथा दलहन उत्पादन की उन्नत प्रौद्योगिकी के बारे में जानकारी का अभाव कृषकों द्वारा समझी गई मुख्य बाधाऐं थी। फील्ड कर्मचारियों की कमी तथा उन पर अन्य क्रिया-कलापों का भार प्रसार कार्यकर्ताओं के मुख्य बाधक थे। सार्वजनिक-निजी सहभागिता को अपनाकर, समय पर गुणवत्तापूर्ण बीज की उपलब्धता सुनिश्चित होने तथा कीट व रोगों पर नियन्त्रण के लिए उचित कीट पूर्वानुमान प्रणाली अपनाकर उपरोक्त समस्याओं का हल किया जा सकता है।
- लघु व मध्यम श्रेणी के पुरुष खेत की तैयारी, कीटनाशियों का छिड़काव, मड़ाई तथा खेत से घर तक भण्डारण में संलग्न रहते हैं, जबकि महिलाएं बीजों की बुवाई (20%), फसल की कटाई, परिपक्व फलियों की तुड़ाई, दानों की सफाई, घर में भण्डारण व दाल बनाने आदि कार्य करती है। बड़े श्रेणी के कृषकों के घर की महिलाएं दलहन उत्पादन में बाहर का कोई कार्य नहीं करती हैं।
- द्विफसली सिंचित दशाओं के अन्तर्गत, स्थानीय प्रजाति की 7.18 कुन्तल/हे. की उपज के विरुद्ध चना की डी.सी.पी. 92-3 तथा जे.जी. 16 प्रजातियों ने क्रमशः 13.07 व 13.50 कुन्तल/हे. की औसत उपज दर्ज की। एकल फसली बारानी दशाओं में, स्थानीय प्रजातियों की अपेक्षा डी.सी.पी. 92-3 तथा

जे.जी. 16 प्रजातियों की खेती से क्रमशः₹ 16,000/- तथा 15,900/- प्रति हे. का अतिरिक्त लाभ मिला।

कृषि अभियन्त्रण

- विभिन्न बीज आकारों के दलहनी फसलों के लिए, कई परिवर्तन करने के बाद विकसित उर्ध्वाधर थ्रेशर का मूल्यांकन किया गया। कटी हुई अरहर के लिए इस मशीन की थ्रेशिंग क्षमता 450 कि. ग्रा./घंटा, चना के लिए 290 कि.ग्रा./घंटा उर्द के लिए 214 कि.ग्रा./घंटा थी।
- कई परिवर्तन करने के बाद एक घिसने वाला बेल्ट थ्रेशर का विकास किया गया है जिसको चना के लिए 88 कि.ग्रा./घंटा तथा कटी हुई अरहर के लिए 285 कि.ग्रा./घंटा मड़ाई क्षमता के साथ हाथ द्वारा मड़ाई को स्थानापन्न किया जा सकता है।
- मड़ाई से पूर्व अरहर के पौधों के लिए विकसित एक स्ट्रिपर का पुनः मूल्याकन पूसा 992 तथा यू.पी.ए.एस. 120 प्रजातियों के लिये किया गया। इसकी स्ट्रिपिंग क्षमता 158 कि. ग्रा./घंटा थी। मजदूरों में धूल की समस्या को कम करने हेतु विकसित सक्शन विनोअर को उपरोक्त प्रजातियों पर पुनः मूल्यांकित करने पर इसकी औसत भटकाई क्षमता 170 कि.ग्रा./घंटा थी।
- अरहर की प्रजातियों की मिलिंग से सह-उत्पाद के रूप में प्राप्त घुलनशील प्रोटीन तथा पॉलीफीनॉल्स क्रमशः 9.4% डी.बी. तथा 219.91 मि.ग्रा./100 ग्राम कैटैकॉल तुल्यांक पाऐ गऐ।

कम्प्यूटर अनुप्रयोग व सांख्यिकीय

- देश के दलहन उत्पादकों एवं प्रसार कार्यकर्ताओं की ऑनलाइन सहायता के लिए एक विशेषज्ञ प्रणाली (*पल्स एक्सपर्ट*) का मूल्यांकन एवं प्रमाणीकरण किया गया। यह प्रणाली http://iipr.res.in/pulseexpert/home page.asp पर उपलब्ध है।
- आँकड़ों के एकत्रण तथा संकल्पित करने को सुगम व आसान प्रक्रिया बनाने हेतु मूंग पर अखिल भारतीय समन्वित दलहन सुधार परियोजना के परीक्षणों के आँकड़ों को प्रयोग करते हुए एक ऑनलाइन सूचना रिट्रीवल प्रणाली का विकास आरम्भ किया गया है।

बाह्य वित्त–पोषित परियोजनाएं

- 64 प्यूटेटिव टी$_2$ पराजीनी मटर (प्रजाति एच.यू.डी.पी. 15) से कुल जीनोमिक डी.एन.ए पृथक किए गए तथा आणविक चरित्रीकरण हेतु आर.एन.ए.आई. जीन, सी.ए.एम.वी 35 एस प्रमोटर, एनपीटी II संसूचक तथा इन्ट्रौन के विशिष्ट प्राइमरों को प्रयुक्त करके पी.सी.आर दशाऐं अनुकूल की गयी। पी.सी.आर के परिणामों ने दर्शाया कि इन्ट्रॉन विशिष्ट प्राइमरों ने 8 लाइनें सकरात्मक पाई। इसके बाद, इन्ट्रॉन विशिष्ट प्राइमरों के साथ धनात्मक एम्पलीफिकेशन दर्शाने वाले पौधो को दक्षिणी संकरीकरण हेतु चयनित किया गया। ए एफ 531160 जीन विशिष्ट बायोटिन लेबेल्ड प्रॉब को प्रयोग करके दक्षिणी संकरीकरण किया गया। परिणामों ने प्लास्मिड डी.एन.ए के साथ मजबूत संकरीकरण पाया गया। जबकि पी.सी.आर. से 8 घनात्मक पाए गए पौधों में, केवल एक पौधा (डी-23-1-4) दक्षिणी घनात्मक पाया गया।
- चना की बी.जी. 256 तथा जे.जी. 315 प्रजातियों के बीच 815 में से कुल 50 संसूचकों ने बहुरूपता दर्शाई। इनमें से 70 (कुल 545 में से) एस.एस.आर. संसूचक बहुरूपी पाऐ गऐ। फ्यूजेरियम उकठा से संलग्न 16 एस.एस.आर. संसूचकों के मूल्यांकन से छह (एच 3ए 12, टीए 194, टीए 59, टीए 110 तथा एच. आई.बी 06) बहुरूपी संसचूक के रूप में चिन्हित किए गए। तीन संलग्न आर.ए.पी.डी. संसूचक (ओ पी एम 03703, ओ पी ए सी 041200 तथा ओ पी ए सी 11500) प्रमाणीकृत किए गए। उपरोक्त जनकों के मध्य अन्य ससूंचको के मूल्यांकन किए जाने पर 45 आर.ए.पी.डी. (कुल 180 में से), 15 आई.एस.एस. आर. (कुल 50 में से), 20 आर.जी.ए. (कुल 40 में से) ससूंचकों ने भी बहुरुपता दर्शायी।
- सूखा सहनशीलता के लिए प्रसंकरण बनाए गए तथा टी.ए.ए 170, आई.सी.सी.एम 0249, एस.टी.एम.एस 11 तथा जीए 24 ससूंचको को प्रयुक्त करके *पैरेन्टल पॉलीमॉरफिज्म* अध्ययन किया गया। दोनों जनकों के मध्य केवल एक ससूंचक टी ए ए 170 ने बहुरूपता दर्शायी। अरहर में उकठा अवरोधिता के आनुवंशकीय मानचित्रीकरण के लिए आशा व यू.पी.ए.एस. 120 में प्राप्त पीढ़ी$_4$ के बीज आर.आई.एल. *मॉपिंग पॉपुलेशन* के विकास के लिए एकत्रित किए गए। इसके अतिरिक्त 20 सीईडीजी एस.एस.आर. प्राइमरों को प्रयुक्त करके दोनों जनको के मध्य *पैरेन्टल पॉलीमॉरफिज्म* अध्ययन किया गया। जिनमें से 12 एस.एस.आर. परस्पर स्थानातंरणीय तथा एक एस.एस. आर. प्राइमर (सी.ई.डी.जी. 057) बहुरूपी पाए गए।
- बी.टी. जीन *कॉन्स्ट्रक्ट, क्राई* 1 ए सी पादप जैवप्रौद्योगिकी के राष्ट्रीय अनुसंधान केन्द्र से प्राप्त किए गए तथा *क्राई*-जीन विशिष्ट प्राइमरों के साथ *रैस्ट्रिक्शन डाईजेशन* तथा *प्रोटोकॉल* के मूल्याकंन के लिए चना (प्रजाति डी.सी.पी. 92-3) तथा अरहर (प्रजाति आशा) के पाँच-पाँच हजार एक्सप्लान्ट बनाए तथा परीक्षित किए गए।
- सात अल्पकालिक नर बंध्य जीनप्रारूप (ए.एल. 201 ए, आई. सी.पी. 2089 ए, पीए. 163ए, यू.पी.ए.एस. 120 ए सी.ओ. आर.जी. 990047 ए.सी.ओ.आर.जी. 990052 ए तथा जी. टी. 290 ए) तथा 12 *रिस्टोरर्स* (ए.के. 261504 आर, ए.के. 261322 आर, ए.के. 261322 आर, ए.के. 261506 आर, 250083 आर., 261322 आर, 250173 आर, 250165 आर, 261345 आर, 261429 आर, 261394 आर तथा 261409 आर को समाहित करके अरहर के कुल 18 अगेती संकर विकसित किए गए।)
- *विगना* में बीजपत्रीय नोड्स से एक प्रभावी एवं जननीय पुनउर्द्भव एवं रूपान्तरण प्रणाली विकसित की गयी है। बीजपत्रीय *नोड एक्सप्लान्ट्स* से अधिकतम पुनउर्द्भव के लिए बी.ए.पी. (6-बेन्जाइल अमीनो प्यूरीन) का लगातार अनावरण महत्वपूर्ण पाया गया तथा इन *एक्सप्लान्ट्स* ने 19 कलिकाऐं/बीजपत्रीय *नोड एक्सप्लान्ट* तथा 5 तना कलिकाऐं बीजपत्रीय *नोड एक्सप्लान्ट* उत्पादित किए। इन *एक्सप्लान्ट* की आयु तथा उनकी सह-खेती

का तापमान भी महत्वपूर्ण कारक रहे जिससे रूपान्तरण की सफलता काफी हद तक प्रभावित होती है। दो दिन पुरानी सीडलिंग से बीजपत्रीय नोड रूपान्तरण के लिए अनुकूलतम *एक्सप्लान्ट* होते हैं तथा 25^0 से. का तापमान इसकी सह-खेती उपयुक्त होता है। चयनित माध्यम में चार सप्ताह बाद रूपान्तरण बारम्बारता 3. 4 के लगभग पाई गई।

- चना की प्रजातियों विजय x पूसा 256 के प्रसंकरण में कुल 70 एफ$_1$ बीज तथा डब्लू.आर. 375 x पूसा 256 के प्रसंकरण में कुल 27 एफ$_1$ बीज उत्पादित किए गए। एस.एस.आर. संसूचकों द्वारा एफ$_1$ पौधो की सत्यता की पुष्टि के उपरान्त प्राप्तकर्ता जनक के साथ इनका पुनः प्रसंकरण किया गया। जिससे दोनो प्रसंकरणों में छह बीसी$_1$एफ$_1$ बीज प्राप्त हुए। पृष्ठभूमि चयन हेतु कुल 374 एस.एस.आर. ससूंचक मूल्यांकित किए गए। इनमें से प्रसंकरण विजय x पूसा डब्लू.आर. 315 x पूसा 256 में समाहित जनकों के बीच 43 बहुरूपी पाए गए।
- वर्षा 2010-11 में विभिन्न दलहनी फसलों का कुल 562.12 कुन्तल प्रजनक बीज उत्पादित किया गया जबकि वर्ष 2009-10 में कुल 501.99 कुन्तल प्रजनक बीज उत्पादित किया गया था।
- गत वर्ष 39 वन्य वंशानुक्रमों से प्राप्त बीज तथा ईरान, टर्की, ईथोपिया व मिस्र के 160 वंशानुक्रमों में से 42 को खेती किए जा रहे जीनप्रारुपों (डी.पी.एल. 62 तथा डी.पी.एल. 58) से प्रसंकरण करने हेतु गमलों में उगाए गए। खेती किए जा रहे जीन प्रारूप (डी.पी.एल. 62 तथा डी.पी.एल. 58) तथा वन्य प्रजातियों (*लेन्स क्यूलेनेरिस स्पे. ओरिन्ट* तथा प्रजाति *टॉमेन्टोसस*) के 8 प्रसंकरणों तथा खेती किए जा रहे जीनप्रारूप (डी.पी.एल. 62 तथा डी.पी.एल. 58) तथा भूमध्यसागरीय लैन्डरेसेज के बीच बनाए गए ४ प्रसंकरणों के एफ$_1$ बीज एकत्रित किए गए।
- उष्मा सहनशील मूल्यांकन के लिए, 237 वशांनुक्रमों के *कोर कलॅक्शन, इकार्डा ड्राउट नर्सरी* (एल.आई.डी.टीएन. 2011) के 42 वशांनुक्रम तथा सक्रिय जननद्रव्य के 55 वंशानुक्रमों में फूल जल्दी आए तथा बुवाई के 80-85 दिनों बाद पक गए। शेष 158 वंशानुक्रमों में से 62 वंशानुक्रमों में फूल नही आए या यदा-कदा आए तथा ये उष्मा सहनशीलता के प्रति अत्यन्त संवेदी पाए गए। 96 वंशानुक्रमों में फूल व फलियाँ बुवाई के 85 दिन बाद आए तथा इनको फली तथा बीज विकास के आंकड़े एकत्रित करने के उपयुक्त पाया गया।
- केवल शाखाऐं निकलने पर अथवा शाखाऐं निकलने एवं फली आने पर टपक सिंचाई करने से असिंचित नियन्त्रण (कृषक पद्धति) की तुलना में 18% अधिक उपज प्राप्त हुई। केवल फलियां आने पर टपक सिंचाई करने से प्राप्त उपज का स्तर शाखाएं निकलने एवं फलियां आने के समय नलियों में सिंचाई करने पर प्राप्त उपज के बराबर ही रहा।
- अनुपचारित नियन्त्रण (1923 कि.ग्रा./हे.) की तुलना में उपचार करने से उपज में 5 से 20% की वृद्धि पाई गई। पी.जी.पी.आर. प्रभेद पी 66, सी.पी. 11, पी.एस.बी. 11 तथा जे. 7 से उपचारित करने पर अनुपचारित नियन्त्रण की तुलना में 14 से 20% की अधिक उपज प्राप्त हुई। इन प्रभेदों में से तीन प्रभेद सी.पी. 11, पी.एस.बी. 11 तथा जे. 7 ने प्रक्षेत्र में चना की उपज में लगातार वृद्धि दर्शाई। चना की फसल में इन पी.जी.पी. आर. प्रभेदों का व्यावसायिक उपयोग किया जाना चाहिए।
- उकठा ग्राही प्रजाति में रोग का प्रभाव 90% से अधिक पाया गया। 79 प्रविष्टियाँ (उकठा अवरोधिता के 27 दाता, दो प्रजनक जीनप्रारूप ना जननद्रव्य वंशानुक्रम, अखिल भारतीय समन्वित दलहन सुधार परियोजना की दो प्रविष्टियां तथा 39 अन्य उन्नत जीनप्रारूप) उकठा अवरोधी पाए गए।
- देश के अरहर तथा चना उत्पादन करने वाले क्षेत्रों से एकत्रित *फ्यूजेरियम ऊडम* तथा *एफ. ऑक्सीस्पोरम एफ. स्पे. साइसेरी* के 20-20 प्रभेद एन.बी.ए.आई.एम, मऊ में दीर्घकालीन भण्डारण के लिए जमा कर दिए गए है।
- अनुपचारित नियन्त्रण की तुलना में कार्बेन्डाजिम कवकनाशी से 2 ग्राम प्रति कि.ग्रा. बीज की दर से बीजोपचार करने से उकठा के प्रकोप में 73.5% की कमी दर्ज की गई। *ट्राइकोडर्मा विरिडी* (कानपुर) भी कार्बेन्डाजिम की भांति ही प्रभावी पाया गया। *टी. विरेन्स* (बंगलौर), *टी. विरिडी* (ढोली) तथा *टी. हार्जियानम* (कानपुर) के उपचार से उकठा अवरोधित में 41-57% की कमी आई तथा प्रभावी रहे।
- *टी. विरिडी* (कानपुर) के कल्चर के घोल से बीज भिगोने से अरहर में उकठा रोग के प्रकोप में 81% की कमी आई जबकि *टी. विरेन्स* (बंगलौर) का दूसरा स्थान रहा। *सेलीसाइलिक* अम्ल से मिट्टी गीली करने से उकठा के प्रकोप में 58% की कमी आई।
- मूँग के 37 जीनप्रारूप (बी.डी.वाई.आर. 2, बी.जी.जी. 1, बी. एम. 111, सी.एन 8090, सी.एन. 9042, डी.एम.जी. 1030, डी.यू. 5-6, ई-38, ई 93161, जी.जी. 1980, जी.जी. 1990, जी.पी. 205, जी.पी. 275, जी.एम. 4, जी.ई.सी. 1921, जी.ई.एस. 1-9-31, जी.एम.एल 70, आई.सी. 52061, आई.सी. 324025, आई.सी. 362096, आई.एन. एम. 646, आई.पी.एम. 03-07, आई.पी.एम. 99-25, जलगांव 1, कोपरगांव मूंग 1, जी.एम. 99-25, एल.एम. 1, एल.एम. 12, एल.एम. 16, एल.एम. 43-1, एल.एम. 55, एल.एम. 97, एल.एम. 228, एल.एम. 236 तथा एल.एम. 237) रोग के प्रति मध्यम अवरोधी चिन्हित किए गए।
- मूँग पर रोग के लक्षण प्रथम बार 9 सितम्बर को नजर आए, जो मध्य अक्टूबर तक कोपरगांव तथा नरेन्द्र मूंग 1 प्रजातियों पर धीरे धीरे करके 22.1 तथा 22.2% तक बढ़ गए। रोग का सर्वाधिक प्रकोप सितम्बर के तीसरे सप्ताह में तथा उससे कम प्रकोप अक्टूबर के प्रथम सप्ताह में हुआ। आने वाले सप्ताहों में तापमान में कमी होने तथा रोग के प्रकोप में प्रतिशत वृद्धि में ऋणात्मक सम्बन्ध पाया गया।
- मूँग में ट्राइकोडर्मा के प्रभेद आई.पी.आर.टी. 2,3,6,7,13,17 तथा 26 सर्वश्रेष्ठ पाए गए जिनसे सर्कोस्पोरा पत्रबुंदकी रोग के प्रकोप में कमी जीवित पौधों की अधिक संख्या तथा वृद्धि व ओज में उन्नति देखी गई। सेलीसाइलिक अम्ल की 10 पी.पी.एम. मात्रा की दर से प्रयोग का inhibitory प्रभाव *सर्कोस्पोरा*

कैनेसेन्स के सभी 14 प्रभेदों पर स्पष्ट नजर आया।

- *सर्कोस्पोरा कैनेसेन्स* के प्रभेदों (27 तथा 34) की कवकीय वृद्धि तथा जीवाणु वृद्धि पर जिंक सल्फेट, कॉपर सल्फेट, बोरॉन, मैग्नीशियम सल्फेट तथा मैगनीज सल्फेट प्रत्येक की 125, 250, 500 व 1000 पी.पी.एम. मात्रा के पड़ने वाले प्रभाव को मूल्यांकित किया गया। दोनो प्रभेदों की कवकीय वृद्धि मैगनीज सल्फेट की 125 पी.पी.एम. मात्रा से बढ़ी जबकि नियन्त्रण की अपेक्षा कॉपर सल्फेट की 1000 पी.पी.एम. मात्रा से वृद्धि में कमी आई।
- इन्डोसल्फान 0.07% के दो छिड़काव से मूंग की सर्वाधिक उपज (778 कि.ग्रा./हे.) प्राप्त हुई। इस कीटनाशी रसायन के प्रयोग से पत्ती काटने वाले, पत्ती चूसने वाले तथा ब्लिस्टर भृगों जैसे कीटों तथा एन्थ्रेकनोज तथा चूर्णिल आसिता रोग के प्रकोप में कमी आई। आई.आई.पी.आर.टी. 31, 11, 21 तथा डाईमीथोएट के छिड़काव का प्रभाव दूसरे स्थान पर रहा। फसल पकने की अवस्था पर भारी बारिश हो जाने के बावजूद भी आई.आई.पी.आर.टी. 10, इन्डोसल्फान, आई.आई.पी.आर.टी. 28, 31, 21, 3 व डाईमीथोएट के छिड़काव से अधिक उपज प्राप्त हुई।
- मूँग में कार्बेन्डाजिम अथवा ट्राइकोडर्मा आई.आई.पी.आर.टी. 31 के छिड़काव से चूर्णिल आसिता रोग में सार्थक कमी आई। कार्बेन्डाजिम अथवा ट्राइकोडर्मा के छिड़काव से, नियन्त्रण में 6 दाने वाले फली की तुलना में, 9 दाने प्रति फली प्राप्त हुए। इन्डोसल्फान के बाद डाईमीथोएट के छिड़काव से कीटों-रोगों एन्थ्रेकनोज तथा सर्कोस्पोरा पत्र बुंदकी के बेहतर प्रबन्धन तथा चूर्णिल आसिता के प्रकोप की कम तीव्रता के कारण अधिक उपज (778 कि.ग्रा./हे.) प्राप्त हुई। इस प्रकार, ट्राइकोडर्मा द्वारा 6 ग्राम प्रति कि.ग्रा. बीज की दर से बीजोपचार + एन्डोसल्फान का बुवाई के 55 दिनों बाद एक छिड़काव सर्वश्रेष्ठ पाया गया।
- *फ्यूजेरियम ऑक्सीस्पोरम एफ. स्पे. साइसेरी* के 60 प्रभेदों को तीन विशिष्ट समूहों में श्रेणीबद्ध किया गया जिनमें से तीन प्रभेद ऐसे थे जिनसे 30% से कम बीजाकुरों की मृत्यु हुई। जबकि 17 प्रभेद मध्यम रोगाणविक क्षमता के थे जिनसे 30.1 से 50% तक बीजांकुरों की मृत्यु हुई। शेष 40 प्रभेद उच्च रोगाणविक क्षमता के थे जिनसे 50.1% से अधिक उकठा का प्रकोप हुआ।
- चना की फसल पर नीमेरिन के छिड़काव से लार्वा की जनसंख्या में कमी आई तब ये 3.8 से 7.53 लार्वा/पंक्ति की सीमा में (औसतन 5.69 लार्वा/मीटर पंक्ति) रहा। फलियां बनने की अवस्था में एच.ए.एन.पी.वी. के छिड़काव से छिड़काव के 5 दिनों बाद लार्वा की संख्या में और कमी आई तथा यह इस उपचार के पूर्व 4 से 7.25 लार्वा/मीटर पंक्ति की सीमा (औसतन 5.59 लार्वा/मीटर पंक्ति) की तुलना में 2.1 से 3.4 लार्वा/मीटर पंक्ति (औसतन 2.83 लार्वा/मीटर पंक्ति) की तुलना में लार्वा की जनसंख्या आर्थिक क्षतिस्तर से भी नीचे अर्थात् 0.3 से 0.65 लार्वा/मीटर पंक्ति की सीमा में (औसतन 0.51 लार्वा/मीटर पंक्ति) रहा।
- अकेले *बायोरैशनल* कीट प्रबन्धन (4494/हे.) की तुलना में *बायोरैशनल* कीट प्रबन्धन के साथ उन्नत प्रजाति के समावेश से कुल मौद्रिक लाभ 16,884/हे. हुआ।
- बलिया जनपद की बारानी दशाओं में एकल फसल लेने की अवस्था तथा फतेहपुर जिले की सिंचित दशाओं के अन्तर्गत धान-मसूर फसल प्रणाली अपनाने वाले अधिकाशं कृषकों की मसूर की प्रजाति एन.डी.एल$_1$ सर्वाधिक पसन्द प्रजाति थी क्योंकि इस प्रजाति में उकठा रोग के विरुद्ध उच्च स्तर की अवरोधिता, अधिक उपज तथा बाजार में ऊँचा मूल्य मिलना जैसे गुण हैं।
- चना में फली भेदक कीट के लार्वा की जनसंख्या में कमी करने में फूल आने की दशा में एच.ए.एन.पी.वी का छिड़काव काफी प्रभावी पाया गया। बांदा में कमासिन में केवल 8.74% फलियाँ क्षतिग्रस्त हुयी जबकि हमीरपुर जनपद के सुमेरपुर ग्राम में 10.48% फलियाँ क्षतिग्रस्त हुई। अधिकांश कृषक फली भेदक के विरुद्ध एच.ए.एन.पी.वी की प्रभावशीलता से सन्तुष्ट थे।
- मसूर की फसल में मूल विगलन तथा उकठा रोगों से होने वाली औसतन उपज में कमी, चना की फसल में होने वाले नुकसान से कहीं अधिक थी। रोगों के बारे में जानकारी का अभाव, कीटों व रोगों से प्रभावित फसल के लक्षणों में पहचानने की जानकारी का अभाव, उच्च गुणवत्तापूर्ण जैव-कीटनाशियों की अनुपलब्धता, जैव-कीटनाशियों को प्रयोग करने की जानकारी तथा कुशलता का अभाव तथा सरकारी बीज/कीटनाशी स्टोरों में सहयोग की भावना का अभाव रोग प्रबन्धन में महत्वपूर्ण बाधक के रूप में चिन्हित किए गए।
- मसूर की उन्नतशील प्रजातियाँ, स्थानीय प्रजातियों की अपेक्षा पौधे का अधिक ओज, पौधे की ऊँचाई, फलियों की अधिक संख्या तथा एफिड्स के कम प्रकोप के कारण बेहतर पाई गई। अरहर की प्रजाति नरेन्द्र अरहर 1 स्थानीय प्रजातियों की तुलना में पकने में एक सप्ताह का अधिक समय लेती है। अरहर बीज उत्पादन में छिड़ककर बुवाई, पौधों की अधिक संख्या, खपरपतवारों की अधिक संख्या, सिंचाई के साधनों का अभाव तथा प्रथक्करण दूरी को बरकरार रखना जैसी प्रमुख बाधाएं थी।
- गत वर्ष चना की डी.सी.पी. 92-3, जे.जी. 16 तथा के.जी.डी. 1168 प्रजातियों का उत्पादित बीज दो से 18 गांवों में फैल गया। चना के कुल उत्पादित 193 कुन्तल बीज में से 140 कुन्तल (75%) संस्थान द्वारा चयनित गांवों में प्रयोग हो गया, जबकि शेष 53 कुन्तल (25%) 24 कि.मी. के दायरे में चारों तरफ के 18 गांवों में फैल गया। चना उत्पादक कृषकों की संख्या भी 60 से बढकर 119 हो गई। कृषक क्लाबों की बैठकों, रिश्तेदारों, राज्य सरकार की विभागीय बैठकों, समाचार-पत्र, परिवार के सदस्यों एवं पड़ोसियों द्वारा बीज का प्रसार तेजी से हुआ। गुणवत्तापूर्ण बीज बिक्री में औसतन 23% अधिक लाभ मिला।

अखिल भारतीय समन्वित शोध परियोजनाएं

विभिन्न अखिल भारतीय समन्वित शोध परियोजनाओं में दलहनी फसलों की निम्नलिखित प्रजातियां विभिन्न कृषि-पारिस्थितकी क्षेत्रों में खेती हेतु अनुमोदित एवं अधिसूचित की गयी :-

फसल	प्रजाति	क्षेत्र/राज्य
चना	आई.पी.सी.के. 2004-29	मध्य प्रदेश, छत्तीसगढ़, महाराष्ट्र, गुजरात, उ.प्र. का बुन्देलखण्ड क्षेत्र व दक्षिणी राजस्थान
	फूले जी 0517	महाराष्ट्र, मध्य प्रदेश व कर्नाटक
	पी.के.वी. काबुली 4	महाराष्ट्र व मध्य प्रदेश
	एम.एन.के. 1	कर्नाटक, आन्ध्र प्रदेश, तमिलनाडु व उड़ीसा

विभिन्न अखिल भारतीय समन्वित शोध परियोजनाओं में दलहनी फसलों की निम्नलिखित प्रजातियाँ विभिन्न कृषि-पारिस्थितकी क्षेत्रों में खेती हेतु चिन्हित की गयी।

फसल	प्रजाति	राज्य
चना	आई.पी.सी.के. 2	पंजाब, हरियाणा, दिल्ली, उत्तरी राजस्थान, पश्चिमी उ.प्र. व जम्मू
	डब्लू.सी.जी.के. 2000-16	पंजाब, हरियाणा, दिल्ली, उत्तरी राजस्थान, पश्चिमी उ.प्र. व जम्मू
मूँग	आई.पी.एम. 02-3	राजस्थान, पंजाब, हरियाणा, दिल्ली, हिमाचल प्रदेश, उत्तराखण्ड का मैदानी क्षेत्र, जम्मू व कश्मीर का जम्मू क्षेत्र
	आई.पी.एम. 02-14	आन्ध्र प्रदेश, कर्नाटक, तमिलनाडु तथा उड़ीसा
उर्द	एल.यू. 391	आन्ध्र प्रदेश, कर्नाटक, तमिलनाडु तथा उड़ीसा
	के.यू.जी. 479	राजस्थान, पंजाब, हरियाणा, हिमाचल प्रदेश व उत्तराखण्ड का मैदानी भाग, जम्मू व कश्मीर का जम्मू क्षेत्र
मसूर	आई.पी.एल. 315	मध्य प्रदेश, छत्तीसगढ़ तथा उ.प्र. का बुन्देलखण्ड क्षेत्र
मटर	एस.के.एन.पी. 04-09	पूर्वी उ.प्र., बिहार, झारखण्ड, पं बंगाल व आसाम
	एच.एफ.पी. 529	पंजाब, हरियाणा, उत्तराखण्ड का मैदानी क्षेत्र, पश्चिमी उ.प्र., दिल्ली तथा राजस्थान का भाग

प्रजनक बीज उत्पादन

कृषि एवं सहकारिता विभाग (*डी.ए.सी.*) की 9380.75 कुन्तल मांग की तुलना में चना की 84 प्रजातियों का कुल 8849.67 कुन्तल प्रजनक बीज उत्पादित किया गया। अरहर में *डी.ए.सी.* की 373.46 कुन्तल मांग की तुलना में 36 प्रजातियों का 1097.95 कुन्तल प्रजनक बीज उत्पादित किया गया। मूँग, उर्द, मसूर व मटर की *डी.ए.सी.* माँग क्रमशः 797.58 कुन्तल, 500.98 कुन्तल, 346.55 कुन्तल तथा 1774.80 कुन्तल थी जिसकी तुलना में मूंग की 62 प्रजातियों का 1168.65 कुन्तल, उर्द की 44 प्रजातियों का 617.15 कुन्तल, मसूर की 33 प्रजातियों का 515.96 कुन्तल तथा मटर की 30 प्रजातियों का कुल 1303.60 कुन्तल प्रजनक बीज उत्पादित किया गया।

Executive Summary

Crop Improvement

- Four high yielding varieties *viz*., Ujjawal (IPCK 2004-29) of *kabuli* chickpea for central zone, IPM 02-3 of mungbean for spring season in NWPZ, IPM 02-14 for summer season in SZ and IPF 4-9 of fieldpea for U.P. State have been released and notified for cultivation.
- Lentil variety IPL 315 and urdbean IPU 2-43 have been identified for cultivation in the central zone and North West Plain Zone respectively.
- In AICRP trials a number of genotypes in different pulse crops have shown good performance. Some of these like IPCK 113 and IPCK 491 in chickpea, IPA 203 in pigeonpea, IPM 06-5, IPM 9901-6 and IPM 05-2-8 in mungbean, IPU 07-3 and IPU 09-16 in urdbean, and IPL 316 and IPL 215 in lentil are being evaluated in advanced breeding trials.
- Total 374 germplasm line and land races of *desi* chickpea, 98 of *kabuli* chickpea, 760 of late pigeonpea, 429 of early pigeonpea, 250 of mungbean, 764 of lentil and 220 of fieldpea were evaluated and characterized for morpho-physiological and phenological traits. Besides this, 98 wild accessions of chickpea, 56 of pigeonpea, 53 of *Vigna* and 153 of lentil were also maintained.
- A total of 132 markers *viz*., 68 AFLP, 30 SRAP, 14 SRAP-RGA and 20 AFLP-RGA showed polymorphism when screened on ICP 8863 and Type 7 genotypes of pigeonpea. Out of these 125 were dominant and 7 were co-dominant in nature.
- For identification of molecular markers linked to *Fusarium* wilt race 2 resistance genes in chickpea, total 460 markers were screened, out of which 32 were found polymorphic between the parents JG 62 and WR 315. For the parents K 850 and IPC 2004-52, only 2 SSR markers were polymorphic out of the 50 SSR and 25 RAPD markers.

Crop Production

- In long-term trials, maximum system productivity of 5244 kg/ha in terms of pigeonpea equivalent (PEY) was recorded in maize-wheat-mungbean system, followed by pigeonpea-wheat system (4334 kg/ha) and the lowest (3125) in maize–wheat system. Thus, maize-wheat-mungbean recorded the highest system productivity under upland condition. Similarly rice-wheat-mungbean recorded highest system productivity in lowland.
- Irrespective of cropping systems, inorganic fertilizer application resulted into the highest pigeonpea equivalent yield (4872 kg/ha), followed by organic treatment (4090 kg/ha) which was 41.2 and 18.6 % higher over control, respectively.
- Highest soil organic carbon (SOC) was also recorded in maize-wheat-mungbean and rice-wheat-mungbean.
- Improvement in urdbean and chickpea productivity was 32.2% and 20.2%, respectively due to raised bed (75 cm) planting.
- About 23-28% improvement in chickpea yield was recorded due to zero tillage planting and mulching under rice fallows.
- Post-emergence application of imazethapyr controlled most of the rainy season weeds and enhanced the grain yield of mungbean upto 68%.
- Incorporation of crop residue of both crops under upland rice-lentil cropping system enhanced the rice yield by 37.42% and lentil yield by 17.64%. Similarly, incorporation of residue of all three crops in rice (transplanted)-wheat-mungbean enhanced the rice grain yield by 42.5% and wheat by 33.2%.
- FYM application to maize gave 13.9 and 9.5 % higher grain yield of maize and chickpea respectively. Phosphorus application and phosphate solubiliser inoculation also significantly increased the yield of maize and chickpea. Agronomic efficiency of phosphorus (kg grain/kg P_2O_5 applied) increased from 5.08 to 9.21 and from 5.33 to 8.42 due to application of FYM and P40+PSB respectively.

Crop Protection

- Two hundred five lines of chickpea were found resistant (< 10% wilt) to wilt. Eight lines were resistant to representative isolates of all the six races *i.e.*, race 1, 2, 3, 4, 5 and 6.
- Out of 51 lentil genotypes screened against wilt pathogen *Fusarium oxysporum* f. sp. *lentis*, five genotypes *viz*., PL 4147, PL 02, GP 3278, GP 4076 and JL 3 had < 30 % mortality.
- In pigeonpea, UPAS 120 had only 13% incidence of *phytophthora* blight. Incidence of the disease mostly ranged between 0.0 to 20%. Accessions which had higher disease incidence were ICP 8859, IPA PB 55-2, KAWR 45, IPA 8-1, BDN 2, ICP 7119, KA 09-01, IPA PB 8-1-8 and Sharan 1.
- ULCD at Kanpur is not transmitted by spotted beetle (*Epilachna dodecastigma)* and whitefly (*Bemisia tabaci*).
- Incidence of leaf curl in summer mungbean and urdbean crops was 1-2%, whereas in *kharif* crops it was up to 10% in and around Kanpur. In general, the leaf curl disease was more in mungbean as compared to urdbean.
- The amplified products from all the ten samples (five of mungbean and five of urdbean) yielded DNA fragment of ~900 bp and ~800 bp corresponding to NSm genes and NP genes of GBNV, respectively, whereas healthy samples gave negative results. This confirms that the leaf curl disease of mungbean and urdbean at Kanpur is caused by groundnut bud necrosis virus.
- Yellow mosaic in wild species/sub-species of *Vigna* grown at Kanpur is caused by MYMIV. This is the first report of nucleic acid based identification of MYMIV as the causal agent of yellow mosaic disease in *V. hainiana, V. trilobata* and *V. radiata* var. *radiata.*
- Yellow mosaic disease of mungbean and urdbean at Kanpur, Ludhiana, Navsari, Dholi is caused by mungbean yellow mosaic India virus (MYMIV), whereas at Vamban and Coimbatore it is caused by mungbean yellow mosaic virus (MYMV).
- The reaction of chickpea accessions for Botrytis gray mold disease severity was rated on 0-9 scale. Accession IPC 2010199 completely escaped the disease. Thirty accessions had disease at rating scale 1, 11 acc. at 1.5, 25 acc. at 2-4, ten acc. at 4.5-7, while remaining 39 acc. were at 7.5-9 scale.
- The incidence of *H. armigera* in chickpea started in the first fortnight of March *i.e.*, 9th standard meteorological week (SMW) with maximum larval population on cv. JKG 1 (2 larvae/plot of 24 sqm), followed by cv. KWR 108 (1 larva/plot) and gradually increased up to second fortnight of March *i.e*.. 12th SMW with maximum larval population on JKG 1 (3 larvae/plot), followed by KWR 108 (2 larvae/plot). Thereafter, the population declined and completely disappeared from first week of April.
- Development of *B. hebetor* in terms of number of larvae, pupae and adult emerged was higher from the *Corcyra* larvae reared on maize-based diet. The rearing of *B. hebetor* on maize-reared *Corcyra* larvae resulted in emergence of 16.0 larvae and 12.0 pupae. The wheat and rice-based rearing of *Corcyra* used for *B. hebetor* resulted in the mean number of emergence of 11.6 and 11.5 larvae and 10.2 and 9.5 pupae, respectively.
- Cypermethrin and spinosad recorded highest mortality on egg (100% mortality), larvae (100 and 61.9% mortality, respectively), pupae (69.3 and 62.8%) and adult (100% mortality) of the parasitoid *B. hebetor*. Emamectin benzoate recorded 85.5, 62.2, 52.8 and 85.0% mortality of eggs, larvae, pupae and adult parasitoid, respectively.
- In pigeonpea at flowering stage, the level of infestation of *Maruca* was rated on standard 1-9 scale (1: no damage; 9: >90%). The lowest damage rating (DR) was recorded in genotypes ICP 12890 and ICP 12882 (DR: 2). Low level of pod damage due to *Maruca* was also observed in ICP 12890 (1.9%) and ICP 12882 (3.7%).
- The higher per cent reduction in larval population of *Maruca* was recorded in short-duration pigeonpea treated with DDVP 76EC+Rynaxypyr 20EC (95.6), followed by garlic bulb as compared to control at 14 days after spraying, which were at par . The lowest pod damage (3.4%) was also recorded in DDVP 76EC+Rynaxypyr 20EC treated plots, followed by garlic bulb extract+Rynaxypyr 20EC (4.6%), which were at par and significantly superior over untreated control (18.8%).
- Under free-choice test in mungbean, none of

the accessions was found resistant against bruchids. Six accessions were found moderately resistant. In urdbean, one accession KU 96-3 (suitability index: 0.049) was found resistant. Two accessions were categorized as moderately resistant. In no-choice test, none of the accessions of urdbean was found resistant. However, three accessions were found moderately resistant.

- Field infestation of bruchids on different cultivars of mungbean ranged from 0.8% (Samrat) to 5.0% (NDM 1) with an average of 2.7% on pod basis. The grain infestation of bruchids on different cultivars of mungbean ranged from 0.1% (Samrat) to 0.8% (NDM 1) with an average of 0.4%. Among urdbean cultivars, bruchid infestation ranged from 2.2% (Type 9) to 3.2% (Shekhar 1) with an average of 2.8% on pod basis and 0.6% (Uttara) to 0.9% (Shekhar 1) with an average of 0.7% on grain basis.
- In mungbean, per cent pod damage and grain damage due to bruchids were positively correlated with pod width. In urdbean, per cent pod damage and grain damage due to bruchids were positively correlated with the pod width, pod trichome density, number of seeds per pod and negatively correlated with pod wall thickness.
- IPM for pigeonpea sole crop sown on ridges recorded lowest incidence of *Fusarium* wilt (33.3%) and *H. armigera* (1.6% pod damage) as compared to 37.5 % and 38.8% *Fusarium* wilt, 2.4% and 2.2% pod damage due to *H. armigera* in IPM module with pigeonpea+urdbean as intercrop and IPM module with pigeonpea+sorghum as intercrop.
- Pod fly damage was lower in IPM module with pigeonpea+urdbean as intercrop (26.4% pod damage and 28.1% grain damage) as compared to IPM module with pigeonpea+sorghum as intercrop (43.6% pod damage and 36.0% grain damage) and IPM for pigeonpea sole crop (30.6% pod damage and 33.4% grain damage).
- Endosulfan was found superior (2.1% pod damage), followed by *Ha*NPV (4.5% pod damage), which was significantly lower than other treatments *viz*., *Bacillus thuringiensis* (6.6% pod damage), sponge formulation of EPN (7.1% pod damage) and untreated check (10.9% pod damage). Similarly, Endosulfan recorded significantly higher grain yield (15.4 q/ha), followed by *Ha*NPV 250 LE (13.1 q/ha). In other treatments, the grain yield ranged from 12.1 q/ha (*B. thuringiensis*) to 11.9 q/ha (EPN sponge formulation) and it was at par with untreated check (11.9 q/ha).
- *Pratylenchus* was observed most frequently in chickpea while *Hoplolaimus* was observed most frequently in pigeonpea, mungbean, urdbean, lentil and fieldpea samples collected from different districts of Bundelkhand.

Crop Physiology, Biochemistry and Microbiology

- Chlorophyll fluorescence image based techniques followed by *in situ* pollen germination on stigma surface were used for diagnoses and selection of heat tolerance in chickpea.
- Five heat tolerant and three sensitive chickpea lines *viz*., JG 74, ICC 637, ICC 8950, Avrodhi and Annegiri (Heat tolerant) and ICC 8522, ICC 1194 and ICC 3230 (Heat sensitive) have been identified based on screening methodologies and yield under late sown conditions.
- In fieldpea, out of 55 genotypes tested seven genotypes *viz*., IPF 523, IPF 99-26, IPF 19, KPMR 11-1, KPF 103, DMR 15, and Pant Pea 5 were found tolerant to heat stress,.
- In lentil, late flowering genotypes *viz*., VL 4, B 77, Ranjan, WBL 58, IPL 203, IPL 403, IPL 404, IPL 517 and P 2016 performed better under irrigated conditions.
- Peroxidase (PO), polyphenol oxidase (PPO) and phenyl alanine ammonia lyase (PAL) helps in formation of acid detergent fiber (ADF) and lignin, which ultimately imparts resistance against wilt in pigeonpea.
- Non-polar group of compounds of calotropis latex showed respectively 50% and 80-90% inhibition in colony growth and number of conidia and their weight in test fungal pathogens.
- Soil quality attributes such as organic carbon, KMnO4-Oxidizable-C, microbial biomass –C and other microbial activity traits like activities of soil enzymes and basal respiration rate improved significantly under organic and integrated production systems as

compared to chemical system.

- Under moisture stress conditions inoculation of chickpea var. RSG 888 with two efficient strains *M. ciceri* improved nodulation and grain yield by 20% over un-inoculated control.
- Field inoculation trial with PGPR strains in chickpea confirmed that growth response to inoculation was higher in soil containing higher organic carbon level (0.35%) as compared to low carbon content 0.20%. Majority of PGPR strains for chickpea belong to *Bacillus* spp.

Agriculture Extension

- Excursion trip, meetings and training were the main methods for transferring pulse production technology. The major constraints perceived by the farmers were non-availability of quality seeds in time, disease and insect infestation and lack of knowledge about the improved pulse production technologies. The major constraints perceived by the extension workers are lack of field staff and overburdened with the other activities. Public private partnership approach may be used for providing quality seed in time and proper insect forecasting system for controlling the insect pests.
- Small and medium category men were predominantly participating in land preparation, spray of insecticide, threshing and storage from field to home, whereas women participation was more in the sowing of seed (80%), harvesting of crop, plucking of matured pods, winnowing, storage in bin and making *dal*. In case of large farmers' category, women were not participating in the outside activities of pulse production.
- Under double cropped irrigated condition, the average yield of DCP 92-3 and JG 16 varieties was recorded 13.07 and 13.5 q/ha, respectively, against 7.18 q/ha yield of local variety . Under monocropped rainfed situation, farmers received additional advantage of Rs. 16 and 15.9 thousand per ha by growing DCP 92-3 and JG 16 varieties against the local varieties.

Agricultural Engineering

- Vertical thresher was evaluated after several modifications for pulse crops of different seed size. The machine gave threshing capacity of 450 kg/h for stripped pigeonpea, 290 kg/h for chickpea and 214 kg/h for urdbean.
- Rubbing thresher, after several modifications, could be used to substitute manual threshing with 88kg/h capacity for chickpea and 285 kg/h for stripped pigeonpea.
- Pigeonpea stripper was re-evaluated for Pusa 992 and UPAS 120 to yield average stripping capacity of 158 kg/h. Suction winnower was also re-evaluated for these genotypes to yield average winnowing capacity of 170 kg/h.
- Soluble protein and polyphenols in milling by-product obtained from pigeonpea varieties was found to be 9.40 %, d.b. and 219.91 mg/100g catechol equivalent, respectively.

Computer and Statistics

- An expert system for pulses (PulsExpert) has been evaluated and validated to provide online help to pulse growers and extension workers of the country. Complete system is available on URL http://iipr.res.in/pulseexpert/home_page.asp for its online access.
- For making the process of data collection and compilation smooth and easier, development of an online information retrieval system using data of AICRP trials on mungbean has been initiated.

Externally Funded Projects

- Total genomic DNA was isolated from 64 putative T_2 transgenic fieldpea lines (*cv.* HUDP 15) and PCR conditions were optimised using primers specific to RNAi gene, CaMV 35S promoter, *npt II* marker and intron for molecular characterization. PCR results showed, only introns specific primers could detect 8 positive lines. Further, plants showing positive amplification with intron-specific primers were selected for Southern hybridization. Southern hybridization was carried out using AF531160 gene specific biotin labelled probe. Result indicated strong hybridization with plasmid DNA . Whereas, out of 8 PCR positive plants, only one plant

(D-23-1-4) was found Southern positive.

- Total 150 (out of 815) markers were found polymorphic between BG 256 and JG 315. Among these, 70 (out of 545) SSR markers were found polymorphic. Screening of 16 SSR markers linked to *Fusarium* wilt resulted in identification of six polymorphic markers *viz.,* H3A 12, TA194, TA 59, TA 110 and HIB 06. Three linked RAPD markers *viz.,* OPM 03703, OPAC 041200 and OPAC 11500 were also validated. Screening of other markers resulted in identification of 45 (out of 180) RAPD, 15 ISSR (out of 50), 20 (out of 40) RGA markers polymorphic between the above parents.
- Crosses were made and parental polymorphism was studied using markers (TAA 170, ICCM 0249, STMS 11 and GA 24) flanking the QTL for drought tolerance. Only marker TAA 170 showed polymorphism between both the parents. For genetic mapping for wilt resistance in pigeonpea, F_4 seeds were harvested successfully for developing the RIL mapping population derived from Asha x UPAS 120. Besides, parental polymorphism was studied between these two parents using 20 CEDG SSR primers, out of which 12 SSRs were found to be cross transferable and one SSR primer (CEDG 057) was found polymorphic.
- The *Bt*-gene construct, *cry*1Ac was obtained from NRCPB and checked for integrity by restriction digestion and PCR with *cry*-gene specific primers. Five thousand explants each of chickpea (*cv* DCP 92-3) and pigeonpea (*cv* Asha) were prepared and tested for evaluation of the existing genetic transformation protocol.
- Total 18 early duration pigeonpea hybrids were developed involving 7 early maturing CMS lines *viz.,* AL 101 A, ICP 2089 A, PA 163 A, UPAS 120 A, CORG 990047 A, CORG 990052 A and GT 290 A and 12 restorers *viz.,* AK 261504R, AK 261322R, AK 261506R, 250083R, 261322R, 250173R, 250157R, 250165R, 261345R, 261429R, 261394R and 261409R.
- Efficient and reproducible regeneration and transformation system was established from cotyledonary nodes of *Vigna*. Continuous exposure to BAP (6-benzyl amino purine) was found important for maximal regeneration from cotyledonary node (CN) explants and these explants produced upto 19 buds/CN explant and 5 shoot-buds/CN explant. The explants age and co-cultivation temperature were also found important factors, which strongly affect the success of transformation. CN from two days old seedlings are suitable explants for transformation and 25^0C is the optimal co-cultivation temperature. It was found that transformation frequency after four weeks in selection medium was around 3.4%.
- Total 70 F_1 seeds were generated in the cross Vijay x Pusa 256 and 27 in the cross WR 315 x Pusa 256. True F_1 plants confirmed by SSR markers were back crossed with recipient parent. Consequently, 6 BC_1F_1 seeds each were obtained in both the crosses. For background selection, 374 SSR markers have been screened. Out of these 46 were found to be polymorphic between parents involved in the cross Vijay x Pusa 256, while 43 were polymorphic between the parents involved in the cross WR 315 x Pusa 256.
- Total 562.12 q breeder seed of different pulse crops was produced during 2010-11 as compared to 501.99 q in 2009-10.
- Thirty nine wild lentil accessions from seeds obtained last year and 42 out of 160 races belonging to Iran, Turky, Ethopia and Egypt were grown in pots for obtaining the cross with cultivated genotypes. F_1 seeds were harvested from 8 crosses made between cultivated (DPL 62 and DPL 58) and wild species (*L. culanaris* sp. *orientalis* and sp. *tomentosus*) and 4 crosses were made between cultivated (DPL 62 and DPL 58) and Mediterranean land races.
- A core collection of 237 accessions, 42 accessions of ICARDA drought nursery (LIDTN-2011) and 55 accessions of active germplasm were grown in late sown conditions (15 January) for heat tolerance evaluation. Out of these, 176 accessions flowered early and matured after 80-85 days of sowing. Among remaining 158 accessions, 62 did not flower or flowered rarely and hence considered highly sensitive to heat. Ninety six accessions had flowering and podding after 85 days of sowing and were considered for recording the data on pod and seed development on the terminal of branches.

- Drip-fertigation either at branching or at both branching and podding produced significantly higher (18%) seed yield over unirrigated control (farmers' practice). Drip-fertigation only at podding which was at par with furrow irrigation at both branching and podding had moderate level of yield .
- There was differential response to inoculation ranging from 5 to 20% increase over uninoculated control (1923 kg/ha). Higher increase in grain yield ranging from 14 to 20% over un-inoculated control was obtained with four PGPR strains *viz*., P 66, CP 11, PSB 11 and J 7. Three strains *viz*., CP 11, PSB 11 and J 7 showed consistent response in increasing the grain yield of chickpea under field conditions. These are potential PGPR strains for commercial use in chickpea crop.
- Cultures of 20 isolates each of *Fusarium udum* and *F. oxysporum* f. sp. *ciceri* from different pigeonpea and chickpea growing areas of the country have been deposited at NBAIM, Mau for long-term storage and maintenance.
- Seed treatment with fungicide carbendazim @ 2.0 g/kg was found most effective causing reduction of 73.5% wilt incidence over control. Among antagonists, *Trichoderma viride* (Kanpur) was at par with carbendazim. *T. virens* (Bangalore), *T. viride* (Dholi) and *T. harzianum* (Kanpur) reduced wilt incidence by 41-57% and were the next effective treatments .
- Seed soaking with culture filtrate of *T. viride* (Kanpur) was most effective in reducing the wilt disease in pigeonpea by 81%, followed by *T. virens* (Bangalore). Soil drenching of salicylic acid was however, the next effective treatment reducing wilt incidence by 58% .
- Thirty seven mungbean genotypes *viz*., BDYR 2, BGG 1, BM 111, CN 8090, CN 9042, DMG 1026, DMG 1030, DU 5-6, E 38, E 93161, GG 1980, GG 1990, GP 205, GP 275, GM 4, GEC 1921, GES 1-9-31, GML 70, IC 52061, IC 324025, IC 362096, INM 646, IPM 03-07, IPM 99-25, Jalgaon 1, Kopergaon 1, Kopergaon Mung 1, GM 99-25, LM 1, LM 12, LM 16, LM 43-1, LM 55, LM 97, LM 228, LM 236 and LM 237 were identified as moderately resistant.
- First appearance of disease on mungbean was noticed on 9th September, which gradually increased up to 22.1 and 22.2%, respectively on cvs. Kopergaon and NM 1 by mid-October. Maximum disease development was recorded in the third week of September, followed by first week of October. Minimum temperature showed significant negative relationship with % increase in the disease in subsequent week.
- IPRT 2, 3, 6, 7, 13, 17 and 26 were the best *Trichoderma* isolates which reduced the growth of *Cercospora canescens*, increased plant stand, promoted growth and vigour in mungbean. Inhibitory effect of salicylic acid @ 10 ppm was evident on all 14 isolates of *C. canescens*.
- Zinc sulphate, copper sulphate, boron, magnesium sulphate and manganese sulphate each at 125, 250, 500 and 1000 ppm were evaluated *in vitro* for their effect on mycelial growth and sporulation of *C. canescens* isolates (27 and 34). Enhancement of mycelial growth of both isolates was observed by $MnSO_4$ @ 125 ppm. On the contrary $CuSO_4$ @ 1000 ppm reduced their growth over control.
- Highest yield of mungbean (778 kg/ha) was obtained with two sprays of 0.07% endosulfan as this pesticide controlled defoliators, sucking pests and blister beetle besides reduction in anthracnose and powdery mildew disease severity. This was followed by spray of IIPRT 31, 11, 21 and dimethoate. As the crop was trapped in heavy rains at maturity, sprays of IIPRT 10, endosulfan, IIPRT 28, 31, 21, 3 and dimethoate gave significantly higher yield.
- Significant reduction in powdery mildew was obtained in mungbean by spray of carbendazim or *Trichoderma* IIPRT 31. Spraying with carbendazim or *Trichoderma* yielded >nine seeds/pod against 6.3 in control. Higher grain yield (778 kg/ha) was recorded in endosulfan, followed by dimethoate sprays because of the better management of insect pests, anthracnose and CLS as also the lower severity of powdery mildew. Thus, seed treatment with *Trichoderma* @ 6g/kg seed+one spray of endosulfan (55 DAS) was found best.
- The variability in amino acid of NSm gene of GBNV isolates of pea is high in comparison to the NP gene. The GBNV-[Pea_SJP] isolate has the highest variability in NSm gene at

amino acid level. However, there is no variability in NP gene of this isolate in comparison to GBNV type isolate. This indicates that the NP gene of GBNV is highly conserved and variability exists in the NSm gene.

- Sixty isolates of *Fusarium oxysporum* f. sp. *ciceri* (Foc) were categorized into 3 distinct groups, in which, three isolates were found weak pathogenic causing <30.0% seedling mortality, while 17 isolates were characterized as moderately pathogenic causing 30.1 to 50.0% seedling mortality. Remaining 40 isolates were characterized as highly pathogenic with >50.1% wilt incidence.
- Spray of antifeedant Neemarin on chickpea resulted in reduction in population of *H. armigera* larvae and it ranged between 3.8 to 7.53 larvae/row (an average of 5.69/meter row). The HaNPV spray during pod formation stage resulted in further reduction in larval population after 5 days of spray and it ranged between 2.1 to 3.40/m row (Av. 2.77) as compared to an average of 5.59/m row (range between 4 to 7.25/m row) in the pre-treated count. The spinosad spray coinciding with pod maturation stage, resulted in reduction in larval population below ETL *i.e.*, 0.3 to 0.65 with an average of 0.51/m. row as compared to 2.83 larvae/m row (2.3 to 3.55) prior to spray.
- Incremental returns was highest in biorationals pest management along with improved variety (Rs. 16,884/ha) as compared to biorationals pest management alone (Rs 4,494/ha).
- Majority of farmers preferred NDL 1 in rainfed monocropped situation of Ballia district and in rice-lentil under irrigated situation of Fatehpur due to its high resistance against wilt, higher yield and remunerative price in market.
- Spray of HaNPV at flower initiation stage was found very effective in reduction of larval population of pod borer in chickpea. Only 8.74 % pod damage was recorded in Kamasin in Banda, whereas 10.48 % pod damage was noticed in Sumerpur in Hamirpur district. Majority of farmers were convinced with the effect of HaNPV against pod borer.
- The average yield loss due to root rot and wilt in lentil was higher than chickpea. The major factors in disease management were identified as lack of knowledge on diseases, poor identification skills between insects and diseases affected symptoms, unavailability of quality bio-pesticide, lack of knowledge and skills in application bio-pesticides and poor cooperation from Govt. seed/pesticide store.
- Improved varieties were observed better over local with more plant vigour, plant height, higher number of pods and less incidence of aphid in lentil. The maturity period of Narendra Arhar 1 was one week higher over the local. Broadcast sowing, higher plant population, high weed intensity, lack of irrigation facilities, and maintaining of segregation distance were the major problems in pigeonpea seed production.
- The chickpea seed (DCP 92-3, JG 16 and KGD 1168) produced in previous season was diffused from two to eighteen villages. Out of 193 q chickpea seed produced 140 q (75%) was utilized in adopted villages and rest 53 q (25%) in other 18 villages in a radius of 24 km. The number of chickpea growers increased from 60 to 119. The major channels in seed diffusion were farmers' club meetings, relatives, state department meetings, Newspapers, family members and neighbourers.

All India Coordinated Research Projects

Improved varities

Under All India Coordinated Research Projects, following varieties were released and notified for different agro-ecological areas:

Crop	Variety	State
Chickpea	IPCK 2004-29	Madhya Pradesh, Chattisgarh, Maharashtra, Gujarat, Bundelkhand tracts of U.P. and southern Rajasthan
	Phule G 0517	Maharashtra, Madhya Pradesh and Karnataka
	PKV *Kabuli* 4	Maharashtra and Madhya Pradesh
	MNK 1	Karnataka, Andhra Pradesh, Tamil Nadu and Orissa

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

Crop	Variety	State
Chickpea	IPCK 02	Punjab, Haryana, Delhi, North Rajasthan, western U.P. and Jammu
	WCGK 2000-16	Punjab, Haryana, North Rajasthan, western U.P., Delhi and Jammu
Mungbean	IPM 02-3	Rajasthan, Punjab, Haryana, Delhi, plains of Himachal Pradesh and Uttarakhand and Jammu region of J & K
	IPM 02-14	Andhra Pradesh, Karnataka, Tamilnadu and Orissa
Urdbean	LU 391	Andhra Pradesh, Karnatka, Tamilnadu and Orissa
	KUG 479	Rajasthan, Punjab, Haryana, plains of Himachal Pradesh and Uttarakhand and Jammu region of J&K
Lentil	IPL 315	Madhya Pradesh, Chhatisgarh and Bundelkhand region of U.P.
Fieldpea	SKNP 04-09	Eastern U.P., Bihar, Jharkhand, West Bangal and Assam.
	HFP 529	Punjab, Haryana, plains of Uttarakhand, western U.P., Delhi and parts of Rajasthan

Breeder Seed Production

Total 8849.67q breeder seed of 84 varieties of chickpea was produced against DAC Indent of 9380.75 q and 1097.95 q breeder seed of pigeonpea (36 varieties) was produced against the DAC indent of 373.46 q. Similarly, breeder seed 1168.65 q of mungbean (62 varieties), 617.15 q of urdbean (44 varieties), 515.96 q of lentil (33 varieties) and 1303.60 q of fieldpea (30 varieties) was produced against the DAC indent of 797.58 q, 500.98 q, 346.55 q and 1774.80 q, respectively.

About The Institute

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

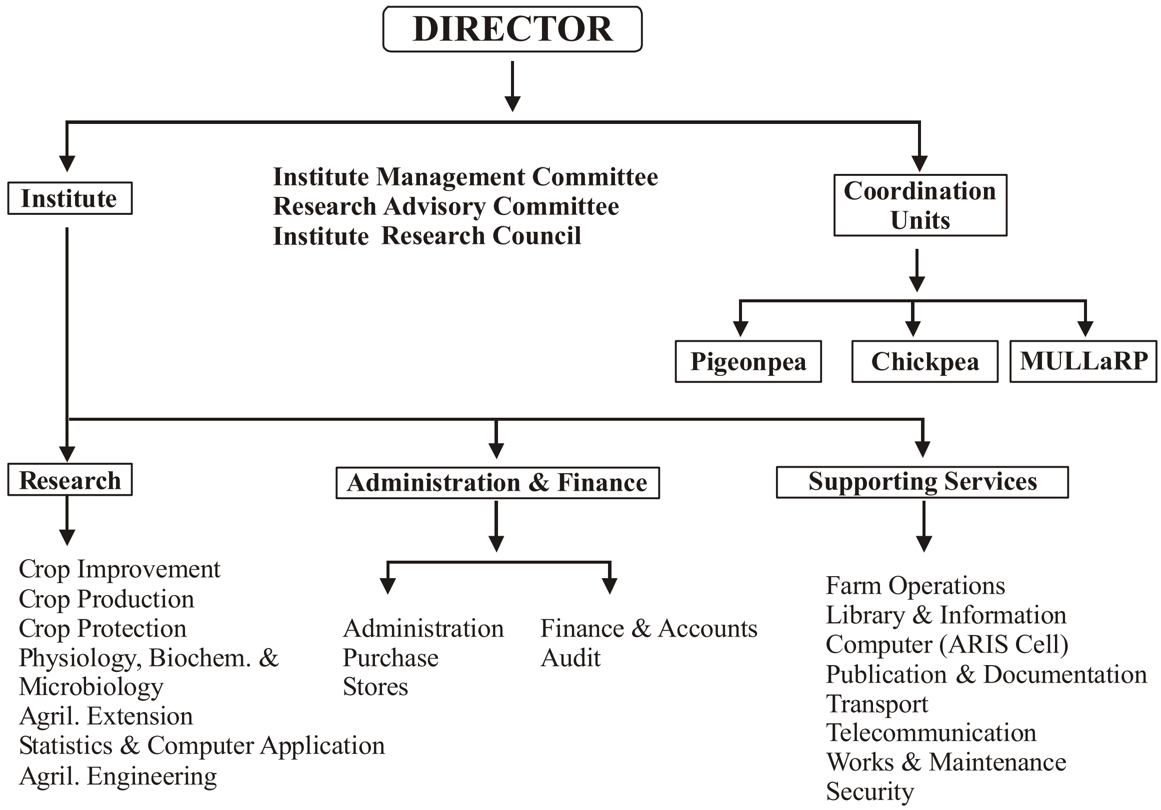
The Institute is located at Kanpur, Uttar Pradesh at $26^0$27'N latitude, $80^0$14'E longitude and 152.4 meter above the mean sea level. It is situated on Grand Trunk Road, 12 km from Kanpur Central railway station towards New Delhi.

The overall climate varies from semi-arid to sub-humid. The summers are very hot and winters are cool and dry. The monthly weather data for the year 2010-11 revealed that the mean monthly maximum temperature varied from 19.7^{0}C in January to 41.2^{0}C in April and the minimum temperature from 7.2^{0}C in January to 29.4^{0}C in July. The relative humidity at 17.30 h varied from 40.4% in May to 85.6 % in August. During the year, total 1132 mm rainfall was received which was normal. The monsoonal rains withdrew by the last week of September. During winter season, 46.4 mm rainfall from November to February was received. Unusually high temperatures were recorded during the months of February (31.8^{0}C), March (36.2^{0}C) and April (42.0^{0}C).

Multi-disciplinary research of both applied and basic nature is conducted under four divisions namely, Crop Improvement, Crop Production, Crop Protection, and Physiology, Biochemistry & Microbiology, besides applied and strategic research in Agricultural Extension, Statistics & Computer Application, Agricultural Economics and Agricultural Engineering sections. 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 the generation of 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 83 scientists, 67 technical, 27 administrative and 61 supporting personnel.

Organizational Set-up



Staff Strength

As on 31.3.2011

Category	Sanctioned	In position	Vacant
RMP	1	1	-
Scientist	82	62	20
Technical	67	64	3
Administrative	27	24	3
Supporting	61	55	6

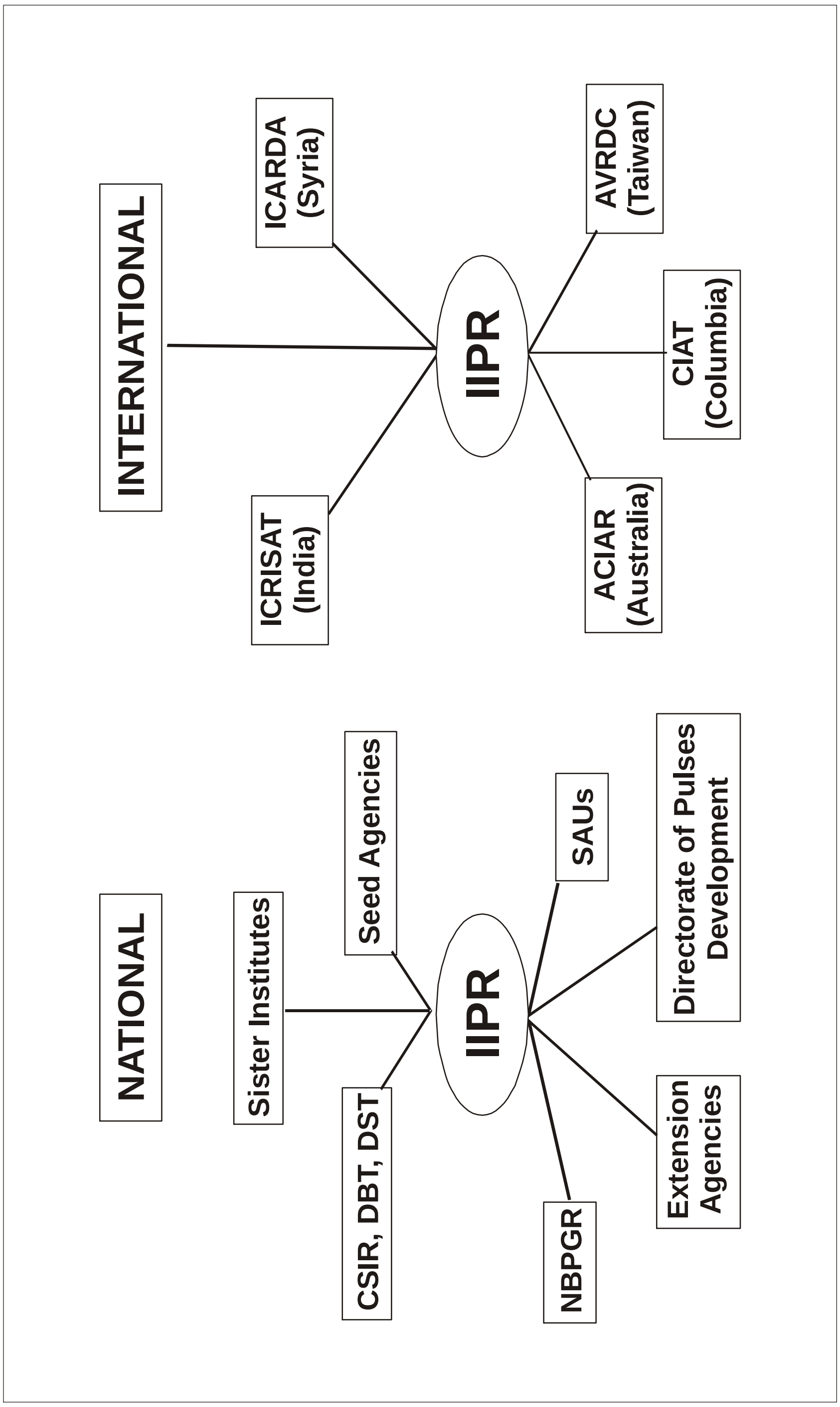
Mandate

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

Major Research Programmes

- Genetic Enhancement for Yield
- Biotechnological Interventions
- Plant Genetic Resources : Collection, evaluation and conservation
- Cropping Systems Research
- Integrated Diseases & Pests Management
- Integrated Nutrients 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 2010-2011

Rs. in lakhs

A.	Receipt		45.45
B.	Expenditure		
	Non-Plan		1209.39
	Plan		699.18
C.	Pension and other retirement benefits		64.05
D.	AICRP		
	Chickpea		
	a.	Coordination Unit	53.09
	b.	Grant-in-aid	659.88
	Pigeonpea		
	a.	Coordination Unit	37.02
	b.	Grant-in-aid	462.95
	MULLaRP		
	a.	Coordination Unit	51.69
	b.	Grant-in-aid	770.25

Status of Implementation of XI Five Year Plan (up to 31.03.2011)

Rs. in lakhs

Head	Approved outlay	Exp. 2007-08	Exp. 2008-09	Exp. 2009-10	Exp. 2010-11	Total Exp.	Balance
A. Recurring							
Pay & Allowances/ Wages	25.00	2.70	3.56	0.00	0.00	6.26	18.74
TA	40.00	5.50	7.00	11.58	9.50	33.58	6.42
HRD	25.00	2.65	4.10	3.60	2.64	12.99	12.01
Contingency	702.00	103.34	152.91	144.73	239.53	640.51	61.49
TOTAL	**792.00**	**114.19**	**167.57**	**159.91**	**251.67**	**693.34**	**98.66**
B. Non-Recurring							
Equipment	700.50	71.00	34.92	155.56	216.82	478.30	222.20
Works	740.00	0.00	82.00	90.76	212.53	358.29	354.71
Library	100.00	19.80	26.00	19.76	18.16	83.72	16.28
Total	**1540.50**	**90.80**	**142.92**	**266.08**	**447.51**	**947.31**	**593.19**
Total (A+B)	**2332.50**	**204.99**	**310.49**	**425.99**	**699.18**	**1640.65**	**691.85**

Crop Improvement

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

Chickpea

Performance of breeding lines in AICRP trials

Entry IPCK 113 (NWPZ) and IPCK 491 (SZ) are being evaluated in AVT 1. Ten new entries including IPC 2005-79, IPC 2006-53 (*desi*), IPC 2006-77, IPC 2006-84 (late), IPC 2007-69, IPC 2007-71 (rainfed), IPCK 2006-78, IPCK 2006-56 (*kabuli*) and IPCK 20008-136 (extra large seeded *kabuli*) are being evaluated in IVT for grain yield and wilt resistance. Similarly, in U.P. State Adaptation Trials, 10 IPC/IPCK entries are being evaluated.

Evaluation of promising breeding lines

Rainfed condition: Total 126 advance breeding lines were evaluated along with checks *viz.*, JG 16, RSG 888, DCP 92-3 in preliminary/station trials. In first trial, genotypes *viz.*, IPC 2010-152 (2931 kg/ha), IPC 2010-134 (2983 kg/ha), IPC 2010-27 (3083 kg/ha), IPC 2010-143 (3114 kg/ha) and IPC 2010-09 (3458 kg/ha) out yielded the best check JG 16 (2839 kg/ha). In another trail, genotypes *viz.*, IPC 2009-50 (2945 kg/ha), IPC 2009-102 (3008 kg/ha), IPC 2008-16 (3012 kg/ha), IPC 2009-187 (3155 kg/ha), IPC 2009-186 (3245 kg/ha) and IPC 2009-21 (3417 kg/ha) out yielded the best check JG 16 (2945 kg/ha). Genotype IPC 2009-21 (2762 kg/ha) also exhibited high yield.

In preliminary yield trial, genotypes *viz.*, IPC 2010-181 (3108 kg/ha), IPC 2010-01 (3175 kg/ha) and IPC 2010-68 (3200 kg/ha) out yielded the best check JG 16 (3072 kg/ha).

Irrigated condition: Total 142 advanced breeding lines were evaluated for yield and other yield attributes under irrigated conditions in 5 trials following standard agronomic practices with pre-sowing irrigation. Later irrigation was given at pre-flowering stage (60 days after sowing). In first trial, 24 lines were evaluated along with 3 checks. Lines *viz.*, IPC 2008-89 (2194 kg/ha: 21.7 g/ 100 seed wt.), IPC 2009-157 (2253 kg/ha: 28.4 g/100 seed wt.) and IPC 2009-191 (2622 kg/ha: 26.7 g/100 seed wt.) out yielded the best check DCP 92-3 (2161 kg/ha: 13.6 g/ 100 seed weight). In second trail, 27 lines were evaluated along with 3 checks. Lines *viz.*, IPC 2007-24 (2907 kg/ha), IPC 2007-28 (2988 kg/ha), IPC 2007-19 (3043 kg/ha), IPC 2007-17 (3096 kg/ha), IPC 2008-83 (3098 kg/ha) and IPC 2007-71 (3113 kg/ha) out yielded the best check GNG 469 (2788 kg/ha). In another trial 27 entries were evaluated and IPC 2008-11 (3195 kg/ha), IPC 2009-21 (3215 kg/ha), IPC 2008-16 (3233 kg/ha), IPC 2009-37 (3240 kg/ha), IPC 2009-192 (3319 kg/ha) and IPC 2008-24 (3402 kg/ha) out yielde the best check DCP 92-3 (2989 kg/ha).

In preliminary yield trials, IPC 2010-142 (3403 kg/ha), IPC 2010-62 (3467 kg/ha), IPC 2010-37 (3531 kg/ha), IPC 2010-88 (3565 kg/ha), IPC 2010-81 (3682 kg/ha), IPC 2010-101 (3692 kg/ha) and IPC 2010-43 (3969 kg/ha) established their superiority in yield over the best check DCP 92-3 (3419 kg/ha).

Specific trial for tall and erect plant type: Total 28 tall and erect breeding lines were evaluated along with 3 checks (KWR 108, HC 5 and DCP 92-3) under normal sown irrigated conditions. Genotypes *viz.*, IPC 2006-27 (81.1 cm; 2988 kg/ha), IPC 2006-11 (85.0 cm; 2992 kg/ha), IPC 2006-14 (83.3 cm; 3175 kg/ha), IPC 2006-142 (80.5 cm; 3083 kg/ha), IPC 2006-142 (80.5 cm; 3083 kg/ha), IPC 2006-14 (83.3 cm; 3175 kg/ha) and IPC 2008-02 (85.5 cm; 3513 kg/ha) out yielded best check varieties KWR 108 (52.5 cm, 2988 kg/ha) and HC 5 (71.7 cm, 2258 kg/ha). One pre-sowing and two more irrigation were provided to this trial and the genotypes exhibited lodging tolerance.

ICSN-*desi*, ICSN-*kabuli* (ICRISAT), LITP2010-11 and CAT Trial (ICARDA) were also evaluated and selections were made from these nurseries.

Generation of breeding material

Total 41 crosses *viz.*, 27 *desi* x *desi*, 11 *desi* x *kabuli* and 3 interspecific (*C. reticulatum* x *C. echinospermum*) were made for bringing desirable genes together and broaden the genetic base. The target traits were yield and its component, biotic and abiotic stresses during generation of breeding material.

Segregating materials/generation advancement

Thirty four F_1s made during 2009-10 were advanced and true F_1 plants (272 SPS) were harvested individually. Total 31 F_2s (470 SPS), 36 F_3s (937 SPS) including crosses received from ICARDA, 52 F_4 (638 SPS), 124 F_5 (584 SPS), 56 F_6 (380 sps), 38 F_7 (119 SPS) and 24 F_8 (39 SPS) were grown and single plants were selected on the basis of plant type, maturity, fecundity, podding behavior and other morphological traits from different crosses in various generations. On the basis of overall expression, 245 progeny bulks from different generations were also harvested.

Quality seed production

Nucleus seed of five chickpea varieties *viz.*, DCP

92-3, IPC 97-67, IPCK 2002-29, IPCK 2004-29 and IPCK 02 and 94.50 q breeder seeds of different varieties were produced.

Germplasm maintenance

Total 274 germplasm accessions, 100 land races and 98 accessions of wild *Cicer* species were multiplied and maintained.

Screening against diseases/insect pests and abiotic stresses

Total 173 IPC *desi* and 42 IPCK *kabuli* breeding lines were screened against *Fusarium* wilt in sick plot. After each test entry, susceptible check JG 62 and resistant check JG 315 were grown. Forty six breeding IPC lines *viz.*, IPC 2010-05, - 2010-16, - 2010-24, -2010-25, - 2010-34, - 2010-38, - 2010-41, - 2010-48, - 2010-54, - 2010-62, - 2010-71, - 2010-72, -2010-74, - 2010-77, - 2010-78, -2010-81, - 2010-113, - 2010-121, - 2010-122, - 2010-123, - 2010-146, - 2010-150, - 2010-152, - 2010-154, - 2010-159, - 2010-167, - 2010-171, - 2010-173, - 2010-174, - 2010-176, - 2010-182, -2010-185, -2010-188, - 2010-192, - 2010-193, - 2010-195, - 2010-198, - 2010-202, - 2010-205, - 2010-207, - 2010-209 and IPC 2010-215 exhibited resistant reaction. Out of 42 *kabuli* chickpea breeding lines, 3 lines *viz.*, IPCK 2010-109, IPCK 2010-91 and IPCK 2010-138 exhibited wilt resistant reaction in sick plot for race 2.

Multi-location evaluation under AICRP resulted in identification of drought tolerant genotype IPC 97-72 due to its high water use efficiency and identification of cold tolerant entry IPC 94-94.

Distribution of breeding material/donors

Total 36 donors/germplasm accessions, 31 F_3 bulks, 234 advanced breeding lines and 7 accessions of wild species were distributed to 10 centers.

Kabuli Chickpea

Varieties developed

High yielding (average grain yield 1941 kg/ha) and white-beige large seeded (33.7 g/100 seed wt.) *kabuli* chickpea variety Ujjawal (IPCK 2004-29) has been released and notified for cultivation in Central Zone comprising of Madhya Pradesh, Maharashtra, Chhattisgarh, Gujarat, parts of Rajasthan and Bundelkhand tracts of Uttar Pradesh. This variety is moderately resistant to wilt. Plants of this variety are semi-spreading and with light foliage. It has shown 15.19% and 10.79% superiority in grain yield over JGK 1 and KAK 2, respectively.

Extra large seeded *kabuli* chickpea genotype IPCK 02 (>55 g/100 seed wt.) with average yield of 13-14 q/ha has been identified for cultivation in North West Plain Zone (Haryana, Punjab, Rajasthan and western Uttar Pradesh).

Evaluation of promising breeding lines

Four station trials (ST) were conducted. In ST I, out of 30 entries five *viz.*, IPCK 08-131 (2619 kg/ha), IPCK 09-115 (2653 kg/ha), IPCK 08-130 (2767 kg/ha), IPCK 09-139 (2828 kg/ha) and IPCK 09-134 (3133 kg/ha) out yielded the best check IPCK 02 (2364 kg/ha). In ST II, IPCK 07-62 (3513 kg/ha) out yielded the best check JKG 1 (3350 kg/ha). In ST II, 2 entries *viz.*, IPCK 09-164 (3041 kg/ha) and IPCK 09-165 (3055 kg/ha) out yielded the best check BG 1053 (3019 kg/ha). In ST III, out of 25 entries two *viz.*, IPCK 10-03 (3266 kg/ha) and IPCK 10-04 (3270 kg/ha) gave higher yield as compared to the checks BG 1053 (3220 kg/ha) and IPCK 02-29 (2850 kg/ha). In ST IV, two entries *viz.*, IPCK 10-96 (2750 kg/ha) and IPCK 2010-10 (2986 kg/ha) were superior over the best check BG 1053 (2750 kg/ha).

Generation of breeding material

Five fresh crosses *viz.*, ILWC 2505 x ILC 3518, ILC 2505 x IPCK 02, Subhra x ICC 4958, Subhra x ILWC 21 and ICC 4958 x Subhra were attempted and segregating generations were advanced for development of better plants types.

Germplasm conservation

Total 93 accessions of *kabuli* chickpea was multiplied and maintained.

Long-duration Pigeonpea

Performance of breeding lines in AICRP trials

IPA 203 (Bahar x AC314-314) showed >13% yield advantage (1871 kg/ha) over the best check MA 6 (1655 kg/ha) at seven locations in NEPZ. It recorded ~11% overall yield advantage over the same check over 3 years (IVT, AVT I and AVT II) at 19 locations. It has also shown resistance to wilt, SMD and *Phytophthora blight* .

Field view of IPA 203

Registration of genetic stock

Two genotypes *viz*., IPA 204 and IPA 234 were registered as donors for resistance to wilt and SMD, respectively. These two lines were assigned the number INGR 10024 and INGR 10025, respectively.

Performance of breeding lines in station trials

Two station trials, each with 8 test entries along with 2 checks (Bahar and NA 1) were conducted. In ST I, IPA 11-1 (a selection from Kudrat 3) out performed (2477 kg/ha : 100 seed wt. of 11.3 g) the best check NA 1 (2300 kg/ha). In ST II, two entries *viz*., IPA 11-9 (IPA 6-1 x Bahar) and IPA 11-10 (a selection from Kudrat 3) recorded 1903 kg/ha and 1757 kg/ha yield with 100 seed wt. of 8.0 and 11.9 g, respectively. The best check Bahar yielded only 1315 kg/ha with 100 seed wt. of 11.7 g.

Performance of breeding lines in SMD and wilt-sick nursery

In wilt-sick nursery, IPA 204 and IPA 234 recorded resistant reaction against wilt during 5th year also. Entries *viz*., IPA 37, IPA 92, IPA 410, IPA 7-2 and IPA 7-3 were observed as moderately resistant to *Fusarium* wilt.

Generation of breeding material

A cleistoline ICPL 87154 was crossed with agronomically superior genotypes *viz*., Bahar and IPA 203. Fifteen F_1, 14 F_2, 25 F_3, 10 F_4, 2 F_5, 15 F_6 and 10 F_7 progenies and 7 BC-F_4 populations were grown and advanced through selfing. Twelve single plant progenies from five sources *viz*., Kudrat 3, Virat, MAL 13, NA 1, and Bahar were grown to confirm their breeding behavior and superiority over the checks Bahar and NA 1. All 4 F_1 crosses carrying A_4 cytoplasm (ICPA 2043) involving IPA 7-6, IPA 234, Kudrat 3 and MA 6 as restorers were advanced through selfing. Other F_1 hybrids derived from crosses between 2 CMS lines (Hy 4A and H 28A: A_2 cytoplasm) and testers *viz*., IPA 7-6, IPA 203, IPA 234, Kudrat 3 and MA 6 were again crossed with the same set of testers as part of CMS conversion programme.

Basic genetic information

- Total 15 F_1's derived from three CMS lines *viz*., ICPA 2043 (A_4 cytoplasm), Hy 4A and H 28A (A_2 cytoplasm) were grown and evaluated for fertility restoration. All F_1's (except that involved IPA 203 as a pollen parent) carrying A_4 cytoplasm were fertile, indicating that all the four pollen parents (Kudrat 3, MA 6, IPA 7-6 and IPA 234) have ability to restore fertility in F_1 generation for A_4 cytoplasm. However, none of these pollen parents restored fertility in F_1's that carried A_2 cytoplasm.
- Ten F_2 populations derived from two CMS lines (ICPA 2039 and ICPA 2043 carrying A_4 cytoplasm) and 5 restorers (Bahar, NA 1, Pusa 9, IPA 7-2 and IPA 204) segregated approximately in 3 (fertile plants) : 1 (sterile plants) ratio, indicating that a single dominant restorer gene governs fertility restoration in F_1 hybrids (carrying A_4 cytoplasm).

Short-duration Pigeonpea

Generation of breeding material

A genotype which flowered extra-early (60 days) and matured in 95 days was selected and selfed for further evaluation. Six crosses *viz*., Prabhat x JA 4, Prabhat x 67B, Prabhat x extra-early selection, JA 4 x 67B, JA 4 x extra-early selection and 67B x extra-early selection) were attempted to get super early types in segregating generations. Total 3 F_1, 19 F_2, 22 F_3, 11 F_4, 13 F_5, 12 F_6 and 11 F_8 progenies were grown and advanced through selfing under individual nylon net. Thirty varieties including some land races were multiplied.

Basic genetic information

Lines belonging to medium or late group *viz*., IPAPB 7-2-7, IPAPB 7-2-1-2, IPAPB 7-2-1, KPL 43 and KPBR 80-2-2 were identified as tolerant to *Phytophthora* blight.

Mungbean

Varieties developed

High yielding variety IPM 02-3 (average yield 1128 kg/ha) a derivative of interspecific cross (IPM 99-125 x Pusa Bold 2) has been released for spring cultivation in North West Plain Zone comprising of Rajasthan, Punjab, Haryana, Delhi, plains of Himachal Pradesh, Uttarakhand, and Jammu region of J&K. It is MYMV resistant and exhibited >18% yield superiority over checks *viz*., Pant M 5, Pusa 9531 and Pusa Vishal. The seeds are green, attractive, medium-large and shining with high protein content (24.68%).

Field view of IPM 02-3

Another high yielding variety IPM 02-14 (average yield 737 kg/ha) developed from the cross PDM 139 x EC 398884 has been released for summer cultivation in South Zone comprising of Tamil Nadu, Andhra Pradesh, Karnataka and Orissa. It exhibited yield superiority of 9-20% over checks PS 16, HUM 1 and Pusa Vishal and has multiple disease resistance to MYMV and leaf crinkle. It has large, green, attractive, shining seeds with high protein content (24.38%) and matures in 62-64 days.

Field view of IPM 02-14

Performance of breeding lines in AICRP trials

Entry IPM 06-5 and four other entries *viz*., IPM 9901-6, IPM 05-2-8, IPM 02K 14-1 and IPM 209-3 were promoted to AVT 2 (summer/NWPZ) and AVT 1, respectively. Three entries *viz*., IPM 9901-10, IPM 2K14-9 and IPM 302-2 were promoted to IVT during *kharif*/ summer seasons.

Evaluation of promising breeding lines

Three station trials in spring/summer, five in *kharif* and four AICRP trials were conducted. In spring/ summer trials, three entries of ST I *viz*., IPM 306-1, IPM 05-2-8 and IPM 06-5 were found promising. Two entries *viz*., IPM 205-5 (1089 kg/ha) and IPM 2K08-7 (1007 kg/ha) yielded the highest in ST II. Two entries *viz*., IPM 9-93-K (1186 kg/ha) and IPM 03-2 (1032 kg/ha) were found most promising in ST III. During *kharif* season, entry IPM 2K 14-9 (1649 kg/ha) yielded highest, followed by IPM 02-14 (1604 kg/ha), IPM 209-3 (1458 kg/ha) and IPM 9901-10 (1351 kg/ha) in ST I. Entries *viz*., IPM 2K 15-4 (1956 kg/ha), IPM 104-3 (1593 kg/ ha) and IPM 9901-8 (1560 kg/ha) were promising in ST II, while IPM 09-282-K (1682 kg/ha), IPM 09-86-K (1607 kg/ha) and IPM 07-159-K (1453 kg/ha) were high yielders in ST III. In PYT I, entries *viz*., IPM 411-2 (1983 kg/ha), IPM 409-3 (1841 kg/ha), IPM 409-1 (1836 kg/ha) and C6VS-1 (1828 kg/ha) derived from mungbean x mungbean crosses were found promising. In PYT II, entries *viz*., IPM 6-327-K (2036 kg/ha), IPM 9-53-K (2000 kg/ha), IPM 9-826-K (1958 kg/ha) and IPM 9-166-K (1925 kg/ha) derived from mungbean x urdbean crosses were high yielders.

Generation of breeding material

In *kharif*, 32 interspecfic crosses were attempted for incorporation of resistance to biotic stresses and yield related attributes. F_2 of five wide crosses (IPM 99-125 x VBG 04-003, IPM 99-125 x VBG 04-008, Saptari Local x VBG 04-008, Bhutan Local Mung 1 x VBG 04-003 and Prateeksha x VBG 04-003) were advanced. Fourteen F_2 populations derived from crosses made during *kharif* 2009 [EC 369223 x MH 3-18, MH 3-18 x EC 369223, MH 3-18 x PDM 139, PDM 139 x NHB 007, EC 369223 x PDM 139, PDM 139 x EC 369223, PDM 139 x MH 3-18, TMB 37 x IC 296679, PDM 139 x F_4 of (IPM 3-1 x SPS 5), IC 296679 x TMB 37, TMB 37 x IPM 99-3, F_7 of (IPM 3-1 x SPS 5) x MH 3-18, MH 3-18 xF_4 of (IPM 3-1 x SPS 5), EC 369223 x F_4 of (IPM 3-1 x SPS 5) and (IPM 3-1 x UPM 02-17) x PDM 139] were also grown. In mungbean x mungbean breeding material, single plant selections were made in 25 F_2 (378 SPS), 13 F_3 (98 SPS), 7 F_4 (109 SPS), 42 F_5 (438 SPS), 4 F_6 (66 SPS) and 5 F_7 (79 SPS). Total 468 SPS were taken in mungbean x urdbean breeding material.

Establishment of wide hybridization garden

A wide hybridization garden of *Vigna* consisting of 53 wild accessions collected from Western Ghats as well as those received from NBPGR, Thrissur has been established at Main Farm of the Institute. The wild species included 12 accessions of *V. radiata*, 9 of *V. mungo*, 8 of *V. trilobata*, 5 each of *V. hainiana* and *V. delzelliana*, 4 of *V. umbellata*, 3 of *V. pilosa*, 2 each of *V. trinervia* and *V. vexillata*, and 1 each of *V. Trinervia* var. *bourneii*, *V. unguiculata* and *V. glabrescens.* Data were recorded on 32 different morpho-physiological traits for their characterization and documentation.

***Vigna* garden at IIPR**

Urdbean

Performance of promising lines in AICRP trials

A high yielding and MYMV and CLS resistant line IPU 07-3 (823 kg/ha) performed well in AVT 2 *kharif* trials. Another high yielding and MYMV and powdery mildew resistant line IPU 09-16 (1297 kg/ ha) was found promising in NWPZ and CZ.

Evaluation of breeding material

Out of 13 entries evaluated in station trial, two entries *viz.*, IPU 10-7 and IPU 10-8 out yielded the best checks Uttara and Shekhar 2. Evaluation of 32 elite lines in separate trial resulted in identification of two elite lines *viz.*, IPU 10-17 and IPU 10-14, which out yielded the best check Uttara by 36% and 38%, respectively.

Generation of breeding material

Eight inter-varietal crosses *viz.*, IPU 99-176 x BLB 67-2, IPU 99-167 x IPU 94-1, IPU 94-1 x Yakoobpur Local, Shekhar 2 x Yakoobpur Local, PU 40 x IPU 99-167, IPU 94-1 x UH 85-5, UH 85-5 x BLB 67-2 and STY 2468 x IPU 94-1 were attempted for incorporation of resistance, plant architecture and early maturity . Single plant selections were made in 11 F_3 (102 SPS), 14 F_4 (92 SPS), 10 F_5 (106 SPS), 20 F_6 (156 SPS) and 16 F_7 (111 SPS) on the basis of plant type, reaction to MYMV and other yield attributes.

Wide hybridization

Total 135 progenies of a wide cross [MUM 2 (Mungbean) x SPS 5 (Urdbean)] has been evaluated and advanced to F_7. Six F_4 interspecific populations (*Vigna mungo* x *V. mungo var. silvestris*) *viz.*, TPU 4 x IPU W 01, PLU 710 x IPU W 01, T 65 x IPUW 06, TPU 4 x IPUW 06, DPU 88-31 x IPUW 07 and PDU 1 × IPUW 04 were evaluated for desired segregants.

Molecular breeding

For mapping MYMV and powdery mildew resistant genes, parent *viz.*, AKU 9904 (for MYMV resistance), DPU 88-31 (for MYMV and powdery mildew resistance) and RBU 38 (for powdery mildew resistance) were used for development of mapping populations. Total 55 SSR primers (out of 170 SSR primers) showed amplification and were used for assessment of parental polymorphism. Out of these, 9 and 10 markers showed parental polymorphism for MYMV and powdery mildew, respectively. Phenotyping of F_2 mapping population was done.

Lentil

Varieties developed

A high yielding variety IPL 315 (average yield 1487 kg/ha) derived from the cross PL 4 x DPL 62 was identified for normal sown conditions in Central Zone comprising of Madhya Pradesh, Chhattisgarh, Bundelkhand tracts of Uttar Pradesh and parts of Rajasthan. This variety has >13% yield superiority over checks DPL 62 and IPL 81. It is medium-tall, sub-compact and matures in 111-113 days. The seeds are brown with back spotted, attractive and large (2.9 g/ 100 seed wt.) and has 23.5 % protein content. It is resistant to rust and tolerant to wilt.

Field view of IPL 315

Another high yielding variety IPL 313 (average yield 1226 kg/ha) and large seeded (2.6 g/100 seed wt.) developed from a three way cross [(ILL 7659 x DPL-58) x KL 178] has performed well over three years in normal sown conditions in UP State Adaptive Research trails.

Performance of breeding lines in AICRP trials

Five entries *viz.*, IPL 316 (LS) and IPL 215 (SS) were promoted to AVT II for Cental and North West Plain Zone, respectively, while one small seeded (IPL 217) and two large seeded (IPL 318 and IPL 319) was promoted to AVT 1. Six new entries *viz.*, IPL 219 (small seeded), IPL 320, IPL 321 and IPL 322 (large seeded) and IPL 531 and IPL 533 (extra early) are being evaluated in IVT.

Evaluation of promising breeding lines

Two station trials each with 15 entries and one preliminary yield trial (PYT) with 60 entries were conducted. In ST I, entry IPL 6227 yielded 2418 kg/ha against the best check DPL 15 (2016 kg/ha), followed by IPL 6029 (2381 kg/ha) and IPL 5145 (2352 kg/ha). Flowering of IPL 6029 and IPL 5145 was recorded within 64 days, which was 7 days earlier than the check DPL 62. In ST II, IPL 8692 (2857 kg/ha) out yielded the best check Sehore 74-3 (2316 kg/ha), followed by IPL 91267 (2439 kg/ha) and IPL 91153 (2397 kg/ha). IPL 7107 yielded 2278 kg/ha and was identified extra early maturing (109 days).

In PYT, 17 entries were identified promising on the basis of yield (2500 to 3311 kg/ha). IPL 10487 (flowered in 60 days and matured in 111 days) was identified 20 days early in flowering and 11 days early in maturity as compared to check DPL 15.

Generation of breeding material

Thirty four fresh crosses were attampted for targeting genetic improvement in earliness, increased biomass, bold seeds and disease resistance. Breeding material in different segregating generations was evaluated and selected on the basis of plant types, desirable traits and resistance to disease. The F_2 seed was harvested from 86 F_1 plants involving 21 crosses (out of 49 crosses). Single plants were selected in 31 F_2 (457 SPS), 27 F_3 (441 SPS) and 24 F_4 (119 SPS) and 95 progeny bulks were identified as promising in 32F_5/F_6 for further evaluation.

Basic genetic information

Genotype ILL 6002 has ability to grow fast as compared to other cultivars in early stage. Genetics of this trait was studied on the basis of height attended after 45 to 60 days of germination in two crosses (ILL 6002 x DPL 15 and DPL 62 x ILL 6002). Data was recorded on 114 individual F_2 plants for former cross and 92 individual F_2 plants for later cross and grouped in two class intervals. Frequency distribution between these two classes analyzed through $\div^2$ test suggested that this trait is controlled by a single gene.

Development of mapping populations

Mapping population of 148 individuals for wilt resistance derived from a cross Precoz (S) x PL 02 (R) was advanced to F_4 and another mapping population of 185 individuals derived from cross L 4603 (early) x Precoz (Late) was advanced to F_5 following single seed decent method. Trait-specific mapping populations for initial seedling vigor (ILL 6002 x DPL 15) and root rot (Sehore 74-3 x L 4603) were advanced to F_2 generation.

Evaluation of ICRADA nursery

Total 42 entries of LIDTN 2011 (drought), 15 entries of LIF3-A 2011 (large seeded) and 23 entries of LIF3N-S 2011 (small seeded) nurseries were evaluated. In drought nursery, 6 entries *viz.*, FLIP 2010-105L, FLIP 2011-62L, FLIP 2011-64L, FLIP 2010-101L, FLIP 2009-55L and FLIP 2009-52L were selected on the basis of earliness, podding and yield potential under rainfed conditions. Twenty individual plants from five pre-breeding F_5 nurseries involving *Lens orientalis* as one of the parents were selected for earliness.

Nucleus seed production

Total 500 kg nucleus seed of four released varieties *viz.*, IPL 81, IPL 406, DPL 15 and DPL 62 was produced and 3500 single plants of these varieties were selected for next year nucleus seed production.

Breeding for quality traits

Total 60 entries were tested for Fe and Zn content during the last two years. Out of these, 20 best entries were again evaluated for yield and other parametric traits. Two entries *viz.*, FLIP 07-30L and FLIP 07-6L with high Fe and Zn content out yielded the check IPL 315. Five entries were also tested under controlled conditions in pots with different doses of Fe and Zn. Selection was made in F_2 generation of the crosses DPL 62 x NEL 857, IPL 406 x NEL 857, FLIP 90-25L x IPL 406, FLIP 90-25L x DPL 62. Two fresh crosses *viz.*, WBL 58 x FLIP 98-3L and DPL 62 x FLIP 98-3L were also attempted and F_1 seeds were harvested.

Fieldpea

Variety developed

A tall fieldpea variety IPF 4-9 (average yield 1665 kg/ha) developed from cross KPMR 144-1 x EC 8495 has been released and notified for cultivation in UP state. It has yield superiority of 12.7 % over the check Rachna and is resistant to powdery mildew and tolerant to rust diseases.

Evaluation of promising breeding lines

Ten dwarf genotypes along with three checks were evaluated in a station trial. IPFD 11-5 (3880 kg/ha) was the highest yielder, followed by IPFD 11-10 (3870 kg/ha) as compared to the best check IPFD 1-10 (3720 kg/ha). In another station trial, 10 tall genotypes were evaluated along with three checks. The highest yielding was IPF 11-15 (3614 kg /ha) against the best check IPF 5-19 (3462 kg /ha).

Generation of breeding material

Total 42 crosses involving IPF 99-25, IPF 5-19, IPFD 1-10, IPFD 2-5, KPMR 522, EC 384275, Satha Matar, Azad P 5, EC 538005, IPFD 10-3, Pant P 14, EC 1, Ageta 6, VRP 22, Azad P 4, IPFD 10-13, MDP 2, P 471, P 1457-7-1, P 1544-4, P 1297-97, EC 53008, and Azad P 31 as parents were made for seed size, pod length, no. of pods, earliness and powdery mildew resistance.

Evaluation of segregating generations

Total 48 crosses were raised in F_1 generation. Single plant selection was made in 31 F_2 (320 SPS), 34 F_3 (350), F_4 (125 SPS) and 50 promising lines were selected in F_5 on the basis of earliness, seed size, pod length, resistance to powdery mildew and rust diseases and yield/plant.

Identification of Donor(s) and QTL Associated with Traits Imparting Drought Tolerance in Lentil

Evaluation of root length and biomass

Total 43 accessions were evaluated for root length and root biomass in PVC tubes at normal moisture level. The range of root length varied from 18.5 (ILL 7219) to 116 cm (ILL 7652), while shoot length varied from 8.75 cm (IPL 121) to 29.5 cm (IPL 98/155). On the basis of last three years data, IPL 98/193 (79.1 cm; 0.76 g), JL 1 (79.7 cm; 0.63 g) and DPL 53 (82.8 cm; 0.68 g) had stability for long root length and genotype EC

208362 (42.8 cm; 0.24 g) for short root length. ILL 6002 reported earlier a donor for root length also showed stability for longer root length over the two years.

Evaluation in rainfed conditions

A set of 118 active germplasm lines involving 43 lines evaluated for root length was grown under rainfed condition and data was recorded on yield and yield contributing traits for last two years. On the basis of performance in each year, following genotypes performed well under rainfed conditions for different yield contributing traits (Table 1).

Table 1: Stability for different traits in lentil genotypes under rainfed conditions

Trait	Genotype	2008-09	2009-10
Days to 50% flowering	ILL 7663	45	64
	IPL 121	52	69
Biomass (65 DAS)	ILL 7663	1	2
(Scale: 1= Very good, 2= Good, 3= Poor)	IPL 121	1.5	1.5
Plant height (cm)	ILL 7663	34	33
Pods/plant (No.)	EC 208362	25	59
	EC 208355	30	65
HI	IPL 307	0.36	0.35
	JL 1	0.33	0.34
	K 75	0.37	0.35
SPAD value	ILL 7663	45	38
	IPL 98/193	53	35
	EC 208345	48	41
	EC 520204	48	41

Development of mapping populations

For root traits: F_2 seeds were obtained from 3-8 F_1 plants from the crosses made between the genotypes having contrasting root length (*i.e.*, IPL 98/193 x EC 208362, JL 1 x EC208362 and EC 208362 x ILL 6002).

For initial seedling vigor: For mapping the genes controlling initial seedling vigor after germination, genotype ILL 6002 was crossed with cultivar DPL 15, which had slow growth in early days. F_2 seeds were harvested from 6 true F_1 plants for developing the RIL mapping population.

Development of molecular markers

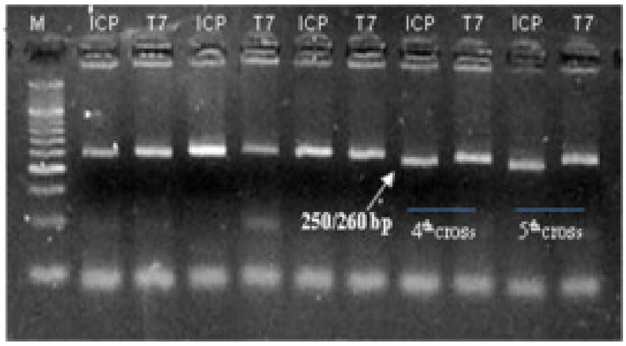
Fourteen SSR markers of related species showed polymorphism among the lentil genotypes.

Genetic Enhancement of Pulses through Distant Hybridization

Total 153 wild accessions of lentil received from ICARDA, Syria (including one accession from *Lens* species, 80 from *L. culinaris* ssp. *orientalis,* 12 from *L. culinaris* ssp. *odemensis,* 33 from *L. ervoides,* 6 from *L. culinaris* ssp. *tomentosus,* 17 from *L. nigricans* and two each from *L. nigricans* ssp. *odemensis* and *L. lamottei)* were grown. Similarly, 46 accessions of wild pigeonpea (3 of *C. heynei*, 34 of *C. lineatus*, 3 of *C. scaraboides*, 1 each of *C. albicans* and *C. platycarpus* and 4 of unknown wild pigeonpea) were also grown and seed was harvested in 27 accessions. In chickpea, 54 wild accessions were grown and seeds were obtained in 26 accessions. Distant hybridization was attempted between cultivated and wild accessions of lentil and F_1 seeds were obtained in 8 crosses made between genotypes DPL 62 and DPL 58 and wild species (*L. culanaris* sp. *orientalis* and sp. *tomentosus*).

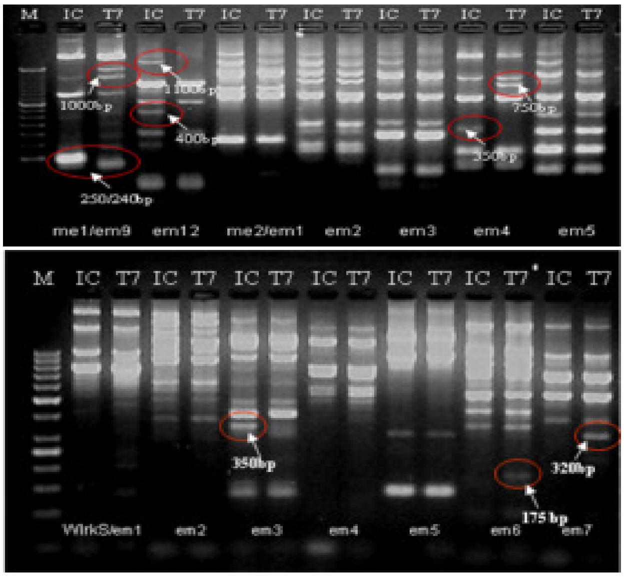
Identification of Molecular Markers Linked to *Fusarium* Wilt Resistance Gene(s) in Pigeonpea

Total 132 (out of 162) markers *viz.*, 68 AFLP, 30 SRAP, 14 SRAP-RGA and 20 AFLP-RGA showed parental polymorphism screened between Type 7 and ICP 8863. Out of these, 125 markers were dominant (76 were specific to ICP 8863 and 49 specific to Type 7) and 7 were co-dominant in nature. Homogeneity of parents involved in 5 crosses was also tested using three polymorphic SSR primers (PP-10, PPMC-1 and PPMC-3) and found that only parents of two crosses were true (Fig. 1). Hybridity of 29 putative F_1 plants derived from one of the true crosses was tested using above three SSR markers and one RAPD marker (OPP 17). Total 16 plants were identified as true F_1s. Parental polymorphism was also studied using first time SRAP (sequence related amplification polymorphism) and SRAP-RGA techniques in pigeonpea (Fig. 2a and b). Further, root cut dip method was standardized for phenotyping against *Fusarium* wilt.



ICP: ICP 8863, T 7: Type 7, M: 50 bp molecular weight ladder

Fig. 1: Parental homogeneity test using SSR marker PP-10



IC: ICP 8863, T7: Type 7, M: 50 bp molecular weight ladder (a) SRAP (b) SRAP-RGA

Fig. 2: Polymorphism between parents involved in a cross (ICP 8863 x Type 7)

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

F_1 progeny of 2 crosses *viz.*, JG 62 x WR 315 and K 850 x IPC 2004-52 were grown for developing mapping populations for *Fusarium* wilt race-2. Total 3 (out of 5) F_1 plants were identified as true F_1s from the cross JG 62 x WR 315 when confirmed by SSR (TA 18, TA 176, TA 146 and TA 110) markers (Fig. 3). Fifteen (out of 29) F_1 plants were true F_1s from the cross K 850 x IPC 2004-52 when confirmed by SSR (TA 176) marker (Fig. 4). F_2 seeds of true hybrids were harvested for advancing the generation. Total 460 (300 SSR, 100 ICCM series marker and 60 RAPD) markers were screened and only 32 (16, SSR + 4, ICCM + 2, RAPD) markers were polymorphic between parents JG 62 and WR 315. Similarly, screening of 50 chickpea SSR and 25 RAPD markers between the parents K 850 and IPC 2004-52 resulted in identification of only 2 polymorphic SSR markers.

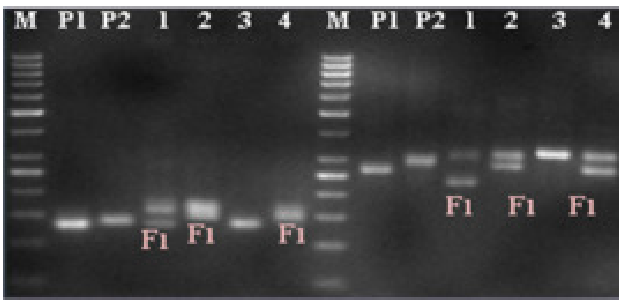


Fig. 3: Identification of true F_1 progeny in JG 62 x WR 315 crosses using TA 18 and TA 176 SSR markers

Fig. 4: Identification of true F_1 progeny in K850 x IPC 2004-52 crosses using TA 176 SSR marker

Development of Chickpea Transgenic for Drought Tolerance

For enhancing drought tolerance by developing the transgenic in chickpea, *Agrobacterium* mediated genetic transformation was attempted in *desi* chickpea cultivar DCP 92-3. The selection pressure for chickpea transformation was assessed using the aminoglycoside antibiotics, kanamycin monosulphate (Fig. 5). A dose of 150 mg/l kanamycin was observed to kill (92%) *in vitro* regenerated shoots after 10 days of inoculation. Explants (~5000) were co-cultivated with the *Agrobacterium* strain (GV 3101) harbouring the binary vector pCAMBIA2300 containing P*rd29A*: AtDREB1A: *nos*T and *nptII* as selection marker. Only 3 kanamycin resistant shoots were obtained that were grafted onto non-transgenic root stocks in the Transgenic Containment Facility (TCF 1).

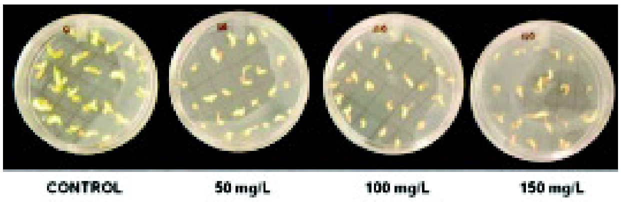


Fig. 5: Effect of different concentration (50, 100, 150 mg/l) of kanamycin on chickpea explants

Plant Genetic Resources

Chickpea

Two sets of germplasm accessions consisting of 298 accessions (Set I) and 115 accessions (Set II) were grown for evaluation of morphological and agronomic traits. The data was recorded on 14 qualitative and quantitative traits. Promising accession selected for further evaluation are JGG 107, ICC 03104, Flip 02-21, H 84-4809, P 236/4628, P 173, P 336, P 831, P 1524, P 3083, P 6358, EC 381889, ICC 1375, ICC 16113, ICC 16123, ICC 16455, ICC 16527, ICC 16561, ICC 16578, ICC 16628, JGG 2002-30 and ICC 12365.

Pigeonpea

Collection: Total 80 accessions were collected from Bundelkhand and Hamirpur area of Uttar Pradesh.

Maintenance and rejuvenation: Total 760 germplasm accessions of late duration, 429 accessions of early, 10 wild species and exotic germplasm were maintained.

Besides, total 221 germplasm accessions of late and 183 accessions of early duration were rejuvenated.

Characterization and identification of donors: Total 105 accessions belonging to early, medium and late maturity group along with checks were evaluated and showed a wide range of variability for quantitative and qualitative characters. Sixteen 16 (out of 251) germplasm lines of late duration *viz*., IPA 9F, ICP 1857 B, ICP 100, ICP 1568, ICP 4107, ICP 12673, DPPA 85-13, ICP 12271, VKG 14/97, ICP 900148, ICPL 1034-35, Bandra Palera, DPPA 85-1, DPPA 85-7, ICP 978 A, and ICP 5394 were identified as resistant to moderately resistant under wilt sick plot condition.

Screening of 123 early maturing accessions against *Maruca vitrata* under field condition resulted in identification of genotypes ICP 12890 (1.9%) and ICP 12882 (DR 2) (3.7%) having low level pod damage (1.9 and 3.7 % respectively). Three pigeonpea genotypes *viz*., IPA 8F, IPA 15F and IPA 16F have been registered as donors for SMD and wilt at NBPGR New Delhi .

Germplasm Enhancement: Under germplasm enhancement programme, 16 single plants from F_6 and six single plants from F_7 were selected for further advancement and selection of desirable segregants.

Mungbean

Total 250 accessions were maintained and evaluated. Promising accessions for quantitative traits on the basis of agronomic data are given in Table 2.

Table 2. Promising donors for quantitative traits among the 250 accessions of mungbean

Character	Promising accessions
Plant height (<35 cm)	CN 8073, IC 39432, LM 581, LM 104
No. of primary branches (> 3)	IC 53-44, EC 304793, LM 236, LM 34
Clusters / plant (>7)	CN 9072, IPMO 3-2, DMG 1108, GG 46
Pod length (> 7.5 cm)	LM 1494, ML 170, DRA 24, ML 405
Number of seeds/pod (> 12)	EC 93161, ML 490, EC 30401, PLM 364, IC 325853
100 seed weight (> 4.25 g)	EC 470097, NSB 7, DPC 1030, GG 1990

Lentil

A core collection of 235 along with 319 new accessions received from NBPGR and 210 accessions of active germplasm were evaluated and maintained. Total 71 (out 160) land races obtained from ICARDA were also multiplied and maintained. The range of variability observed for four quantitative traits among the 319 accessions is given in Table 3.

Table 3. Range of variability in quantitative traits among accessions received from NBPGR

Trait	Range	Genotype	
		Minimum value	Maximum value
Days to 50% flowering (no.)	61-92	L 830	ILL 10634
Pods per plant (no.)	6- 110	Precoz	IC 560181
Plant height (cm)	15.8-39.64	IC 383379	IC 282888
Days to maturity (no.)	101-112	IC 424522	ILL 10314

Fieldpea

Total 220 accessions were maintained and evaluated. Promising accessions for quantitative traits based on agronomic data are given in Table 4.

Table 4 Promising donors for quantitative attributes in 220 accessions of fieldpea

Character	Promising Accessions
Plant height (<50 cm)	EC 341787, P 1525, P 868-2, EC 412881
No. of primary branches (>4.5)	EC 538004, P 1469, P 1630, P 1627
Pods/plant (>64)	P 1579, MD 1918, P 315, P 1070
Pod length (> 7.5 cm)	IP 2K 82, EC 414480, P 1668, P 1038
Number of seeds/pod (> 7.5)	MD 73-140, P 346, P 1579
100 seed weight (> 4.25 g)	P 1042, P 1400, P 1459, P 1089

Crop Production

Long-term Fertility and Cropping System Studies

A permanent 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 intensive cropping systems.

Maize based cropping system

Four cropping sequences *viz.*, maize-wheat (M-W), maize-wheat-mungbean (M-W-Mb), pigeonpea-wheat (P-W) and maize-wheat-maize-chickpea (M-W-M-C) were evaluated at three nutrient management practices *viz.*, control, organics (crop residues+biofertilizers viz., *Rhizobium* for pulses and phosphate solubilising bacteria for cereals+farm yard manure @ 5t/ha) and inorganic fertilizers (recommended dose of N,P,K,S,Zn & B). Maize (Azad Uttam) was sown during third week of June and pigeonpea (UPAS 120) on 22 May. The succeeding crop wheat (PBW 343) and chickpea (DCP 92-3) were sown on 10 November after maize harvest, while wheat (PBW 343) was sown on 29 November, 2010 after pigeonpea harvest. Mungbean (Samrat) was sown on 14 April,2011.

During 2010-11, (end of 8th year), the yields of various component crops were affected considerably by the preceding crops. The highest seed yield of maize and wheat were recorded in maize-wheat-mungbean system. Supplementing a mungbean yield to the tune of 767 kg/ha in M-W-Mb, yield of both maize and wheat were increased by 10.2 and 15.1%, respectively over M-W. As regards nutrient management practices, the maximum yield of maize and wheat were recorded in inorganic treatment, whereas pigeonpea yielded highest (1968 kg/ha) in control plots over both organic and inorganic fertilizer system (both at par). Based on two years cropping system cycle (2009-11), maximum

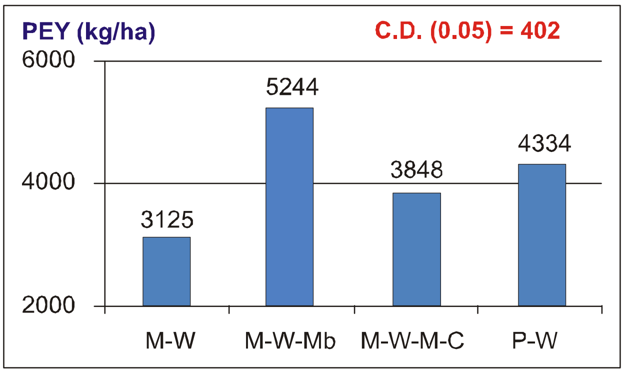


Fig. 6. Pigeonpea equivalent yield (PEY) under maize based cropping systems

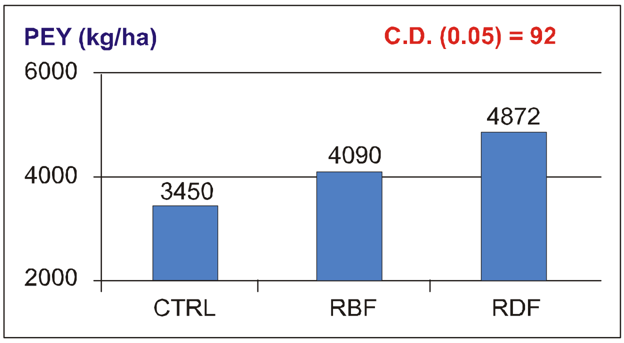


Fig. 7. Pigeonpea equivalent yield (PEY) under various nutrient management systems

system productivity of 5244 kg/ha in terms of pigeonpea equivalent (PEY) was recorded in maize-wheat-mungbean system (Fig. 6), followed by pigeonpea-wheat system (4334 kg/ha). Among fertilizer management systems, inorganic fertilizer application resulted into the highest pigeonpea equivalent yield (4872 kg/ha), followed by organic treatment (4090 kg/ha), which was 41.2 and 18.6 % higher over control, respectively (Fig. 7). Irrespective of cropping systems, the basic and cumulative infiltration rate was higher in organic manure treated plots as compared with inorganic nutrient treated plots (Fig. 8). In pigeonpea-wheat system, higher total living population of nematodes (783/100 cc soil) and cyst population (35/100 cc soil) were recorded in inorganic treatments.

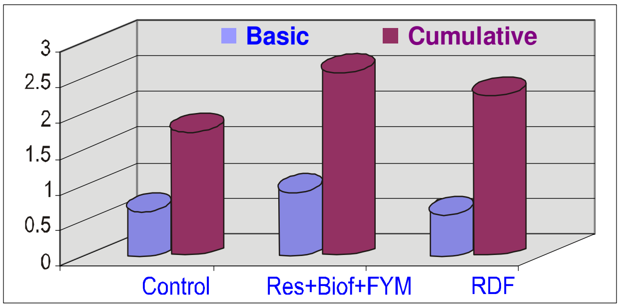


Fig. 8. Basic and cumulative infiltration in maize based system

Rice based cropping system

Four rice based cropping systems *viz.*, rice-wheat (R-W), rice-chickpea (R-C), rice-wheat-mungbean (R-W-Mb), and rice-chickpea-rice-wheat (R-C-R-W) were evaluated at three fertilizer management systems *viz.*, control, organics (crop residues+biofertilizers *viz.*, rhizobium for pulses and phosphate solubilising bacteria for cereals+farm yard manure @ 5t/ha) and inorganic fertilizers (recommended dose of N, P, K, S, Z and B). Rice (Pant Dhan 12) was transplanted on 7 July, while wheat (PBW 343) and chickpea (KWR 108) were sown on 19 November. Mungbean (Samrat) was sown in summer season on 14 April, 2011 after harvest of wheat in rice-wheat-mungbean system.

Of the four systems, rice-wheat-mungbean recorded the highest seed yield of rice and wheat, respectively, followed by rice-chickpea system with seed yield of 4065 and 1936 kg of rice and chickpea, respectively. The component crops of the four systems also responded differentially to fertilizer management systems. Rice and wheat produced highest seed yield under inorganic nutrient management system, while chickpea yielded maximum with organic nutrients. The system productivity in terms of chickpea equivalent yield (CEY) was also considerably affected due to inclusion of pulses (Fig. 9). Rice-wheat-mungbean recorded double the CEY over rice-wheat system. Rice-wheat-mungbean also produced 21.6 and 37.6% higher CEY over rice-chickpea and rice-chickpea-rice-wheat systems. The system productivity of organic and inorganic nutrient management systems were differentiable (7886 and 8864 kg/ha) and was significantly higher over absolute control (Fig. 10). Available nutrient status was significantly higher in inorganic nutrient treatment, followed by organic applied plots. Among the cropping systems higher nutrient status was recorded in rice-chickpea system (Table 5).

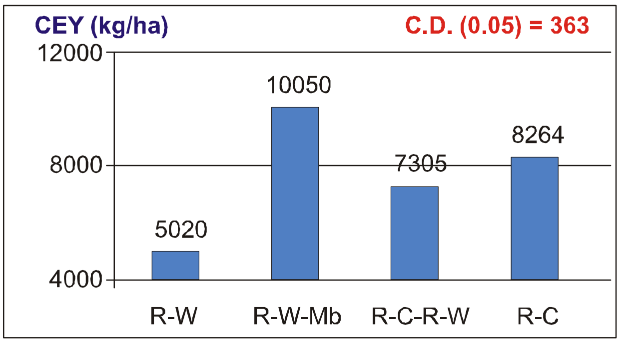


Fig. 9. Chickpea equivalent yield (CEY) under rice based cropping systems

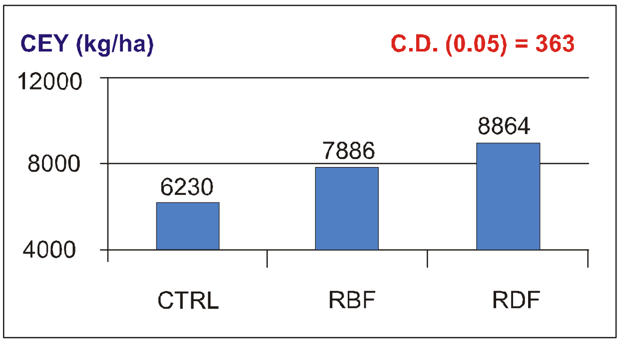


Fig. 10. Chickpea equivalent yield CEY under various nutrient management systems

Table 5. Available nutrient status in rice based system

Treatment	Available P (kg/ha)	Available S (kg/ha)	Available Zn (ppm)
Cropping System			
R-W	18.55	14.10	1.68
R-W-Mb	18.36	16.71	1.60
R-C-R-W	21.20	17.54	1.56
R-C	21.54	18.25	1.82
Fertility level			
Control	16.88	14.86	1.26
CR+BF+FYM	19.58	17.31	1.71
NPKSZnB	23.28	17.61	2.03

Nutrient Management

Integrated phosphorus management in maize-chickpea cropping sequence

Field experiment was conducted for the 4th year with treatments including two levels of FYM (0 and 5 t/ha) in main plots and 3 levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) in sub-plots for maize (Azad Uttam) during *kharif* season. In *rabi* season, two levels of phosphorus (0 and 40 kg P_2O_5/ha) and two levels of phosphate solubilising bacteria (PSB) *i.e., Bacillus polymyxa* (no PSB and PSB) were super imposed over *kharif* treatments for chickpea (DCP 92-3) in sub-sub plots.

FYM application to maize gave 13.9 and 9.5 % higher grain yield of maize and chickpea respectively (Table 6). Phosphorus application and phosphate solubiliser inoculation also significantly increased the yield of maize and chickpea. Agronomic efficiency of phosphorus (kg grain/kg P_2O_5 applied) increased from 5.08 to 9.21 and from 5.33 to 8.42 due to application of FYM and P40+PSB, respectively.

Basic and cumulative infiltration rate was more under FYM application over no FYM treatment. Among different P application treatments, 30 kg P/ha resulted higher basic and cumulative infiltration over control and 60 kg P/ha.

Table 6. Effect of FYM, P levels and PSB on grain yield of maize–chickpea cropping sequence

Treatment	Maize yield (kg/ha)	Chickpea yield (kg/ha)
A. Maize		
FYM level		
No FYM	4352	2182
FYM @ 5t/ha	4956	2390
P levels		
No P	4416	2230
30 kg P_2O_5/ha	4660	2284
60 kg P_2O_5/ha	4886	2343
B. Chickpea		
No P, No PSB	4481	2284
Only PSB	4601	2322
40 kg P_2O_5/ha	4747	2399
40 kg P_2O_5/ha + PSB	4787	2616

Critical level of zinc in mungbean

A pot experiment was conducted on zinc deficient sandy loam soil of IIPR farm to determine the critical level of zinc in mungbean. Graded levels of zinc were applied to soil @ 0, 2.5, 5.0, 7.5, 10.0, 12.5, 15, 20, 30 and 50 ppm. Dry matter yield was recorded at 30, 45 DAS and at maturity by destructive sampling. Polynomial regression equations were computed using dry matter yield and zinc content at different growth stages and critical limit of zinc was worked out for different plant parts at different stages. Critical limit of zinc ranged between 5.5 to 12.3 ppm.

Individual and interactive effect of P, Mo and PSB in chickpea

A pot experiment was conducted to evaluate the effect of phosphorus, molybdenum and PSB in chickpea. There were 16 treatment combinations consisting of 2 levels of phosphorus (0 and 40 kg/ha), 2 levels of PSB (with and without PSB) and 4 methods of molybdenum (control, soil application @ 1 kg/ha, seed treatment @ 4 g/kg seed and foliar application @ 0.1%). Highest plant dry weight of chickpea (5.18 g/plant), root length (38.2 cm), root dry weight (0.97g) were recorded in P40+PSB+ soil application of molybdenum.

C-dynamics and carbon sequestration potential in pulse based cropping system under long-term experiments

A study was conducted to examine long-term effect of cropping system and applications of organic and inorganic amendments on total soil organic carbon and on the properties of soil C fractions. Soil was sampled at 2 depths (0-20 and 20 to 40 cm) from 12 treatments (four cropping system *viz*., maize-wheat, maize-wheat-maize-chickpea, maize-wheat-mungbean and pigeonpea-wheat along with 3 nutrient levels *viz*., control, inorganic fertilizer and organic fertilisers) and analysed for TOC and various soil C pools (active pool, passive pool, lability index). There were differences in the magnitude of carbon pools among the treatments. Cereal-cereal system had comparatively lower carbon pool and liability index than cereal-pulse system. Inclusion of pulses in cropping system improved active pool (AP), liability index (LI) and carbon management Index (CMI). In maize based system, maize-wheat-mungbean and maize-wheat-maize-chickpea (2 years rotation) recorded higher AP, LI than maize-wheat system. However, pigeonpea- wheat system had the highest CMI. In rice based system, rice–chickpea recorded highest carbon liability index. The CMI was maximum in rice-chickpea-rice-wheat (2 years rotation), followed by rice-wheat-mungbean system. Irrespective of cropping systems under both the set of trials, organic treatment had the higher CMI than inorganic treatment (Table 7).

Table 7. Organic carbon pool in long-term maize and rice based experiments

Treatment	Active pool (%)	Passive pool (%)	Lability index	Carbon management index
Maize based cropping system				
Maize-wheat	0.32	0.26	1.75	105
Maize-wheat-maize-chickpea	0.34	0.24	1.92	120
Maize-wheat-mungbean	0.34	0.15	1.92	146
Pigeonpea-wheat	0.34	0.22	1.75	167
Fertility level				
Control	0.30	0.21	1.80	--
Inorganic fertilizers (NPKSZnB)	0.35	0.21	1.90	120
Organic fertilizers (CR+BF+FYM)	0.37	0.24	1.85	149
Rice based cropping system				
Rice-wheat	0.20	0.37	1.32	109
Rice-chickpea	0.20	0.36	1.46	99
Rice-wheat-mungbean	0.27	0.42	1.41	103
Rice-chickpea-Rice-wheat	0.30	0.31	1.42	136

Resource Conservation Technology

Residue incorporation in rice-lentil system

A field experiment was conducted to find out the best method of crop residue incorporation and its effect on soil chemical and biological properties in rice – lentil system. Four methods of rice residue incorporation *i.e*., incorporation of rice+lentil residue, incorporation of rice residue+removal of lentil residue, removal of rice residue+incorporation of lentil residue and removal of both crop residue in main plots and three doses of fertilizer to lentil crop (0, 50 and 100 % RDF of NPKS) in sub-plots.

Significantly higher rice grain yield (4102 kg/ha) was recorded in both crop residue incorporation treatments. Lowest rice grain yield (2985 kg/ha) was observed when crop residues of both the crops was removed. Vigorous rice roots were obtained in all those treatments where the crop residue was incorporated.

Significantly higher lentil grain yield was obtained with incorporation of both crop residue (1647 kg/ha) and it was lowest (1400 kg/ha) when crop residue of both the crops was removed. But lentil grain yield did not change significantly due to application of different doses of fertilizer. Increase in seed yield of lentil was evident from significant increase in number of pods/plant over removal of both crop residues. The number of nodules recorded at 45 and 60 DAS followed the trend similar to seed yield. Significant improvement in earthworm population was recorded especially in those plots where residues of both the crops were incorporated. Sporadic incidence of wilt was observed in few plots in the range of 1-2 % plant.

Residue incorporation in rice-wheat-mungbean system

Experiment was conducted to work out the integrated management practices by inclusion of crop residue and nutrients in rice-wheat-mungbean systems. Total 16 treatments were evaluated consisting of combination of crop residue incorporation or removal at the time of their harvest and 100 and 75% recommended dose of NPK to each crop.

Higher grain yield of rice (4508 kg/ha) was obtained when crop residue of all the three crops was incorporated, while lowest grain yield (3385 kg/ha) was obtained in all the crop residue removal treatment. Highest seed yield of wheat (5668 kg/ha) was obtained in the treatments where rice and mungbean residue was incorporated but wheat residue was removed. Lowest wheat seed yield (3977 kg/ha) was obtained when crops residues of all three crops were removed. Application of 100% fertilizer dose brought significantly more seed yield than 75% fertilizer application. Last year mungbean yield was not affected significantly by the crop residue and the fertility levels treatments but slightly more seed yield was obtained in combine harvested treatment (900 kg/ha) than normal harvesting (825 kg/ha). The soil microbial biomass carbon, earth worm population and infiltration rate were recorded higher in crop residue incorporation treatment over residue removal treatment (Fig. 11).

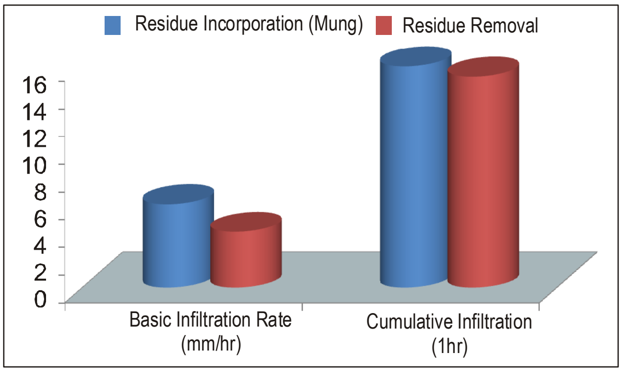


Fig. 11: Infiltration rate after rice harvest in rice-wheat-mungbean system

Effect of planting method, seed rate and fertility levels on urdbean productivity

A field study was carried out to assess the effect of sowing method, seed rate and fertility level on *kharif* urdbean. Four sowing methods *viz.*, flat bed (conventional), ridge and furrow, raised bed of 67.5 cm and 75 cm in main plots and two levels of seed rate (75 and 100% of recommended) and fertilizers (75 and 100% of recommended NPK) in sub-plots were used. Significant improvement in grain yield of urdbean was recorded due to improved sowing techniques over flat bed or conventional sowing. The average improvement in yield was 33.6% in case of raised bed of 75 cm, 32.2% in raised bed of 67.5 cm and 9.2% in ridge and furrow over flat bed system (751 kg/ha). However, seed rates and fertility levels did not show significant differences on urdbean yield (Fig. 12).

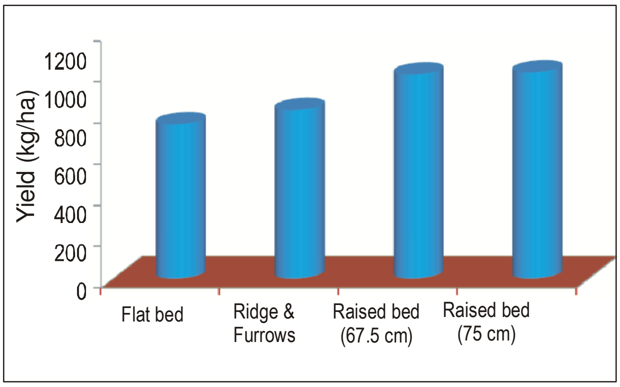


Fig. 12. Effect of sowing methods on urdbean yield

Effect of planting method, seed rate and irrigation levels on chickpea productivity

A study was carried out to assess the effect of sowing methods, seed rates and irrigation levels on chickpea productivity. Four sowing methods *viz.*, flat bed (conventional), ridge and furrow, raised bed of 67.5 cm and 75 cm in main plots and two levels of seed rate (75 and 100% of recommended) and two levels of irrigation (flowering and pod development stage) in sub-plots were tested. Highest grain yield (1593 kg/ha) was obtained under raised bed planting of 75 cm, followed by raised bed of 67.5 cm (1578 kg/ha). The lowest yield was under flat bed (1278 kg/ha). Significant improvement (11.6%) in seed yield was recorded due to two irrigations applied at flowering and pod development stages over one irrigation at flowering stage (1355 kg/ha).

Effect of tillage and residue incorporation in rice (transplanted)-pulse based cropping system

A field experiment was conducted to study the effect of resource conservation technology in pulse based cropping system. Treatment included two tillage practices (zero tillage and conventional tillage) in main plots, three cropping systems (rice-wheat, rice-chickpea, rice-chickpea-mungbean) and two residue management practices (residue retention and residue removal) in sub-sub plots. Highest chickpea equivalent yield was recorded in rice-chickpea-mungbean (6959 kg/ha), followed by rice-wheat (5736 kg/ha) and lowest was under rice-chickpea (4615 kg/ha).

Conservation of soil moisture through tillage and mulching in chickpea under rice fallows

A study was initiated during *kharif* to assess the effect of soil moisture conservation practices on chickpea productivity in rice fallows. Transplanted rice was grown during rainy season and chickpea was grown on residual soil moisture condition. The treatments comprised of five moisture conservation practices *viz.*, zero tillage+dibbling sowing+mulching, zero tillage+no till drill sowing+mulching, deep tillage (disc plough+harrow), deep tillage+mulching and conventional method (harrow+cultivator). Significant variations in yield were recorded due to moisture conservation practices. Highest grain yield of chickpea was recorded in zero tillage+dibbling sowing+ mulching (1660 kg/ha), followed by zero tillage+no till drill sowing+mulching (1589 kg/ha) over conventional method (1295 kg/ha). The improvement in chickpea yield was 23-28% due to zero tillage and mulching over conventional method (Fig. 13). The highest relative water content (72.4%) at flowering stage was also recorded in zero tillage+dibbling sowing+mulching followed by zero tillage+no till drill sowing + mulching (69%) and lowest under conventional practice (61.2%).

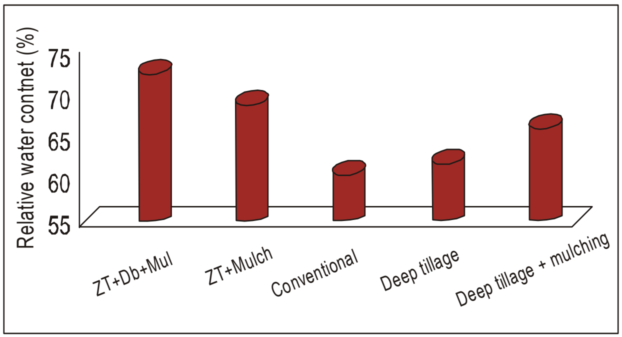


Fig. 13. Relative water content (%) of chickpea leaves at flowering stage

Weed Management

Efficacy of post-emergence herbicides in rainy season mungbean

Two post-emergence herbicides *viz.*, imazethapyr and quizalofop–ethyl were evaluated for their efficacy in controlling weeds in rainy season mungbean. The treatments comprised of imazethapyr (50 g/ha) and quizalofop–ethyl (60 g/ha) applied at 15 and 25 days after sowing (DAS) and in combination with pendimethalin (1.25 kg/ha). The major weeds in the fields were *Digera arvensis, Cyperus rotundus, Phyllanthus niruri* and *Trianthema monogyna*. The reduction in grain yield of mungbean due to weed infestation was 42%. The weed biomass at mungbean harvest was highest in case of weedy check (399.3 g/ m^2), followed by quizalofop-ethyl (60 g dry matter/ha) applied at 25 DAS. However, lowest weed biomass was recorded in weed free treatment (34.03 g dry matter/m^2). Highest weed control efficiency (68%) was recorded with imazethapyr applied at 15 DAS. Grain yield of mungbean was highest in weed free (1221 kg/ ha), followed by imazethapyr applied at 15 days after sowing (1175 kg/ha) and lowest under weedy check (701 kg/ha).

Herbicides for pulses under zero tillage in rice fallows

A field trail was carried out to see the effect of non-selective herbicides in chickpea under zero tillage in rice fallows. Two non-selective herbicides *viz.*, paraquat (0.5 and 1.0 kg/ha) and glyphosate (1.0 and 1.5 kg/ha) were applied at 30, 15 and 7 DAS of chickpea with or without combination of pendimethalin (pre-emergence application @ 1.25 kg/ha) in rice fallows under zero tillage. All the weeds including emerging green tillers of rice were killed by application of both the herbicides. However, in case of paraquat, weeds which were initially suppressed started regenerating after 25-30 days of application and therefore the weed biomass recorded at 30 and 60 DAS (26.7 and 82.9 g dry weight/m^2) was higher than glyphosate (12.1 and 20.0 g/m^2). None of the herbicides did affect germination and plant stand. Average grain yield of chickpea under glyphosate was 20.1% higher than paraquat perhaps due to less crop-weed competition.

Screening of post-emergence herbicides in pulses

Six post-emergence herbicides *viz.*, quizalofop-ethyl, imazethapyr, metribuzin, metsulfuron methyl, chlorimuron and metsulfuron methyl+chlorimuron were evaluated at different doses and application time for their effectiveness in managing weeds in pulses. Metribuzin, metsulfuron methyl, chlorimuron and metsulfuron methyl+chlorimuron had shown phytotoxicity to most of the pulses grown during *kharif* and *rabi* season. However, during *kharif* season imazethapyr @ 100 g/ha applied at 20-25 days after sowing controlled most of the weeds in mungbean and urdbean fields. However, its optimum dose is under test. During *rabi* season, imazethapyr had shown phytotoxicity to chickpea, lentil and fieldpea. The application of imazethapyr even at lower dose of 15 g/ ha showed phytotoxicity in chickpea. However, application of quizalofop-ethyl along with pre-emergence application of pendimethalin resulted in better weed control in lentil.

Nutritional Quality of Pulses

Assessment of quality parameters and mineral content in popular varieties of pulses

Thirteen varieties of urdbean and 19 varieties of mungbean were analysed for their miniral content in whole grain as well as in *dal* and potential *dal* recovery.

Urdbean: Highest Fe content in whole grain was found in NUL 7 (72.8 ppm), while lowest was observed in Pant U 31(46.9 ppm). Highest Zn (48.5 ppm) and S content (0.18%) in whole grain was found in LBG 645 and KU 96-3, respectively. Analysis of nutrient content in *dal* (made after removal of husk) showed that Pant U 30 and Pant U 31 with content of 72 ppm and 49.7 ppm of Fe are considered the highest and lowest values. Highest Zn (36.97 ppm) and S (0.19 %) content was found in WBU 108 and TU 94-2, respectively. Lowest Zn content (16.5 ppm) and S content 0.103 % was observed in KU 96-3 and NUL 7 varieties.

Mungbean: In whole grain, highest value of Fe (77.6 ppm) was recorded in KM 2241 and lowest (30 ppm) was in ML 131. While higher Zn (31 ppm) and S (0.213%) content was found in NDM 1 and ML 131 varieties. The variety ML 818 with the Zn content of 10.2 ppm and variety Co 66-912 with S content of 0.132 % are considered to be lower nutrient containing varieties. The highest and lowest values for Fe was found in KM 2241 and ML 131(83.2 and 31.6 ppm), for Zn in HUM 1 and Co 66-912 (24.1 and 9.8 ppm) and for S in PKV AKM 4 and Meha (0.312 and 0.141 %).

Potential *dal* recovery in mungbean and urdbean genotypes ranged between 85.3 to 90.4 and 85.2 to 90.3 per cent, respectively.

Crop Protection

DISEASES

Wilt

Chickpea

Total 722 accessions were screened against Kanpur race (race 2) in wilt-sick plot. Disease development was very high with 99% mortality in susceptible check JG 62 by the end of February. Out of these, 205 lines including 12 donors *viz.*, JG 315, MPJG 89-9023, H 82-2, IPC 2004-52, DCP 92-3, MPJG 2002-108, BCP 91, BG 212, BCP 17, JG 74, MPJG 89-1155 and BG 112, 16 lines showing stable resistance for last five years *viz.*, IPC nos. 2005-44, 2005-34, 2005-18, 2005-24, 2005-19, 2005-43, 2005-62, 2005-115, 2005-26, 2005-30, 2005-54, 2005-41A, 2005-45, 2005-52, 2004-3 and 2004-8, 60 AICRP lines, 51 IIPR breeding lines, 10 ICARDA lines, four ICRISAT lines *viz.*, ICCV nos. 04514, 98505, 08124 and 07305, and 51 other lines were found resistant (< 10% wilt).

Race-specific resistance: Total 43 lines were screened against race 1, 2, 3, 4, 5 and 6 (Fig. 14a). Out of these, 29 were resistant to race-1, 32 to race-2, 26 to race-3, 34 to race-4, 23 to race-5 and 20 to race-6. Eight lines *viz.*, IPC nos. 2004-3, 2004-8, 2004-34, 2004-52, 2005-15, 2005-19, 2005-24 and KGD 1255 were resistant to representative isolates of all the six races.

Development of race-specific sick plots: Inoculum of *Fusarium oxysporum* f. sp. *ciceri* (*Foc*) race 1, 2, 3 and 4 was added to micro-plots of 50 sqm each (Fig. 14b) and cv. JG 62 was sown. At the end of crop season, wilt incidence was recorded 85% due to race 1, 76 % in race 2, 60% in race 3 and 55% in race 4.

Fig.14(a): Wilt resistant chickpea lines against individual races of *Foc*

Fig. 14(b): Race-specific screening of chickpea lines against wilt pathogen *Foc*

Lentil

Out of 51 lentil genotypes screened against wilt pathogen *Fusarium oxysporum* f. sp. *lentis*, five genotypes *viz.*, PL 4147, PL 02, GP 3278, GP 4076 and JL 3 had =30 % mortality.

Phytophthora Blight

Pigeonpea

Total 102 accessions of pigeonpea and sixteen wild relatives of *Cajanus* were screened for resistance to phytophthora blight (*Phytophthora drechsleri* f. sp. *cajani*) with UPAS 120 as check after every two rows of test entry. While 27 of them did not germinate, UPAS 120 (check) had only 13% incidence of phytophthora blight. Incidence of the disease mostly ranged between 0.0 to 20%. Accessions which had higher disease incidence were ICP 8859, IPA PB 55-2, KAWR 45, IPA 8-1, BDN 2, ICP 7119, KA 09-01, IPA PB 8-1-8 and Sharan 1.

Collar Rot

Total 130 genotypes of lentil were screened against collar rot (*Sclerotium rolfsii*) under green house. All the genotypes were found susceptible and the mortality ranged between 60-100%. Least mortality (60%) was recorded in genotype IC 559786. Three genotypes *viz.*, IC 560051, IC 559853 and IC 560263 showed 70% mortality.

Urdbean Leaf Crinkle Disease

Total 250 genotypes were screened against urdbean leaf crinkle disease (ULCD) under field condition. None of the genotypes planted in disease nursery was free from the disease. Incidence level ranged between 1.52 -37.4%. Genotype IPU 94-1 (susceptible check) had 24.3% crinkle. Twenty nine genotypes *viz.*, SPS-5, UG 27, PLU 836, IPU 96-1, IPU 01-370, IPU 99-40, AKU 9904, No. 13111, IC 56048,

PLU 1077, PLU 446, PDU 3, IPU 99-185, IC 2/001, GF 215, IPU 99-123, CN 32-15, No 7668-4B, IPU 99-22, IPU 99-23, PLU 62, LBG 20, SPS 32, PLU 59, IPU 99-89, IC 43647, IPU 99-96, IPU 99-149, IPU 99-34 and U 17 had ULCD incidence below 5%.

All the 16 genotypes screened by artificial inoculation [inoculum prepared by macerating crinkle affected leaves of urdbean genotype T 9 collected from the field, in a mortar using chilled 0.1M phosphate buffer at neutral pH containing 0.1% thioglycollic acid (1:1 w/v); three batches of ten plants of each genotype were sap inoculated using celite powder as abrasive] were susceptible.

Transmission of ULCD by spotted beetle *E. dodecastigm*

Pot culture experiment was conducted to study the role of spotted beetle *Epilachna dodecastigma* in transmission of ULCD using urdbean var. Uttara as test plant. Healthy beetles of *E. dodecastigma* were given an acquisition access of 24 h to ULCD affected leaves in the laboratory at room temperature (~25°C), which were transferred onto 15 days old healthy urdbean plants grown in pots @ one beetle per plant and covered with the plastic cylinder cage (30 cm high, 15 cm dia) with a gauze top and a gauze covered side vent (Fig. 15a and b). Similarly, beetles reared on the healthy leaves were also transferred as control. In each experiment, 30 plants were used. At the end of the inoculation period (48 h), the beetles were removed and plants were sprayed with monocrotophos. Inoculated plants were kept under observation for 30 days. None of inoculated plants showed crinkle symptoms.

Fig. 15a: Culturing of spotted beetle on urdbean leaves

Fig. 15b: Plants caged and observed for disease development

Transmission of ULCD by whitefly *Bemisia tabaci*

Healthy whiteflies raised on brinjal (*Solanum melongena*) were given 24 h acquisition access feeding on ULCD affected urdbean plant (cv. T 9), which were transferred @ 10 flies/ plant onto 15 days old healthy urdbean plants and allowed to feed (inoculation access feeding) for 48 h. Twenty plants were inoculated. After inoculation feeding period was over, whiteflies were killed by spraying monocrotophos and the whitefly inoculated plants were observed for 30 days for development of symptoms. None of the plants showed crinkle symptoms. Negative results of these experiments indicate that the ULCD at Kanpur is not transmitted by spotted beetle (*Epilachna dodecastigma)* and whitefly (*Bemisia tabaci*).

Leaf Curl Disease

Status of leaf curl of mungbean and urdbean

Incidence of leaf curl in summer grown mungbean and urdbean crops was 1-2%, whereas in *kharif* crops it was upto 10% in and around Kanpur. In general, the leaf curl disease was more in mungbean as compared to urdbean.

Mechanical transmission and host range of leaf curl

The virus associated with leaf curl of mungbean and urdbean was successfully transmitted by mechanical inoculation from infected to healthy plants. It was also transmitted to cowpea, a diagnostic host for Tospoviruses. Addition of 0.1% sodium sulfite+0.1% beta mercaptoethanol in extraction buffer (0.1 M phosphate buffer, pH 7.0) was found to improve efficiency of transmission of GBNV on to mungbean, urdbean and cowpea. Out of 16 different hosts mechanically sap inoculated, only three (rajmash, cowpea and pea) showed symptoms.

Detection of the virus associated with leaf curl disease

The identity of the leaf curl causal virus was confirmed by reverse transcription polymerase chain reaction (RT-PCR). Total RNA from naturally infected and artificially inoculated mungbean and urdbean leaves was extracted using RNeasy Plant Mini Kit. RT-PCR amplification of targeted gene was performed. The amplified products from all the ten samples (five of mungbean and five of urdbean) yielded DNA fragment of ~900 bp and ~800 bp corresponding to NSm genes and NP genes of GBNV, respectively, whereas healthy samples gave negative results. This confirms that the leaf curl disease of mungbean and urdbean at Kanpur is caused by Groundnut bud necrosis virus.

Transmission of leaf curl by thrips

Adults of *Thrips palmi* and *Scitrothrips dorsalis* collected from leaf curl affected mungbean plants were released onto the healthy mungbean seedlings (15-day old) raised in a plastic tray and covered with the muslin cloth cage after the release of the insect. The transmission of virus in the plants was observed 30 days after the release of thrips. Transmission efficiency in case of *Thrips palmi* was 60%. Results with *S. dorsalis* were negative.

The thrips associated with leaf curl diseased plants were identified with the help of Taxonomist (Thysanoptera), National Bureau of Agriculturally Important Insects, Bengaluru and Insect Identification Service, Division of Entomology, IARI, New Delhi. On the foliage of mungbean, six species of plant damaging thrips (*Caliothrips indicus, Megalurothrips usitatus, Scirtothrips dorsalis, Thrips palmi, Anaphothrips sudanensis* and *Haplothrips* sp.) and one species of predatory thrips (*Aleurodothrips fasciapennis*) were recorded. Five species of thrips *viz., Caliothrips indicus, Megalurothrips usitatus, Scirtothrips dorsalis, Thrips palmi* (Fig. 16) and *Plicothrips apicalis* were recorded on the foliage of urdbean. However, only one species of thrips (*Megalurothrips usitatus*) have been found associated with flowers of both the crops.

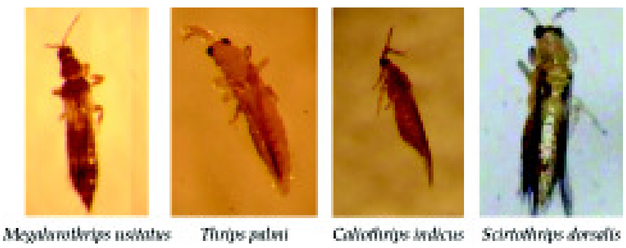


Fig. 16: Thrips species associated with leaf curl infected mungbean and urdbean

Yellow Mosaic Virus

Detection of mungbean yellow mosaic India virus in wild accessions of *Vigna*

Nine accessions of two wild species of *Vigna viz., V. hainiana* and *V. trilobata*, and five accessions of sub-species of *Vigna* spp. *viz., V. mungo* var. *silvestris* and *V. radiata* var. *radiata* were observed to be affected by yellow mosaic disease. The symptoms (bright yellow spots on the leaflets) were similar to those noticed in cultivated genotypes of *Vigna* and appeared to be of viral etiology. The causal virus was identified by PCR using specific primers designed to amplify a segment of DNA A that contained CP gene of four begomoviruses *viz., Mungbean yellow mosaic virus* (MYMV), *Mungbean yellow mosaic India virus* (MYMIV), *Horsegram yellow mosaic virus* (HgYMV) and *Dolichos yellow mosaic virus* (DoYMV), known to cause yellow mosaic in many pulse crops; and movement protein gene located on DNA B. All accessions showing yellow mosaic symptoms tested positive with primers specific to segments of DNA A and DNA B of MYMIV. PCR results with primers specific to MYMV, HgYMV and DoYMV were negative. Accessions of *Vigna umbellata* and *Vigna glabrescens* were free from yellow mosaic symptoms and yielded negative results in PCR with primers specific to all the four viruses. Results indicate that the virus causing yellow mosaic in wild species/ sub-species of *Vigna* grown at Kanpur is caused by MYMIV. This is the first report of nucleic acid based identification of MYMIV as the causal agent of yellow mosaic disease in *V. hainiana, V. trilobata* and *V. radiata* var. *radiata.*

Yellow mosaic affected samples of mungbean and urdbean plants were obtained from Ludhiana, Vamban and Coimbatore. In PCR, samples from Ludhiana gave amplification with primers specific to coat protein gene of mungbean yellow mosaic India virus (5 GTA TTT GCA KCA WGT TCA AGA 3/ 5 AGG DGT CAT TAG CTT AGC 3) there was no amplification with primers specific to coat protein gene of mungbean yellow mosaic virus. Samples obtained from Vamban and Coimbatore (Fig. 17) gave amplification with primers

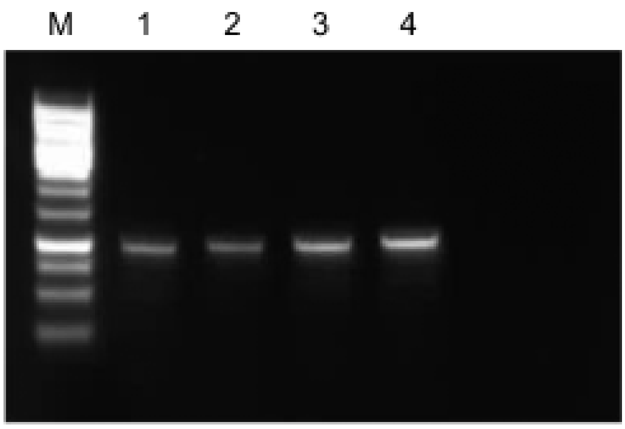


Fig. 17: A portion of DNA A of MYMV containing Cp gene amplified with specific primers. M=1Kb DNA ladder, 1-2= Yellow mosaic affected urdbean from Vamban, 3-4=Yellow mosaic affected green gram from Coimbatore

specific to coat protein gene of MYMV (5 ATG GG (T/G) TCC GTT GTA TGC TTG 3/ MYMV-CP-R 5 GGC GTC ATT AGC ATA GGC AAT 3) indicating that the yellow mosaic virus at Vamban and Coimbatore is MYMV. Results confirmed that the yellow mosaic disease of mungbean and urdbean at Kanpur, Ludhiana, Navsari, Dholi is caused by mungbean yellow mosaic India virus (MYMIV), whereas, yellow mosaic disease of mungbean and urdbean at Vamban and Coimbatore is caused by mungbean yellow mosaic virus (MYMV).

Dry Root Rot

Eighteen sick tanks were developed using highly pathogenic *Rhizoctonia bataticola* isolate Rb-9, wherein 51 chickpea lines were screened. None of the lines were found resistant. However, NND 18 and IPC nos. 2005-15, -19, -24, -27, -37, -39, -52 and -64 were moderately resistant.

Wet Root Rot and Botrytis Gray Mold

Total 115 accessions of chickpea were screened for resistance to wet rot (*Rhizoctonia solani*) and botrytis gray mold (*Botrytis cinerea*) in pots containing autoclaved soil. After germination of seeds, the soil in pots was added with inoculum of *Rhizoctonia solani* (chickpea isolate) grown in potato dextrose broth for 15 days at ~25°C. The symptoms of the disease were expressed as girdling of collar region of affected plants ~12-14 days after addition of inoculum to soil. All the accessions were found completely susceptible to the disease. However, one accession (IPC 2009 04) had one plant, which seemed to have escaped the disease and hence incidence was 92.3%; otherwise others had 100% wet rot incidence.

Another set of the pots containing the same set of chickpea accessions were sprayed with inoculums of *Botrytis cinerea* at flowering. To enable favourable condition for the inoculum, misting was done in the screening chamber of the glasshouse with temperature maintained at ~25°C. The reaction of the chickpea accessions for Botrytis gray mold disease severity was rated on 0-9 scale. Accession IPC 2010 199 completely escaped the disease. Thirty accessions had disease at rating scale 1, 11 acc. at 1.5, 25 acc. at 2-4, ten acc. at 4.5-7, while remaining 39 acc. were at 7.5-9 scale.

Variability in *Sclerotium rolfsii*

To study the molecular variability among 23 collected isolates of *Sclerotium rolfsii*, they were grown on potato dextrose broth medium in 250 ml conical flasks for 15 days at ~25°C. DNA was extracted from the mycelial growth and sclerotia using the DNA extraction kit. Use of 60 randomly amplified polymorphic DNA (RAPD) decamer primers indicated existence of genetic variability among the 23 *S. rolfsii* isolates (Fig. 18).

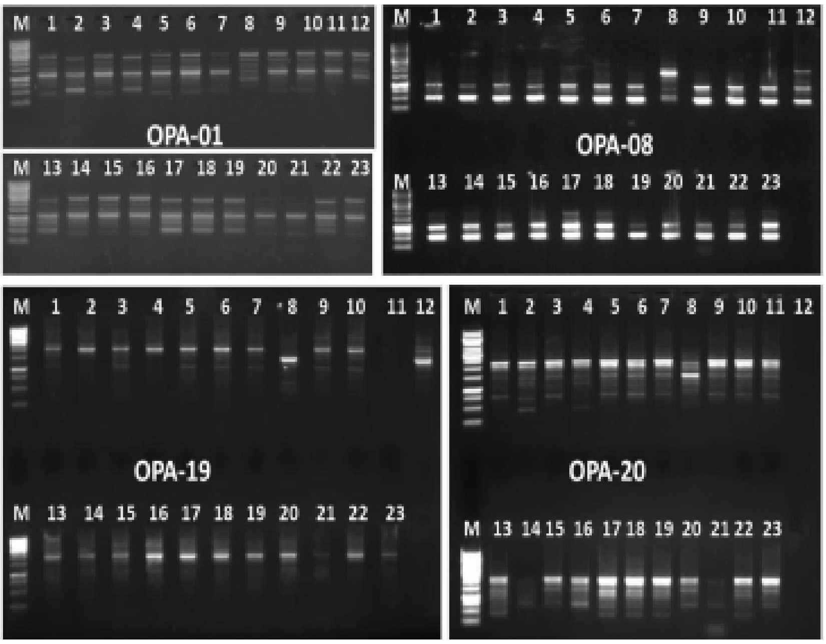


Fig. 18: RAPD variation patterns of 23 isolates of Sclerotium rolfsii observed with primers OPA-01, OPA-8, OPA-19 and OPA-20 (Lane M=1 kb DNA ladder-Fermentas; Lane 1-23 different isolates of *S. rolfsii*)

INSECT PESTS

Helicoverpa armigera

The incidence of *H. armigera* in chickpea started in the first fortnight of March *i.e.*, 9th standard meteorological week with maximum larval population on cv. JKG 1 (2 larvae/plot of 24 sqm), followed by cv. KWR 108 (1 larva/plot) and gradually increased up to second fortnight of March *i.e.*. 12th standard meteorological week with maximum larval population on JKG 1 (3 larvae/plot), followed by KWR 108 (2 larvae/plot). Thereafter, the population declined and completely disappeared from first week of April.

Bracon (Habrobracon) hebetor Say is one of the potential larvae parasites of *H. armigera*. It is reared and multiplied in the laboratory on the larvae of *H. armigera*, *Corcyra cephalonica* and *Galleria mellonella*. Laboratory rearing of *H. armigera*, *C. cephalonica* and *B. hebetor* was continued in the laboratory.

Comparison of artificial diets for rearing of *C. cephalonica* and its influence on *B. hebetor*

Rice, wheat and maize based diets were used for rearing of *Corcyra* larvae. Late instar larvae of *Corcyra* reared on each diet were exposed to *B. hebetor* to identify the cheapest and nutritious diet for the multiplication of *B. hebetor*. Development of *B. hebetor* in terms of number of larvae, pupae and adult emerged was higher from the *Corcyra* larvae reared on maize-based diet. The rearing of *B. hebetor* on maize-reared *Corcyra* larvae resulted in emergence of 16.0 larvae and 12.0 pupae. The wheat and rice-based rearing of *Corcyra* used for *B. hebetor* resulted in the mean number of emergence of 11.6 and 11.5 larvae and 10.2 and 9.5 pupae, respectively.

Influence of size of *C. cephalonica* larvae on biology and development of *B.hebetor*

Three sizes of *C. cephalonica* larvae *viz.*, small (<1.0 cm), medium (1.1 – 1.4 cm) and large (1.5 – 1.8 cm) for the rearing of *B. hebetor* and its influence on the biology, development of the parasitoid was studied. Among the different sizes, *B. hebetor* reared on big size larvae recorded more number of larvae (12.6 larvae of *B. hebetor*/larva of *C. cephalonica*), cocoon (11.3 cocoons/ larva of *C. cephalonica*) and adult (10.2 adults/larva of *C. cephalonica*) emergence, shorter developmental period (egg to adult period: 10.0 days). *B. hebetor* reared on medium size larvae recorded emergence of 7.7, 6.5 and 4.5 larvae, pupae and adults/larva of *C. cephalonica*, respectively. *B. hebetor* reared on small size larvae recorded emergence of 2.4 larvae and 1.9 pupae/ larva of *C. cephalonica*, respectively. But, there was no emergence of adults of *B. hebetor* reared on small size larvae of *C. cephalonica*

Influence of size of *G. mellonella* on biology and development of *B. hebetor*

Three sizes of *G. mellonella* larvae *viz.*, small (<1.5 cm), medium (1.5 – 1.9 cm) and large (2.0 – 2.5 cm) for rearing of *B. hebetor* and its influence on the biology, development of the parasitoid was studied. Among the different sizes, *B. hebetor* reared on big size larvae of *G. mellonella* recorded more number of larvae (10.5 larvae of *B. hebetor*/larva of *G. mellonella*), cocoon (7.0 cocoons/larva of *G. mellonella*) and adult (5 adults/ larva of *G. mellonella*) emergence, shortest developmental period (egg to adult period: 10.8 days). *B. hebetor* reared on medium-sized larvae recorded 4.4, 3.5 and 2.75 larvae, pupae and adults per larva of *G. mellonella*, respectively. But, there was no emergence of larvae, cocoon and adults of *B. hebetor* reared on small-sized larvae of *G. mellonella.*

Comparative evaluation of biorationals and synthetic chemicals against *B. hebetor*

For comparative evaluation of biorationals against different life stages of *Bracon hebetor,* four insecticides *viz.*, Emamectin benzoate, Indoxacarb, Spinosad, Cypermethrin, two botanicals *viz.*, Neem Bann (Azadirachtin 0.03% - a neem formulation), neem seed kernel extract (NSKE) 5% were tested against the different stages of the parasitoid and was compared with untreated check. Toxicity of insecticides and botanicals on the eggs, larvae and pupae of the parasitoid were assessed by foliar spray. The adult parasitoid was allowed to parasitize the *C. cephalonica* larvae serving as alternate host. The eggs, larvae and pupae of the parasitoid (*B. hebetor*) of *Corcyra* larvae were sprayed with the recommended dosage of the insecticides in a petri-dish using small hand atomizer. In untreated check distilled water was sprayed. The number of parasitoids that emerged from each treatment was recorded and per cent mortality over untreated check was calculated. Among the treatments, cypermethrin and spinosad recorded highest mortality on egg (100% mortality), larvae (100 and 61.9% mortality, respectively), pupae (69.3 and 62.8%) and adult (100% mortality) of the parasitoid. Emamectin benzoate recorded 85.5, 62.2, 52.8 and 85.0% mortality of eggs, larvae, pupae and adult parasitoid, respectively. It was followed by Indoxacab with 89.2, 62.1, 63.5 and 71.4% mortality of eggs, larvae, pupae and adults of the parasitoid, respectively. The botanical Neem Bann (neem formulation) recorded mortality of 88.0, 45.6, 66.1 and 65.5% of eggs, larvae, pupae and adults of the parasitoid, respectively. In case of NSKE 5%, the mortality was 62.8, 19.3, 16.4 and 14.0% of eggs, larvae, pupae and adults of the parasitoid, respectively (Fig. 19). NSKE 5% and Neem formulation was found comparatively safe against the parasitoid, *B. hebetor.*

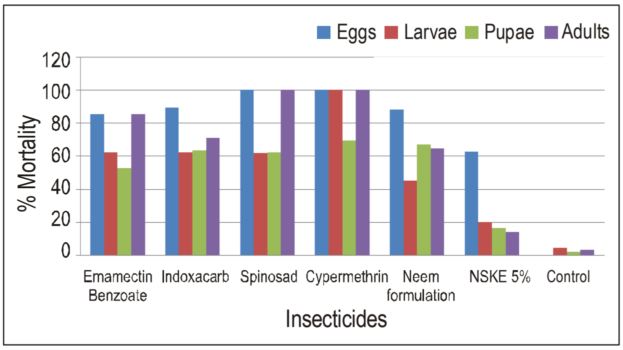


Fig. 19: Comparative evaluation of biorationals and synthetic chemicals against different life stages of *B. hebetor*

Storage of *B. hebetor* pupae under low temperature for different periods

Two-day old pupae of *B. hebetor* were stored at 4-5ºC for 1, 15, 30, 45, 60 and 75 days. The per cent survival of the cocoon of *B. hebetor* decreased with increase in period of storage. It was 80.2, 67.2, 53.9 and 7.7%, when cocoons of *B. hebetor* were stored at 4-5ºC for 1, 15, 30 and 45 days, respectively. But there was no survival of *B. hebetor* pupae when stored at 4-5ºC for 60 and 75 days.

Maruca vitrata

Short-duration pigeonpea

Total 123 short-duration pigeonpea genotypes were screened for resistance against *M. vitrata* under field condition. The observations were taken both at flowering and pod formation stages. At flowering stage, the level of infestation was rated on standard 1-9 scale (1: no damage; 9: >90%). Lowest damage rating (DR) was recorded in genotypes ICP 12890 and ICP 12882 (DR: 2). Low level of pod damage due to *Maruca* was also observed in ICP 12890 (1.9%) and ICP 12882 (3.7%).

Population dynamics

The occurrence of spotted pod borer, *M. vitrata* studied in short-duration pigeonpea (cv. ICPL 87) varied from 0.2 to 13.4 larvae/plant. The insect occurrence started from 1st week of August (31st standard meteorological week/SMW) with first peak (11.3 larvae/plant) during third week of September (38th SMW) and second peak (13.4 larvae/plant) during first week of October (42nd SMW). The highest population occurred when the number of rainy days was 4 with mean rainfall as 13.3mm during 41st SMW (Fig. 20).

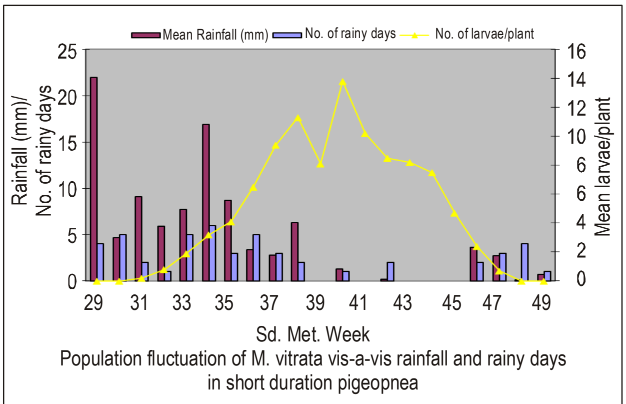


Fig. 20. Population fluctuation of *M. vitrata vis-a-vis* rainfall and rainy days in short duration pigeonpea

Toxicity of chemical/biorational insecticides against *M. vitrata*

The toxicity of biorational *viz.*, T_1: *Bt* @ 1.5kg/ha, T_2: *Beauveria bassiana* @ 1.5kg/ha, T_3: Garlic bulb extract (1%), T_4: Spinosad 45 SC @ 73g a.i/ha, and chemical insecticides *viz.*, T_5: Methomyl 40SP @ 400g a.i./ha, T_6: Emamectin benzoate 5SG @ 11g a.i/ha, T_7: Rynaxpyr 20EC @ 30 g a.i/ha, T_8: Indoxacarb 14.5SC @ 60g a.i./ha, T_9: Endosulfan 35EC @ 700g a.i./ha and T_{10}: Chlorfenapyr 10SC @ 100g a.i./ha, T_{11}: Novaluron 10EC @ 100g a.i./ha, T_{12}: Flubendiamide 20WG @ 50 g a.i./ha, T_{13}: DDVP 76EC @ 200g a.i./ha, T_{14}: DDVP 76EC @ 200g a.i./ha + Rynaxypyr 20EC @ 30g a.i./ha, T_{15}: Garlic extract (1%)+Rynaxypyr 20EC @ 30g a.i./ha and T_{16}: Untreated control against *M. vitrata* in early pigeonpea (cv. Pusa 992) was determined in terms of % reduction in population, pod damage and grain yield. The highest per cent reduction in larval population of *Maruca* was recorded in the plots treated with DDVP 76EC+Rynaxypyr 20EC (95.6), followed by garlic bulb with respect to control at 14 days after spraying, which were at par (Fig. 21). The lowest pod damage (3.4%) was also recorded in DDVP 76EC+Rynaxypyr 20EC treated plots, followed by garlic bulb extract+Rynaxypyr 20EC (4.6%), which were at par and significantly (P=0.05) superior over untreated control (18.8%).

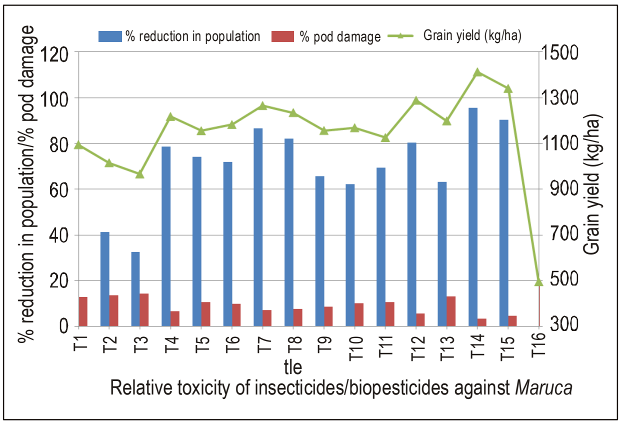


Fig. 21. Relative toxicity of insecticides/biopesticides against *Maruca*

Bruchids

Mungbean and urdbean

Fifty four accessions of mungbean and 53 accessions of urdbean were screened under free-choice test for their relative resistance to bruchid, *Callosobruchus chinensis* under laboratory conditions. Observations on the eggs laid, percentage survival, mean developmental period and index of suitability were calculated. In mungbean, none of the accessions was found resistant. Six accessions *viz.*, IPM 09-213-K, IPM 2K-15-4, IPM 07-159-K, IPM 07-146-K, IPM 09-87-K and IPM 09-197-K (index of suitability: 0.051 - 0.060) were found moderately resistant. Six accessions were found moderately susceptible. In urdbean, KU 96-3 (suitability index: 0.049) was found resistant. Two accessions *viz.*, SPS 5 and IPU 99-232 (suitability index: 0.051, 0.059) were categorized as moderately resistant. The remaining 50 accessions were categorized as susceptible to highly susceptible.

Nine urdbean accessions *viz.*, PLU 99-52, PLU 96-6, IC 8219, UH 84-1, SPS 35, SPS 143, PLU 25, UH 82-5 and L 23 found having low index of suitability in the free-choice test were evaluated under no-choice test in comparison with the susceptible accession (PLU 158). In the no-choice test, none of the accessions was found resistant. However, three accessions *viz.*, UH 82-5, IC 8219 and SPS 143 were found moderately resistant (suitability index: 0.055, 0.057, 0.058, respectively) as compared to susceptible accession PLU 158 (0.08). The resistant accessions exhibited longer developmental period (26.8 - 28.1 days) and lesser percentage survival (33.7 - 42.1%) as against the least developmental period of 24.2 days and higher per cent survival of 83.2% in PLU 158.

Field infestation and relative susceptibility to bruchids

Field infestation and relative susceptibility of mungbean and urdbean cultivars to bruchids were assessed. Field infestation of bruchids on different cultivars of mungbean ranged from 0.8% (Samrat) to 5.0% (NDM 1) with an average of 2.7% on pod basis. The grain infestation of bruchids on different cultivars of mungbean ranged from 0.1% (Samrat) to 0.8% (NDM 1) with an average of 0.4%. Among the urdbean cultivars, the bruchid infestation ranged from 2.2% (Type 9) to 3.2% (Shekhar 1) with an average of 2.8% on pod basis and 0.6% (Uttara) to 0.9% (Shekhar 1) with an average of 0.7% on grain basis.

Mechanisms of resistance against bruchids

The influence of seed size, seed lustre and seed colour on the incidence of bruchids in mungbean and urdbean were studied under laboratory conditions. In mungbean, lower number of eggs was recorded in small (62.6/50 seeds) and shiny (69.9/50 seeds) seeds as compared to large (85.0 eggs/50 seeds) and dull seeds (75.3 eggs/50 seeds). Similarly, in urdbean, small (22 eggs/50 seeds) and black seeds (40.5 eggs /50 seeds) recorded lower number of eggs as compared to large (73.8 eggs) and green seeds (85.8 eggs).

The influence of morphological pod traits (pod length, pod width, pod wall thickness, pod trichome density and number of seeds per pod) on the field infestation of bruchids was studied. In mungbean, percent pod damage and grain damage due to bruchids were positively correlated with pod width (r = 0.560, r = 0.810). In urdbean, per cent pod damage and grain damage due to bruchids were positively correlated with the pod width (r = 0.656, r = 0.607), pod trichome density (r = 0.864, r = 0.830), number of seeds per pod (r = 0.646, r = 0.596) and negatively correlated with pod wall thickness (r = -0.763, r = -0.803).

Validation of Integrated Pest Management Module in Pigeonpea

Three IPM modules of pigeonpea (cv. NDA 1) *viz.*, pigeonpea+urdbean as intercrop (1:1) sown on broad-bed, pigeonpea+sorghum as intercrop (1:1) sown on broad-bed, pigeonpea sole crop sown on ridges were tested. All the three modules included IPM components *viz.*, seed treatment with Carbosulfan @ 3 ml+*Trichoderma viride* @ 10 g and Vitavax @ 1 g/kg of seed, installation of pheromone trap of *H. armigera* @ 10 no./ha and use of need based insecticides (Profenofos 50 EC @ 2ml/lit. of water, Indoxacarb 14.5 SC @ 0.4 kg/ha and Dimethoate 30 EC @ one l/ha during early pod formation, milk and dough stages, respectively). The IPM practice was compared with the non-IPM (farmers' practice *viz.*, pigeonpea cv. NDA 1 as normal sown crop with four sprays of Endosulfan during reproductive stage of the crop) and control (pigeonpea cv. NDA 1, ICPL 332 and Bahar). The data on per cent incidence of *Fusarium* wilt, *Phytophthora* and termite damage was assessed randomly at five spots in each plot. The damage due to gram pod borer (*H. armigera*), spotted caterpillar (*M. vitrata*) and podfly (*M. obtusa*) were assessed by collecting total number of pods, number of pods damaged on 5 randomly tagged plants and the per cent pod and grain damage was calculated.

Among the IPM modules, pigeonpea sole crop sown on ridges recorded lowest incidence of *Fusarium* wilt (33.3%) and *H. armigera* (1.6% pod damage) as compared to 37.5 % and 38.8% *Fusarium* wilt, 2.4% and 2.2% pod damage due to *H. armigera* in IPM module with pigeonpea+urdbean as intercrop and IPM module with pigeonpea+sorghum as intercrop, respectively. However, pod fly damage was lower in IPM module with pigeonpea+urdbean as intercrop (26.4% pod damage and 28.1% grain damage) as compared to IPM module with pigeonpea+sorghum as intercrop (43.6% pod damage and 36.0% grain damage) and IPM for pigeonpea sole crop (30.6% pod damage and 33.4% grain damage). Farmers' practice recorded higher incidence of *Fusarium* wilt (41.7%) and pod damage due to *H. armigera* (2.4 %). However, there was no difference in podfly damage among farmers' practice (35.0 % pod damage and 34.5% grain damage) and IPM practices. The variety NDA 1 grown without any treatment recorded higher incidence of *Fusarium* wilt (43.6%), *H. armigera* (7.2% pod damage) and podfly (52.6 % pod damage, 39.3% grain damage). The pigeonpea variety ICPL 332 grown without any treatment recorded 17.6 % *Fusarium* wilt, 1.2% pod damage due to *H. armigera* and 35.6% pod and 37.7% grain damage due to podfly. The variety Bahar grown without any treatment recorded highest incidence of wilt (92.6 %).

NEMATODES

Entomopathogenic Nematodes (EPN) for Management of Pod borer in Chickpea

Foliar application of sponge formulation of EPN *Steinernema masoodi* was evaluated under field condition for management of *Helicoverpa armigera* in chickpea (cv. JG 16). The treatments included sponge formulation of EPN *S. masoodi* @ 30 x 10^5 IJs /ha; *Ha*NPV @ 250 LE, *Bacillus thuringiensis* formulation @ 500 ml/ha, Endosulfan @ 350 g a.i./ha and untreated check. Two sprays were given at pod formation stage coinciding with the pest incidence and the efficacy was assessed based on pod damage at harvest and on yield basis. Endosulfan was found superior (2.1% pod damage), followed by *Ha*NPV (4.5% pod damage), which was significantly lower than other treatments *viz*., *Bacillus thuringiensis* (6.6% pod damage), sponge formulation of EPN (7.1% pod damage) and untreated check (10.9% pod damage). Similarly, Endosulfan recorded significantly higher grain yield (15.4 q/ha), followed by *Ha*NPV 250 LE (13.1 q/ha). In other treatments, the grain yield ranged from 12.1 q/ha (*B. thuringiensis*) to 11.9 q/ha (EPN sponge formulation) and it was at par with untreated check (11.9 q/ha).

Root-knot Nematode *Meloidogyne javanica*

Five mungbean entries and ten mungbean cultivars were screened for resistance to root-knot nematode *M. javanica* under pot culture. Entry TJM 15 and cultivar Pant Mung 1 were observed moderately resistant. Similar screening of ten urdbean entries and 10 cultivars indicated entry KUG 479 as moderately resistant. Similar screening indicated three (out of 37) fieldpea entries (IPF 0917, NDP 9-404 and VL 52) as moderately resistant and two (out of 13) lentil lines (PL 084 and HUL 57) as resistant. Six lentil lines (VL 516, VL 139, NDL 9-802, NDL 8-606, RLG 112 and SL 2-24) were moderately resistant. Out of 29 accessions of lentil evaluated for resistance against root-knot nematode, none showed resistance, while eight accessions of wild relatives of lentil, *viz*., *Lens nigricans* (ILWL 23, 31, 32, 33, 15 and 17) and *Lens culinaris* ssp. *odemensis* (ILWL 36 and 39) showed moderately resistant reaction.

Status of Nematode Infestation in Pulses in Bundelkhand Region

Chickpea

Twenty seven soil and root samples collected from chickpea fields of Hamirpur, Jalaun, Jhansi, Tikamgarh and Mahoba districts of Bundelkhand region showed presence of eight nematode genera in soil samples. The soil type of this area was generally heavy and black. *Pratylenchus* was observed most frequently (55.6%), followed by *Hoplolaimus* (51.9%) and *Tylenchorhynchus* (40.7%). Highest absolute density was observed for *Pratylenchus* (832 nematodes/100 cc soil), followed by *Hoplolaimus* (290 nematodes/100 cc soil) and *Tylenchorhynchus* (289 nematodes/100cc soil). Relative density was maximum for *Pratylenchus* (53.5%), followed by *Hoplolaimus* (18.6%) and *Tylenchorhynchus* (18.6%). Other nematodes were present in very few samples and were having very low relative density. Similarly, the prominence value was highest for *Pratylenchus* (620.5), followed by *Hoplolaimus* (208.8) and *Tylenchorhynchus* (184.0). *Pratylenchus* was also observed causing lesion on the roots and reduced the root system (Fig. 22). The fields having *Pratylenchus* population were sparse exhibiting uneven growth pattern, which was probably due to nematode infestation (Fig. 23). However, this needs to be confirmed under controlled conditions.

Fig. 22 : Chickpea roots damaged by lesion nematode

Fig. 23: Chickpea field infested with lesion nematodes at village Nohai (Rath)

Pigeonpea

Fifteen soil samples collected from pigeonpea fields in Jalaun, Jhansi, Tikamgarh, and Mahoba districts of Bundelkhand region showed the presence of nine nematode genera. *Hoplolaimus* was observed most frequently (60%), followed by *Tylenchus* (46.7%) and *Tylenchorhynchus* (40%). Absolute density was highest for *Hoplolaimus* (344.7 nematodes/100 cc soil), followed by *Tylenchorhynchus* (338 nematodes/100 cc soil) and *Tylenchus* (197.5 nematode/100 cc soil). Other nematode genera were present in few numbers. *Hoplolaimus* was having highest prominence value (267), followed by *Tylenchorhynchus* (214). *Heterodera cajani* cysts were observed in 40% of the soil samples. The number of cysts varied from 2 to 35 cysts/100 cc soil.

Vigna

Hoplolaimus was the most prominent nematode in mungbean/urdbean with 100% frequency, 335 nematodes/100 cc soil absolute density and 335 as prominence value. This was followed by *Tylenchorhynchus*, which was present in 50% of the samples with absolute density of 450 nematodes/100 cc soil and prominence value of 318.2. Other nematodes present in some samples were *Pratylenchus*, *Helicotylenchus*, *Tylenchus*, etc. *Heterodera cajani* cysts were observed in two (number of cysts: 11 and 26 cysts/100 cc soil) out of four samples.

Lentil

The most frequently observed nematode genus in lentil fields was *Hoplolaimus* with 60% frequency. Other nematodes present were *Pratylenchus*, *Hirschmanniella*, *Tylenchus* and *Basiria*. The absolute density was 492 nematodes/100 cc soil for *Hoplolaimus*, followed by 111 nematodes/100 cc soil for *Pratylenchus*. Other nematodes were present in very few numbers. The prominence value of *Hoplolaimus* was highest (381.1), followed by *Pratylenchus* (49.6). *Pratylenchus* was also observed in roots of lentil.

Fieldpea

Few samples collected from fieldpea fields showed three prominent nematode genera *viz*., *Hoplolaimus*, *Pratylenchus* and *Helicotylenchus*. The average density was 1216, 570 and 480 nematodes/100 cc soil for *Pratylenchus*, *Helicotylenchus* and *Hoplolaimus*, respectively.

Crop Physiology, Biochemistry and Microbiology

Development of Screening Techniques and Physiological Characterization for Heat Tolerance in Chickpea

Forty two chickpea genotypes were evaluated for heat tolerance under late sown condition. These genotypes experienced day time maximum temperature in the range of 35-40^{0}C during podding stage. Thermotolerance of the genotypes was evaluated based on their pollen germination ability at 25, 35, 41 and 43^{0}C. Pollen loading and germination on stigmal surface was also observed using specific stain aniline blue for heat tolerant and sensitive genotypes. Further screening was made using chlorophyll stability index, fluorescence imaging, membrane stability and sucrose synthase activity. Significant variation was observed in thermotolerance and grain yield. In general, pollen germination almost inhibited at temperature 43^{0}C (Fig. 24).

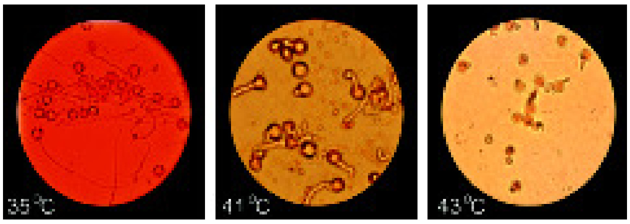
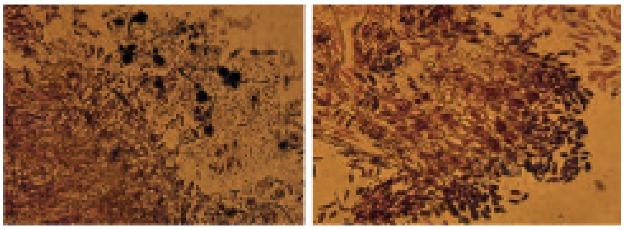


Fig. 24: *In vitro* pollen germination in chickpea at different temperatures

The heat sensitive genotypes (*e.g.*, ICC 1194) did not show any pollen loading or germination over stigma surface. Therefore this was found one of the best technique to demonstrate the reproductive stage tolerance in chickpea (Fig. 25). The flowering and single row yield (about 50 plants) of each test genotypes is shown in Table 8. Mean yield deviation of the genotypes tested under high temperature > 35^{0}C was about 60-80% as compared to normal sown crop.



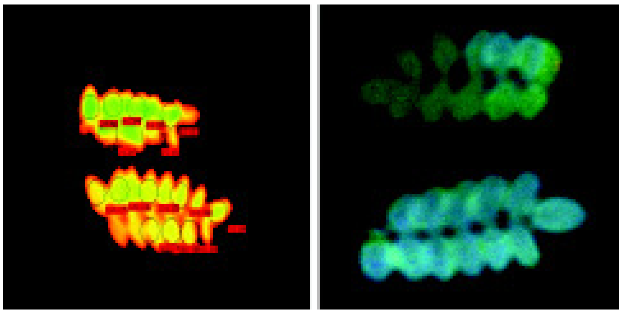
Heat tolerant (ICC 8950) Heat sensitive (ICC 1194) no pollens

Fig. 25: Germinating pollens on stigma surface at 35^{0}C

Large screening was done using leaf disorder in respect to fluorescence imaging. The fluorescence signal significantly deviated at 46^{0}C as compared to 20^{0}C treated leaves. The imaging pattern of high temperature treated leaves is sown in the Fig. 26.

Table 8 : Genotypes identified as heat tolerant, moderately tolerant and sensitive

Genotype	First flower (Days)	Row yield (g)
Heat tolerant		
JG 74	52.7	111.0
ICC 637	52.2	105.0
ICC 8950	53.7	106.0
Avrodhi	53.0	112.0
Annegiri	52.2	109.0
K 850	51.7	103.0
ICCV 92944 (check)	45.0	110.7
Moderately tolerant		
ICC 1923	56.8	99.0
ICC 6811	55.2	98.0
ICC 3362	51.5	98.0
DCP 92-3	48.8	89.0
RSG 963	51.7	99.0
Heat sensitive		
ICC 8522	42.7	64.68
ICC 1194	52.8	57.52
ICC 3230	55.8	49.70



For minimal fluorescence For quantum yield (Fv/Fm)

Top 46^{0}C treated leaf; Bottom 20^{0}C treated leaf

Fig. 26: Fluorescence imaging

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

To create three different temperature regimes, 55 fieldpea (*Pisum sativum L.*) genotypes were planted under three dates at an interval of 25 days *viz.*, 16 November (normal planting), 10 December and 3 January under irrigated condition. During normal sown condition, crop was naturally exposed to cool temperature, while warmer to high temperature prevailed for crop at reproductive phase under late plantings. Crop was monitored for various phenological days, plant height, dry matter accumulation and its distribution in different plant parts at various growth stages *viz.*, vegetative stage (26 days after seeding), at flowering, podding and maturity. It was observed that genotypes failed to set pods when there was a sudden rise in temperature beyond 38 ^{0}C. Only few genotypes could set pods with reduced seed size and shrivelled grain. The critical temperature range for damage of reproductive organs was found in between 30-35^{0}C. Vegetative period were also reduced under late seeding condition. Leaf fluorescence reading was observed at flowering. Estimates for SPAD values were made at all the crop growth stages. Genotypes were grouped according to their yield reduction in D-3 over D-1 and on basis of resistance, moderately resistance and sensitivity to high temperature.

Resistant type: <20% reduction: IPFs 5-23, 99-26, 19, KPMR 11-1, KPF 103, DMR 15, Pant 5, HUDP 16, IPFD 3-17, IPFD 2-6, IPFD 1-10

Moderate resistant type: 21-40% reduction: IPFs 98-1, 98-18, 16, 17, 6- 20, 1-22, 2-13, IPFDs 4-6, 99-13, 4-5

Suceptible type: >40% reduction: IPFs 14, 5-19, 99-25, 99-27, 62, 99-31, 4-9, 4-26, KPMRs 18, 344, 400, JP 868, IPFDs 3-7, 99-7, 5-8, 6-5, 3-6, 2-5, 3-17, 1-9, 99-15, 5-3, 13, KPMRDs 44, 38, DPFD 2, 20, 34, 47, HUDP 12, DPR 13, Swati, DPRs 17, 27, 23.

Study revealed that pea genotypes expressed different response towards temperature changes under normal, medium and late seeding, and both maximum and minimum temperature during seed filling period have definite relation with yield differences. Yield differences are mainly due to the differences in pod weight, seed weight, seed size and harvest index under late seeding as compared to normal seeding. Sugar content in leaves (Fig. 27), membrane stability (Fig. 28) and SPAD values also supported above yield differences under different temperature regimes.

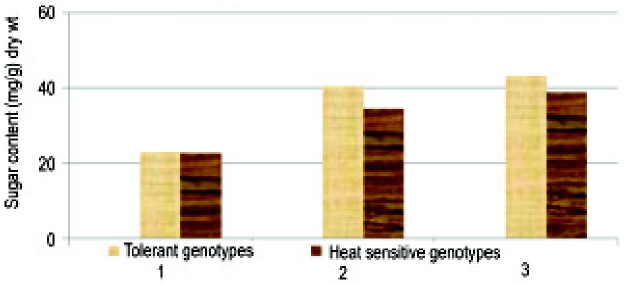


Fig. 27 : Leaf sugar content (mg/g dry wt.) in fieldpea genotypes at flowering stage

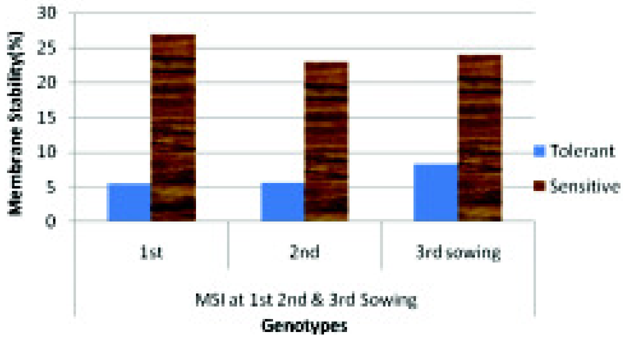


Fig. 28 : MSI (Membrane stability index %) value observed in sensitive and tolerant genotypes

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

Twenty genotypes of lentil were subjected to field trial under irrigated and rainfed conditions. The genotypes exhibited genotypic differences towards their response for soil moisture deficit as soil moisture percentage and leaf relative water content (RWC) are highly related. RWC increased upto 15% moisture content in soil under irrigated and 10.5% under rainfed condition. Based upon the observations recorded on phenological and morpho-physiological traits, the genotypes were grouped in accordance to their days to flowering under irrigated as well as rainfed conditions.

Early flowering : IPL 59, IPL 60, ILL 7663, EC 208362

Medium flowering: Ranjan, IPL 121, IPL 133, IPL 522, WBL 58, EC 208355, EC 520204, Bihar local

Late flowering : B77, IPL 203, IPL 403, IPL 404, IPL 517, 94/1468, P 2068, VL 4.

The variability within the genotypes for days to flowering under irrigated condition was somewhat narrower (between 48-70 days) as compared to rainfed condition (between 50-80 days). Phenological days of the genotypes changed under rainfed as compared to irrigated condition. Genotypes differed in their leaf RWC, membrane stability under irrigated and rainfed condition. Leaf area at podding had greater association with lentil seed yield than leaf area at flowering.

Biochemical Basis and Mechanism of Wilt Resistance in Pigeonpea

Four wilt resistant genotypes of pigeonpea *viz.*, Banda Palera, ICP 8863, ICP 9174 and JA 4, and four wilt susceptible genotypes *viz.*, Bahar, Type 7, ICP 2376 and UPAS 120 were raised in pots under inoculated and un-inoculated conditions. The activity of peroxidase (PO), polyphenol oxidase (PPO), phenyl alanine ammonia lyase (PAL) and total phenols were estimated in roots and leaves of the plants at pre- and post-wilting stages under both conditions. Different phenolic acids were also estimated in root and leaf samples of resistant and susceptible plants.

Inoculated plants showed lower PO and PAL activity in leaf of susceptible as well as resistant genotypes as compared to uninoculated plants. The activity of PPO in leaf was marginally increased in inoculated plants as compared to uninoculated plants.

The total phenol of leaves was not affected in inoculated plants (Fig. 29).

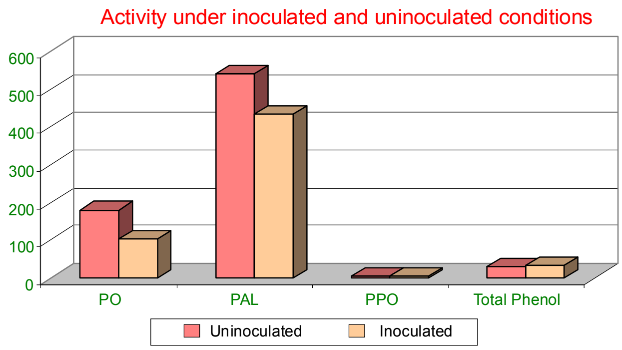


Fig. 29: Biochemical changes in leaves under inoculated and uninoculated conditions

Wilting of susceptible genotypes caused remarkable increase in PO, PPO and PAL activities of the leaves (Fig. 30). Resistant genotypes also showed higher activity of PO and PPO during later stages of growth. Total phenol content of leaves also increased during later stages of growth (Fig, 31).

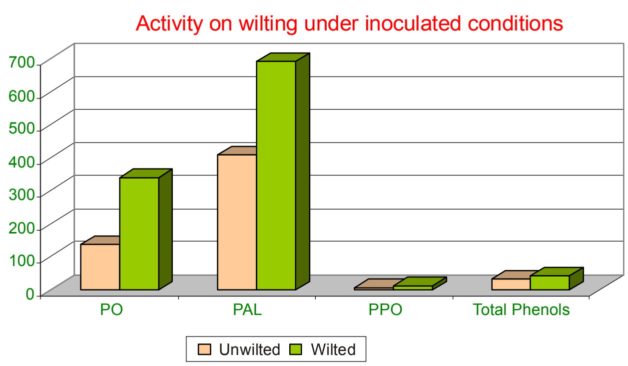


Fig. 30: Biochemical changes in leaves during wilting

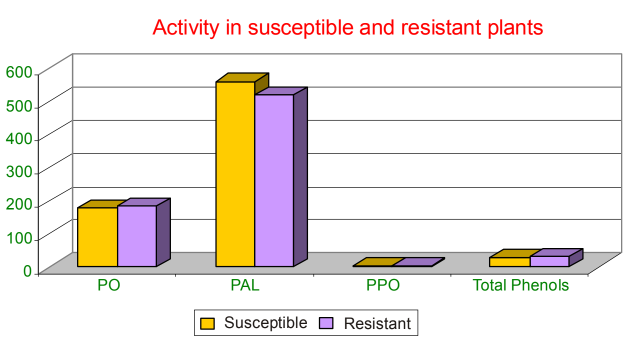


Fig. 31: Biochemical changes in leaves of susceptible and resistant plants

Activity of PPO and PAL in roots of susceptible plants under inoculated conditions was significantly lower than uninoculated plants. Total phenols reduced drastically in roots of susceptible plants during wilting. Roots as well as leaves of the resistant and susceptible plants of pigeonpea showed presence of protocatechuic, chlorogenic, caffeic and coumaric acids, but no correlation was observed in different phenolic acids.

Development of Production Technology for Organic Production of Lentil and *Kabuli* Chickpea

Sorghum fodder, chickpea and lentil crops were grown under three different production systems *viz.*, chemical, integrated and organic systems. During *kharif*, prior to sowing of fodder sorghum crop, compost @ 20 t/ha along with the crop residue of mustard crop was incorporated under organic production system, whereas under integrated and chemical production systems recommended doses of NPK were added with and without application of compost @ 5 t/ha, respectively. Mustard crop residues were removed from the plots under integrated and chemical production systems. After harvest of fodder sorghum, three varieties of chickpea (Subhra, RSG 888 and KWR 108) and bold seeded lentil (DPL 62) were sown under three different production systems during *rabi* season. Fodder sorghum yield was highest under integrated system. Application of compost @ 5 t/ha along with recommended doses of NPKS produced green fodder biomass of 493 q/ha as compared to 230 q/ha obtained under chemical production system. Under organic system, fodder yield was 380 q/ha which was less than integrated system, but significantly higher as compared to chemical production system.

Soil analysis of samples collected from two depths *viz.*, 0-15 and 15-30 cm showed that application of compost under both integrated and organic production systems improved organic carbon content as well as availability of N, P and K (Table 9a). Soil organic carbon content in the upper layer was 0.47% under organic system and 0.27% under chemical and integrated production system. At lower depth of 15-30 cm, soil organic carbon content under integrated and organic system was similar, but significantly higher as compared to chemical production system. Similarly, availability of nitrogen, phosphorus and potassium under organic system was significantly higher as compared to integrated and chemical production system.

Improvement in soil chemical properties also showed beneficial effect on the soil biological parameters in both the layers under organic and integrated as compared to the chemical production system (Table 9b). Soil mineralizable-N and mineralization of the applied urea in soils under different management systems showed that improvement in soil properties resulted in maintenance of higher mineral nitrogen content under organic as compared to integrated and chemical production systems (Fig. 32 and 33). Mineralizable-N content measured after incubation of soil showed that soil under organic system contained two fold higher amount of mineral nitrogen as compared to the chemical production system at different period of incubation up to 60 days. Urea-N mineralization in soil also showed higher amount of mineral nitrogen content in organic compared to integrated and chemical production systems. The grain yield of chickpea was higher under integrated than the other two production systems, but the differences between integrated and organic system was not significant (Fig. 34). Lentil grain yield under organic system was 888 kg/ha as compared to 757 and 686 kg/ha under integrated and chemical production systems, respectively.

Table 9: Changes in soil chemical and biological properties

a) Chemical properties

System	Soil depth (cm)	Organic-C (%)	NO_3-N (ppm)	Available P (ppm)	Available K (kg/ha)
Chemical	0-15	0.27	1.25	5.43	125.4
	15-30	0.09	<1.0	2.80	73.7
Integrated	0-15	0.27	6.08	13.60	166.1
	15-30	0.17	<1.0	9.32	134.2
Organic	0-15	0.47	19.72	20.05	278.3
	15-30	0.17	3.53	5.71	168.0

b) Biological properties

System	Soil depth (cm)	Basal respira-tion rate (µg CO2-C/100 g soil/hr)	Acid phosphatase (µg p-nitro-phenol/g soil/hr)	Alkaline phosphatase (µg p-nitro-phenol/g soil/hr)	KMnO4 oxidizable -C (µg C/g soil)
Chemical	0-15	179	25.71	132.23	436.7
	15-30	146	8.21	39.91	285.2
Integrated	0-15	176	37.49	173.81	464.7
	15-30	163	12.14	62.81	357.3
Organic	0-15	195	50.34	245.85	508.5
	15-30	166	18.57	90.58	391.11

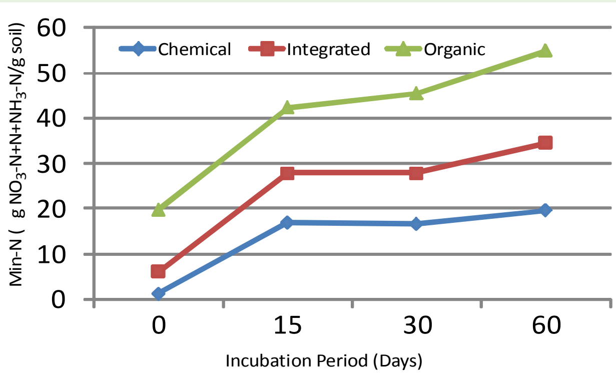


Fig. 32: Mineralizable nitrogen in soil under different management systems

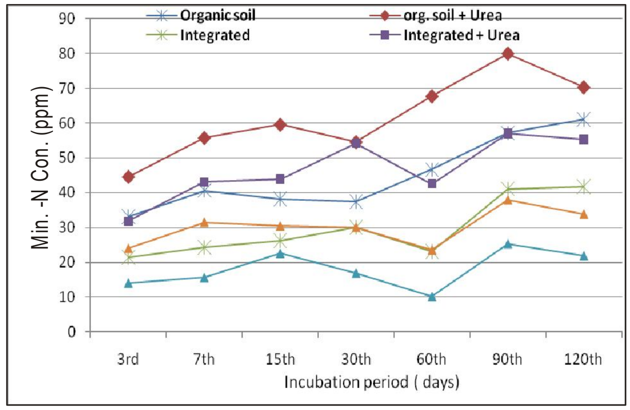


Fig. 33: Mineralization of nitrogen in soil under different management systems

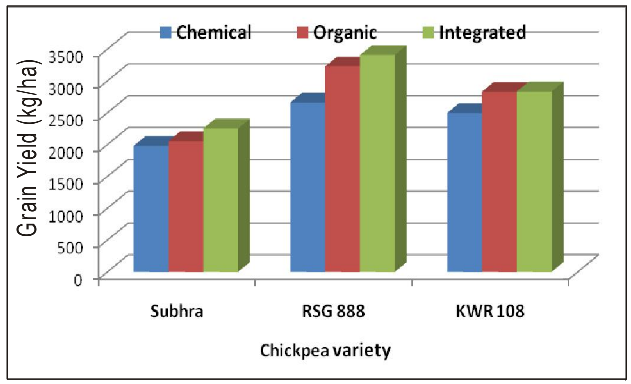


Fig. 34: Grain yield of chickpea varieties under different production systems

Increasing Nodulation and Nitrogen Fixation in Chickpea under Moisture Stress

A field trial was conducted to evaluate the relative performance of five efficient strains of *Mesorhizobium ciceri* isolated from chickpea grown under rainfed areas. Chickpea variety RSG 888 was sown after inoculation with different rhizobium strains along with un-inoculated control. Moisture stress was imposed on crop by withdrawing the irrigation during pod filling stage. Inoculation with efficient strains improved nodulation over un-inoculated control. Plant growth measured at 45 and 90 days of crop development showed significant improvement in shoot biomass due to inoculation with the *M. ciceri* strains. At harvest, chickpea grain yield increased from 1665 kg/ha in un-inoculated control to 2008 kg/ha due to inoculation with *M. ciceri* strain no. 30 (Fig. 35). Among the five different strains, maximum increase of 20 % over un-inoculated control was obtained with strain no. 30 and 13. These two strains of *M. ciceri* showed prominence in improving the grain yield under moisture stress at pod filling stage.

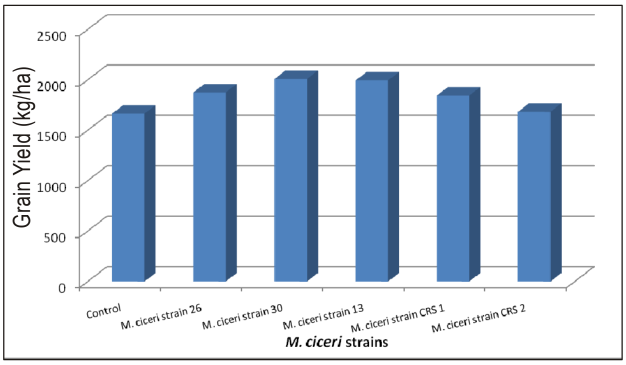


Fig. 35: Effect of inoculation with different strains of *Mesorhizobium ciceri* on grain yield of chickpea under moisture stress conditions

Bioefficacy of Sorghum and Linseed Root Exudates and Biocidal Compounds of *Calotropis latex* against Soil Borne Diseases and Nematodes of Pulse Crops

Biocidal compounds of different polarity (polar to non-polar) extracted from *Calotropis latex* were tested for their fungicidal action against five different fungal pathogens after converting them into suitable EC and EW formulations. EC formulations especially developed from non-polar groups of bio-compounds were observed more toxic as compared to the EW formulations of polar compounds. Developed EC formulation of non-polar compounds mainly containing isoprenoid carbamate were observed more toxic to *Sclerotium rolfsii* (LD_{50} 100 µg/ml), followed by *Rhizoctonia solani* (LD_{50} 224 µg/ml). For other fungal pathogens *viz*., *Fusarium udum*, *Fusarium oxysporum sp. ciceri* and *Fusarium lentis* all the developed formulations (polar to non-polar) were observed least effective. Nearly 50-60% inhibition in colony growth was observed uniformly in the treatment of all the five developed formulations at 750 µg/ml concentrations. Detrimental effect of all the developed formulations was also observed on the production of conidia and their viability of two most sensitive fungal pathogens *viz*., *S. rolfsii* and *R. solani*. In both of the fungal species, nearly 80-90% inhibition in number of conidia and their weight at concentration of 250 µg/ml was observed uniformly in treatment of all the developed formulations (Fig. 36).

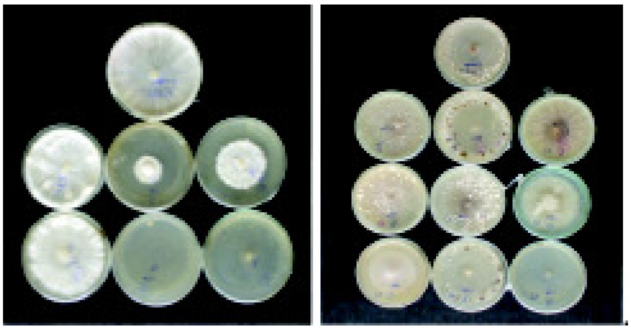


Fig. 36: Effect of extracted compounds on colony growth inhibition and production of conidia

Identification and Characterization of Biochemical Compounds Imparting Resistance to Fungal Pathogens and *H. armigera*

Three resistance varieties *viz*., KWR 108, IPC 2004-52 and JG 315 and one susceptible genotype JG 62 were grown in field. After attaining suitable biomass, plant materials were taken out and grinded to fine powders for extraction of bio-compounds. Bio-compounds from JG 62 and KWR 108 were extracted in ten different fractions of authentic solubility. The extracted fractions were further purified for their genuine solubility by repeatedly following different column chromatographic techniques.

Agriculture Extension

Analysis of Pulse Production Technologies Disseminated in Uttar Pradesh

Survey was conducted in six selected districts *viz*., Lakhimpur Kheri, Baheraich, Jalaun, Faizabad, Allahabad and Banda of Uttar Pradesh. Data were collected from 300 farmers and 60 extension workers to know the status of transfer of pulse production technology (Table 10). The study indicated that excursion trip, meetings and training were the main methods for transferring pulse production technology. The progressive farmers and local traders play vital role in transferring pulse production technology. Adoption of improved pulses technologies varies from low to medium in all the districts. The major constraints perceived by the farmers were non-availability of quality seeds in time, disease and insect infestation and lack of knowledge about the improved pulse production technologies. The major constraints perceived by the extension workers are lack of field staff and overburdened with other activities. SWOT analysis was also conducted by involving the farmers and was found that all the six districts have substantial potential of enhancing pulse production, income and socio-economic condition. The weakness is non-availability of quality seed and proper guidance. Opportunity is farmers' preparedness for pulse cultivation under different situations. The farmers are having enthusiasm and desire to adopt the improved technologies for enhancing the pulse production. The major threats may be the low price due to glut in market and blue bull problem. It can be concluded that public private partnership approach may be used for providing quality seed in time and proper insect forecasting system for controlling the insect pests and solving other related problems.

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

Survey was conducted in Tenduwari and Kamasin blocks of Banda district of Bundelkhand among 150 farmers (75 men and 75 women) to ascertain role of women in different activities of pulse production, decision making, drudgery perceived in work and sources of information. It was revealed that small and marginal category farmers (men and women) were participating in pulse production activities, whereas in large farmers' category, women were not participating in outside activities of pulse production. It was observed that small and medium category farmers were predominantly participating in land preparation, spray of insecticide, threshing and storage from field to home, whereas women participation was more in the sowing of seed (80%), harvesting of crop, plucking of matured pods, winnowing, storage in bin and making *dal*. In case of large farmers, women were actively participating in indoor activities and less in outdoor activities. The study revealed that women were involved in most of the decisions, but due to lack of knowledge they did not have say. Men perceived very high drudgery in carrying of compost, intercultural operations, harvesting, winnowing and women perceived very high level drudgery in intercultural operations, harvesting, plucking, winnowing and threshing of pigeonpea plants. They get injury in hands, finger, legs, eyes and get backache, headache,

Table 10: Adoption of improved pulse production technologies

Practice	Category	Jalaun (n = 50)		Faizabad (n = 50)		Allahabad (n=50)		Banda (n=50)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
Seed	Improved seed	12	24	8	16	6	12	10	20
	Local seed	38	76	42	84	46	92	40	80
Fertilizer	DAP	18	36	14	28	10	10	06	12
	Urea	5	10	02	4	0	0.0	0	0.0
Rhizobium		10	20	7	14	06	12	8	16
Trichoderma		0	0.0	0	0.0	0	0.0	0	0.0
Soil testing		2	4	3	6	0	0.0	0	0.0
Weedicide		4	8	5	10	12	24	0	0.0
Plant protection	Disease management	06	12	03	6	02	4	3	6.0
	Insect management	21	42	08	16	20	40	25	50
Implements	Improved	15	30	18	36	38	38	9	18
	Local	35	70	32	64	12	24	41	82
Processing	Improved	0	0.0	0	0.0	0	0.0	0	100
	Local	50	100	50	100	50	100	50	100
Post-harvest technology	Improved	8	16	12	24	36	72	10	20
	Local	42	86	38	76	14	28	40	80

vomiting, *etc*. The important sources of information are block development office, Deputy Director (Agriculture), IIPR and private seed traders. Farmers were also getting information from radio, TV and farmers' fairs related to pulse production. The women reported that they get information from their husbands and neighboring women farmers.

Validation of Farmer to Farmer Model of Extension for Dissemination of Pulse Production Technologies

Farmer to farmer model of extension (FFE) is one of the farmer centred participatory methodologies for dissemination of agricultural technologies to the diverse farming community. The said methodology sets well in Indian context, where the ratio of extension personnel to farmers is low. To validate FFE for speedy diffusion of improved pulse technologies among the farming community, 15 farmers from two villages *viz*., Kasikheda and Barai of two blocks *i.e*., Kadaura and Maheva of Jalaun district were identified as key farmers. These key farmers were provided improved seeds of recommended chickpea varieties (JG 16 and DCP 92-3) for one acre area each, along with technical knowhow related to pulse production. DCP 92-3 was demonstrated in 10 acres and JG 16 was demonstrated in 3.5 acres. Monitoring visits by the project team were made at different crop stages, wherein farmers were trained on various aspects of pulse production and protection. Under the double cropped irrigated condition, the average yield of DCP 92-3 and JG 16 varieties was recorded 13.07 and 13.5 q/ha, respectively, against 7.18 q/ha yield of local variety (Fig. 36). Under mono-cropped rainfed situation, farmers received additional advantage of Rs. 16 and 15.9 thousand per ha by growing DCP 92-3 and JG 16 varieties against the local varieties (Fig. 37).

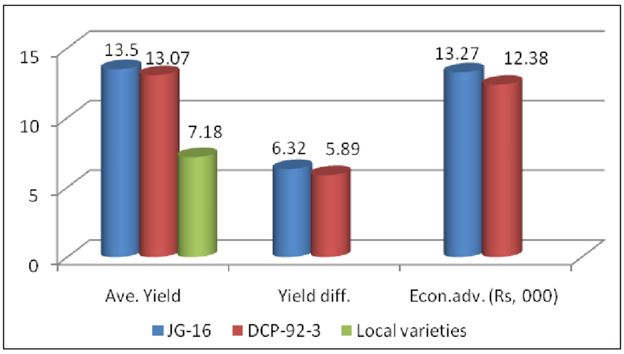


Fig. 36: Yield advantage (q/ha) over local chickpea varieties in double cropping situation

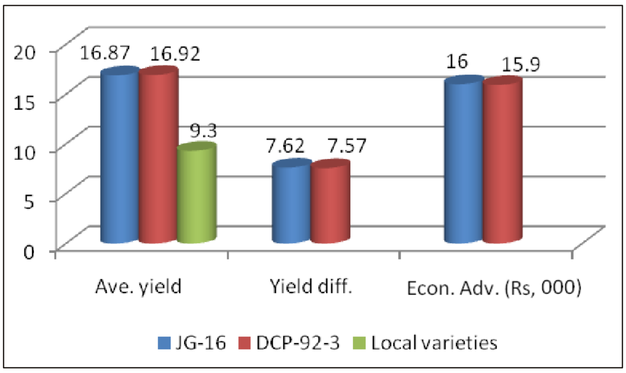


Fig. 37: Yield advantage (q/ha) over local chickpea varieties in monocropped situation

For structured diffusion of improved technologies, the identified key farmers will further diffuse the improved seed to four new farmers after harvesting at the rate of 15 kg to each farmer *i.e*., for half acre area for the next season. Thus, the improved pulse production technology along with the seed of improved varieties is expected to diffuse to 52 new farmers covering 26 acres of area along with 13 acres initially covered under the demonstration in *rabi* 2010-11 (Table 11).

Table 11: Farmer to farmer diffusion of pulse production technologies

Planned interventions in *rabi* 2010-11				Expected structured diffusion in *rabi* 2011-12		
Variety	Farmers covered	Quantity of seed provided (q)	Area covered (acres)	New Farmers covered	Quantity of seed diffused (q)	Area covered (acres)
JG 16	05	1.10	4	16	2.20	8
DCP 92-3	12	3.30	9	36	5.40	18
Total	17*	4.40	13	52	7.60	26

Agricultural Engineering

Development of Efficient Machines for Pulse Production System

Vertical thresher

The vertical thresher developed by IIPR was modified by reducing the number of beaters to 22 (11 rows of double beaters) instead of 64 beaters. Length of beating section was also reduced to 30 from 60 cm. Twin choppers were introduced to reduce chaff length to have better pneumatic cleaning. Softened rubberized casing was also provided over beaters to minimize

breakage. Spiral orientation was given to the beaters. Sieve with 20 mm opening was provided at the lower end of threshing drum. The vertical thresher so improved, was evaluated for stripped pigeonpea, chickpea and urdbean (Table 12).

Table 12: Evaluation of vertical thresher for different pulses

Paramter	Chickpea mixture	Pigeonpea (UPAS 120)
Plant/ stripped material	15 kg	20 kg
Threshing time	607 s	252 s
Threshing capacity	89.0kg/h	285.7 kg/h
Grain+Pod+Chaff	10.75 kg	-
Grain Recovered	5.85 kg	4.5 kg
Grain Recovery %	39	22.5

Rubbing type thresher

Improvements were made in rubbing type thresher *viz*., increase in length of upper belt, making upper belt stationary to increase residence time, change in drive pulley system, reduction in speed of belt, increase in blower RPM and introduction of inclined plate to separate plant and seeds. Only lower belt was allowed to move. The modified rubbing thresher could

substitute beating operation in manual threshing, followed by manual cleaning and winnowing. Capacity of the thresher was evaluated for stripped pigeonpea and chickpea (Table 13).

Table 13: Evaluation of rubbing type thresher for chickpea and pigeonpea

Pigeonpea stripper

A pigeonpea stripper was developed to strip leaves and pods from the plants with least disturbance to plant structure. The stripped material thus obtained can directly be fed to commercial threshers. Performance of pigeonpea stripper was revalidated for different cultivars (Table 14).

Table 14: Evaluation of pigeonpea stripper

Parameter	Pusa 992	UPAS 120
Plant material (kg)	35	50
Stripping time (s)	790	1140
Stripping capacity (kg/h)	159.5	157.9
Leaf+pod+chaff (kg)	16.15	19.5
Stick weight (kg)	18.85	30.6
Stick weight (%)	53.86	61.2

Suction winnower

A suction winnower has been developed at IIPR, to provide better working conditions while winnowing. To reduce dust hazard to operator, suction winnower blows light impurities away from the operator. The winnower basically comprises of hopper, falling chamber and suction blower. Threshed material falls in two stages in front of suction air to remove lighter particles. The winnowing results were revalidated during the year (Table 15).

Table 15: Evaluation of suction winnower in pigeonpea

Parameter	Pusa 992	UPAS 120
Threshed material (kg)	10	22
Winnowing time (s)	204	482
Winnowing capacity (kg/h)	176.5	164.3

Value Addition to the By-products of Pulse Milling Industry-Development of *Dal* Analog

Chemical properties for whole grain, dehusked splits and pulse milling by-product, *i.e.*, mixture of husk and powder of some pigeonpea cultivars (Narendra 1, MAL 6, UPAS 120 and Bahar) were analyzed and revalidated. Effect of different pre-milling treatments, *viz.*, water, oil and thermal treatment were compared with that of untreated grains. The results of biochemical analysis for soluble protein and polyphenols for milling by-product are tabulated as below:

A) Soluble protein (%, d.b.)

Treatment	Narendra-1		MAL 6		UPAS 120		Bahar	
	Cotyl-edons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture
Untreated	21.4	7.3	20.9	9.9	19.0	10.2	19.4	8.0
Water treated	17.7	7.7	18.3	7.5	20.0	12.1	19.0	7.4
Oil treated	18.3	9.4	19.5	8. 7	21.2	8.7	18.6	7.4
Thermal treated	21.4	7.7	20.9	11.0	19.5	12.0	20.0	6.6

Mixture of cotyledons of all the above varieties: 20.46 %, d.b. Mixture of husk and powder of all the above varieties: 9.40 %, d.b.

B) Polyphenols (mg/100g catechol equivalent)

Treatment	Narendra-1		MAL 6		UPAS 120		Bahar	
	Cotyle-dons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture	Cotyle-dons	Husk + powder mixture
Untreated	28.7	102.5	19.6	227.2	24.8	293.6	22.6	77.8
Water treated	7.5	99.0	15.8	265.0	20.4	273.9	28.7	87.9
Oil treated	15.2	116.2	22.6	279.1	27.2	277.6	22.7	98.5
Thermal treated	25.0	111.0	24.9	290.3	38.5	281.5	12.1	92.3

Mixture of cotyledons of all the above varieties: 15.09 mg/100g catechol equivalent . Mixture of husk and powder of all the above varieties: 219.91 mg/100g catechol equivalent.

Agricultural Statistics and Computer Application

Development of Prototype Expert System for Identification and Control of Insect-pests/Diseases in Pulse Crops

A questionnaire set was developed with the help of domain experts and designed disease/insect-pests information sheet for collection of disease/insect-pest identification symptoms and control measures of mungbean and urdbean. Data related to the problem domain have been collected from variety of sources including books, bulletins, reports, domain experts for the major insect-pests of mungbean and urdbean. Structures of acquired knowledge/information were updated and designed as per the expert advice. A task specific knowledge acquisition tool has been validated to provide user-friendly interface to domain expert(s) for entering the knowledge.

Pulse disease/insect-pest knowledge base (PDI-KB) has been developed, which contains knowledge about the disease/knowledge insect-pest identification symptoms (textual and pictorial with high quality image) and remedies of major diseases (yellow mosaic virus, *Cercospora* leaf spot, powdery mildew and anthracnose) and insect-pests (hairy caterpillar, whitefly, thrips, blister beetle, stemflies, tobacco caterpillar, spotted caterpillar and pod bugs) of mungbean and urdbean. An expert system for pulses (PulsExpert) has been evaluated and validated to provide online help to pulse growers and extension workers of the country. Complete system is available on URL http://iipr.res.in/pulseexpert/home_page.asp for its online access.

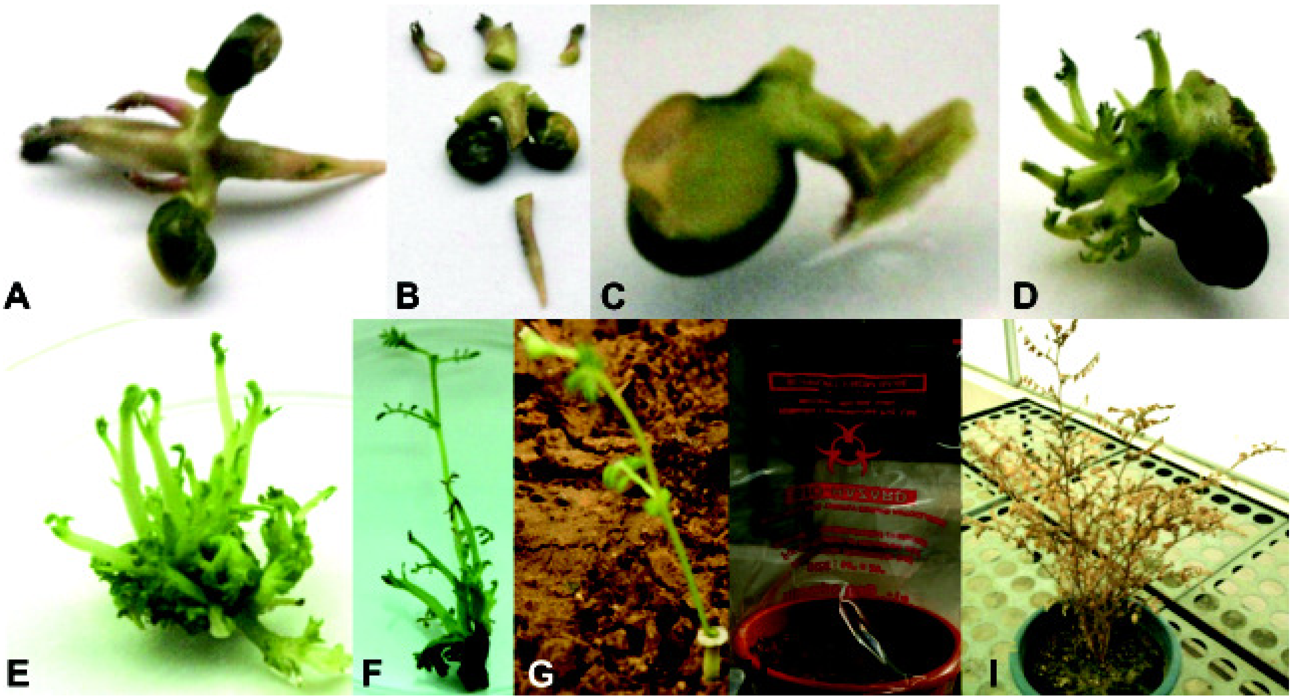
Development of Online Information Retrieval System of AICRP on Mungbean Plant Breeding Trial Data

For making the process of data collection and compilation smooth and easier, development of an online information retrieval system using data of AICRP trials on mungbean has been initiated. This system has three components *viz.*, administrator end, user end and database development. The various pages at the administrator end have been developed with their relevant database using ASP.NET with C#/VB as the backend coding. For database development, SQL server 2005 is used.

Externally Funded Projects

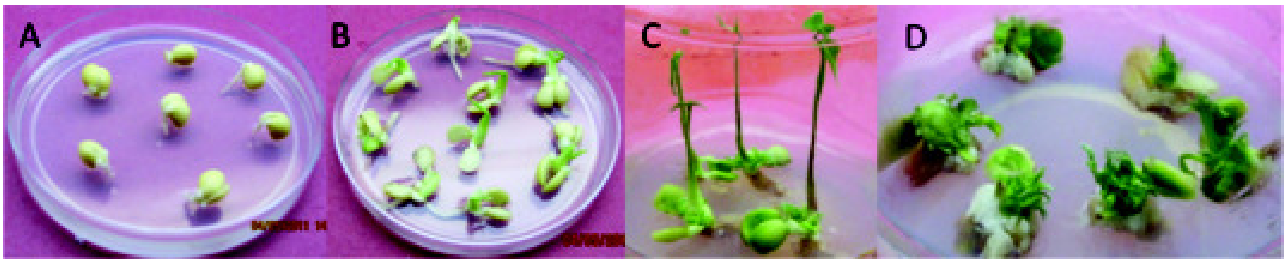
Transgenic Development in Chickpea and Pigeonpea for Pod borer Resistance

Modified regeneration protocol involving axillary meristem as explant was used for genetic transformation with *Agrobacterium* strain (EHA 105) bearing *Bt* construct (*cry1Aabc* gene). Total 7550 seeds (DCP 92-3) were inoculated in shoot induction media, out of which 1690 kanamycin resistant shoots were obtained. Finally, 65 shoots were successfully grafted onto pre- germinated root stock in transgenic containment facility, out of which six healthy T_0 putative transgenic plants survived to maturity (Fig. 38). Similarly, in pigeonpea, modified regeneration procedures were tried to develop efficient *in vitro* regeneration protocol with more number of healthy multiple shoots. Total 950 seeds (Asha) were inoculated in shoot induction media and 450 shoots were used for preparing axillary meristem explants, out of which 200 shoots survived in the elongation medium (Fig. 39). In pigeonpea, insect bioassay was carried out successfully using 8 putative T_2 transgenic pigeonpea lines. Detached leaf bioassay using neonatal larvae of *Helicoverpa armigera* showed up to 30-80% mortality.



A. Germination of chickpea seeds in SIM medium. B. Preparation of explants. C. Co-cultivation of explants. D. Multiple shoot initiation. E. Elongation of multiple shoots. F. Separation of multiple shoots. G. Grafting of regenerated shoots. H. Establishment of plants. I. Mature fertile transgenic chickpea lines

Fig. 38: Different stages of chickpea transformation



A: Inoculation of seeds. B: Germination of seeds. C: Generation of primary and axillary shoots. D: Preparation of explants after removal of primary shoots

Fig. 39: *In vitro* regeneration system in pigeonpea

Bioassay of *Bt*-transgenic pigeonpea against *H. armigera*

Transgenic pigeonpea events with *Bt*-gene have been evaluated against *Helicoverpa armigera* along with their non-transgenic Asha (as negative check) and *Bt*-cotton (as positive check) under laboratory and contained green house conditions.

Detached leaf and pod assay: Bioassay was conducted in laboratory to assess the response of neonate and third instar larvae of *H. armigera* to *Bt*-pigeonpea events using detached leaf and pod assay. Laboratory reared neonate (1-18 h old) and third instar larvae of *H. armigera* were released (5 neonate larvae per leaf/pod and one third instar larva per leaf to avoid cannibalism). Observations on survival of larvae (for neonates and 3rd instars) and weight of larvae (3rd instar) were recorded at five days after the release of the insect. Among the *Bt*-pigeonpea events evaluated against neonate larvae, one event recorded 60% mortality as compared to 100% mortality in *Bt*-cotton. In the detached pod assay, there was no mortality of neonate larvae recorded. However, larval weight at five days after infestation was significantly lower in larvae reared on transgenic events as compared to other transgenic non-transgenic version. Also, the larvae reared on two *Bt*-transgenic pigeonpea events had longer larval period (25.0 and 24.7 days) as compared 17.0 to 22.7 days in other transgenic events and 21.0 days in non-transgenic pigeonpea (Fig. 40).

Cup assay: Fully expanded trifoliate leaf/green pods of pigeonpea were inserted into a plastic cup through a small split on the bottom of the cup. After insertion of leaf, the inserted opening was closed. Five neonate larvae of *H. armigera* were released into each leaf/pod and the cup was covered by muslin cloth to allow proper aeration. Insect mortality was recorded after five days. The result indicated significant difference among transgenic and non-transgenic events. In the transgenic events, the larval mortality ranged between 53.3 and 80.0% as compared to 33.3% mortality in non-transgenic pigeonpea and 100% mortality in *Bt*-cotton. Similarly, the mortality of neonates on pod ranged between 6.7 and 13.3% in transgenic pigeonpea as compared to 3.3% in non-transgenic pigeonpea and 100% mortality in *Bt*-cotton bolls (Fig. 40).

Whole-plant assay: Ten third instar larvae of *H. armigera* were released onto the pigeonpea plants. The plants were covered by finely perforated nylon net supported by cylindrical iron tripod. Observations on survival of larvae and weight of larvae were recorded five days after the release of the insect. No mortality was recorded both in transgenic and non-transgenic pigeonpea. Larval weight after five days of exposure varied from 287 to 357 mg in transgenic pigeonpea and it was 323 mg in non-transgenic pigeonpea, though it was statistically non-significant (Fig. 40).

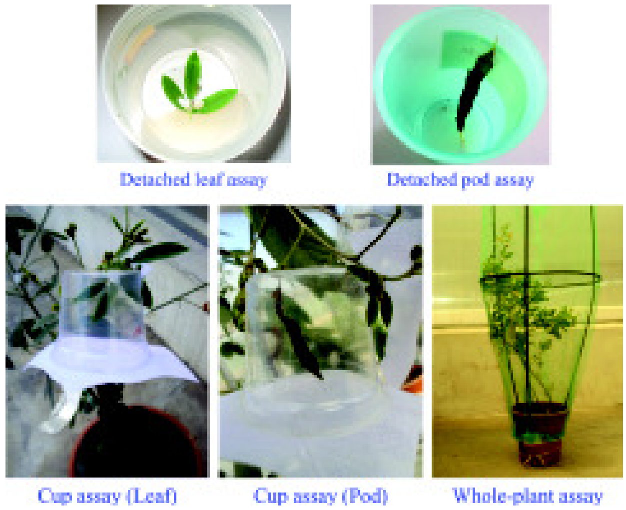
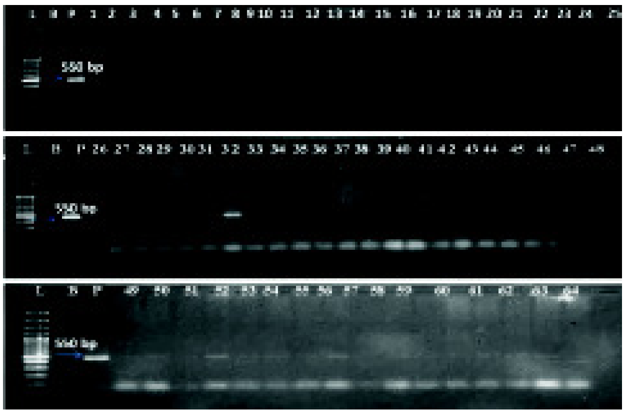


Fig. 40: Different bioassay of *Bt*-transgenic pigeonpea against *H. armigera*

Understanding Plant – Nematode Interactions using RNAi

Total genomic DNA was isolated from 64 putative T_2 transgenic fieldpea lines (*cv.* HUDP 15) and PCR conditions were optimised using primers specific to RNAi gene, CaMV 35S promoter, *npt II* marker and intron for molecular characterization. PCR results showed, only introns specific primers could detect 8 positive lines (Fig. 41). Further, plants showing positive amplification with intron-specific primers were selected for Southern hybridization. Southern hybridization was carried out using AF531160 gene specific biotin labelled probe. Result indicated strong hybridization with plasmid DNA (Fig. 42). Whereas, out of 8 PCR positive plants, only one plant (D-23-1-4) was found Southern positive.



Lane 1:100bp DNA ladder, Lane 2: negative control, Lane 3: positive control (Plasmid DNA), Lane 4 onwards: DNA of transformed shoots

Fig. 41: PCR amplification using primer specific to intron (Gel 1, 2 & 3)

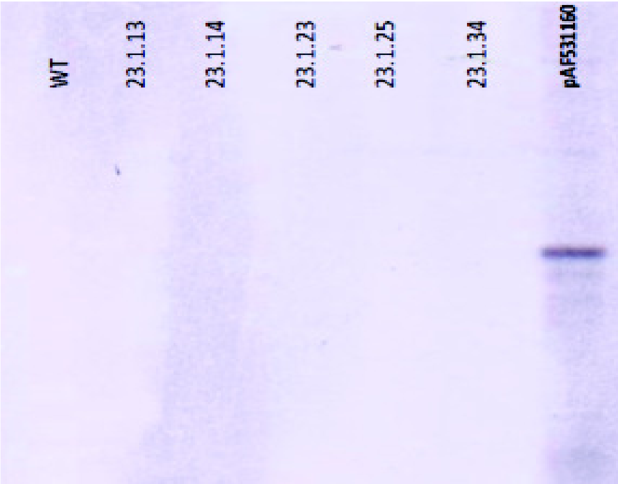


Fig. 42: Southern blotting of PCR positive plants with wild type and plasmid DNA

Further to improve multiple shoot induction in fieldpea, 10 medium combinations were tried. Only one medium combination *i.e.*, MS4 (MS salt +B5 vit.+2mg/l BAP+2mg/l NAA), 3% (w/v) sucrose, with 0.75% agar, followed by MS9 (4.5 mg/lt BAP and 0.02 mg/lt NAA) after 15 days responded better in producing on average 15 shoots/explants (Fig. 43).

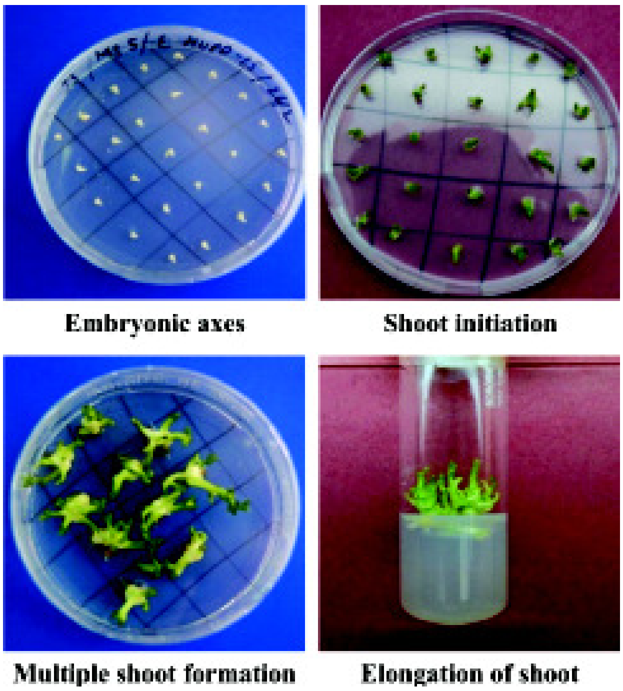


Fig. 43: Various stages of plant regeneration of fieldpea variety HUDP 15

Functional Genomics of Chickpea

Total 150 (out of 815) markers were found polymorphic between BG 256 and JG 315. Among these, 70 (out of 545) SSR markers were found polymorphic (Fig. 44). Screening of 16 SSR markers linked to *Fusarium* wilt resulted in identification of six polymorphic markers *viz.*, H3A 12, TA194, TA 59, TA 110 and HIB 06. Three linked RAPD markers *viz.*, OPM03703, OPAC041200 and OPAC11500 were also validated. Screening of other markers also have resulted in identification of 45 (out of 180) RAPD, 15 ISSR (out of 50), 20 (out of 40) RGA markers polymorphic between the above parents. Phenotypic assessment of F_6 population (BG 256 × JG 315) was done for resistance to *Fusarium* wilt (Foc *race* 2) and other agronomic parameter *viz.*, days to flower, growth habit, leaflet size, days of maturity and yield. The DNA from F_6 population was isolated and genotyping of these individuals were carried out using few parental polymorphic markers. Some of the marker like TA 96 showed co-segregating with wilt resistance in F_6 population.

For allele mining for drought tolerance genes (DREB1A and others candidate genes), DNA was isolated from 280 plant samples (chickpea core set) and used to screen with the primer set (DREB1A gene) designed using Primer 3 programme.

Centre of Excellence for High Throughput Allele Determination for Molecular Breeding

Marker assisted breeding for draught tolerance in chickpea and mapping of *Fusarium* wilt resistance in pigeonpea has been undertaken. For introgression of QTL for drought tolerance from ICC 4958 into elite chickpea cultivar DCP 92-3, marker assisted back crossing (MABC) was followed. Crosses were made and parental polymorphism was studied using markers (TAA 170, ICCM 0249, STMS 11 and GA 24) flanking the QTL for drought tolerance. Only marker TAA 170 showed polymorphism between both the parents (Fig. 45). For genetic mapping for wilt resistance in pigeonpea, F_4 seeds were harvested successfully for developing the RIL mapping population derived from Asha x UPAS 120. Besides, parental polymorphism was studied between these two parents using 20 CEDG SSR primers, out of which 12 SSRs were found to be

Fig. 44: Parental polymorphism study using SSR primers

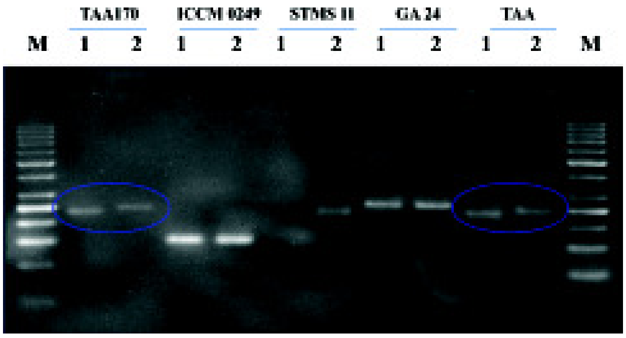


Fig. 45: Parental polymorphism studied between DPC 92-3 (1) and ICC 4958 (2) using markers flanking drought QTL

cross transferable and one SSR primer (CEDG 057) was found polymorphic.

Development of Pod Borer Resistant Transgenic Pigeonpea and Chickpea

The *Bt*-gene construct, *cry*1Ac was obtained from NRCPB and checked for integrity by restriction digestion and PCR with *cry*-gene specific primers. Five thousand explants each of chickpea (*cv* DCP 92-3) and pigeonpea (*cv* Asha) were prepared and tested for evaluation of the existing genetic transformation protocol.

Enhancing Yield and Stability of Pigeonpea through Heterosis Breeding

Development of F_1 hybrids

Total 18 early duration hybrids were developed involving 7 early maturing CMS lines *viz.*, AL 101 A, ICP 2089 A, PA 163 A, UPAS 120 A, CORG 990047 A, CORG 990052 A and GT 290 A and 12 restorers *viz.*, AK 261504, AK 261322, AK 261506, 250083R, 261322R, 250173R, 250157R, 250165R, 261345R, 261429R, 261394R and 261409R.

Evaluation of early hybrids

Coordinated trials: IHT (early) and AHT 1 (early) trails of AICRP for North zone were conducted for evaluation of early duration hybrids. In IHT (early) trial, 8 hybrids *viz.*, PHP 39, PHP 42, ICPH 2433, IPH 10-1, IPH 10-2, IPH 10-3, IPH 10-4 and IPH 10-5 along with 3 checks *viz.*, UPAS 120, Pusa 992 and AL 201 were evaluated. Among these, IPH 10-3 was identified as most superior (38.43% and 36.30% superiority over best check UPAS 120), followed by IPH 10-2 (36.72% and 31.51% superiority over best check UPAS 120). Both these hybrids also possess more than 80% plant fertility and 4-5 days earlier maturity than the UPAS 120.

In AHT 1 (early) trial, only one hybrid IPH 09-5 along with 3 checks *viz.*, UPAS 120, Pusa 992 and AL 201 was evaluated. This hybrid showed 40.4% superiority over best check UPAS 120. Hybrid IPH 09-5 possesses more than 80% plant fertility and its maturity is at par with UPAS 120.

Station trial: Among 13 early hybrids, CORG 990047 A x AK 261394 (2249.37 kg/ha) showed 33% yield superiority over the check UPAS 120 (1691.25 kg/ha). This hybrid has large seeds (8.95g/100 seed), matures in 142 days and plant fertility is 90%.

Transfer of male sterility into genetically diverse backgrounds

CMS line ICP 2089A was used as female parent for transferring its male sterility to Pusa 992, which was used as male (recurrent) parent. Sufficient BC_4F_1 seeds have been harvested. Beside this, BC_2F_1 generation of GT 288A x ICP 88039 was grown and backcrossed with male parent ICP 88039 for transferring the male sterility of GT 288 A in the background of ICP 88039.

Identification and development of new restorers

Ninety six test crosses were developed involving 99 germplasm lines (male parent) and one CMS lines ICP 84023 A (female parent with *Cajanus scarabaeoides* cytoplasm) to identify new restorers for *C. scarabaeoides* cytoplasm. Two crosses *viz.*, ICP 84023A x ICP 2852 and ICP 84023A x ICP 5994 showed fertile plants. Pollen parents of these two crosses will be crossed with each other to develop restorers with more restorability.

Maintenance of parental lines

Twenty one A lines of early, mid-late and long-duration have been maintained by hand pollination for development of hybrids. Maintainer lines of these A lines are being maintained by selfing of single plants under nylon net. Sixty one (36 early, 16 medium and 11 long duration) restorer lines have been maintained under strict selfing.

To Develop MYMIV Resistant Transgenic Legumes by Incorporating Hairpin Ribozyme Gene Targeted to Viral *rep* mRNA

The efficient and reproducible regeneration and transformation system was established from cotyledonary nodes of *Vigna*. Continuous exposure to BAP (6-benzyl amino purine) was found important for maximal regeneration from cotyledonary node (CN) explants (Fig. 46 and 47). These explants produced upto 19 buds/CN explant and 5 shoot-buds/CN explant. The explants age and co-cultivation temperature were also found important factors, which

(A) transformed plants after 1 week in selection media (MS containing 2 µM BAP, 100 mg /l Kanamycin and 250 mg/l cefotaxime) (B) Shoots after 2 weeks in selection media (C) 3 weeks elongated shoots in selection media (D) Healthy multiple shoots after 4 weeks in selection media

Fig. 46: Different transformation stages of *Vigna mungo* plants from cotyledonary node explant

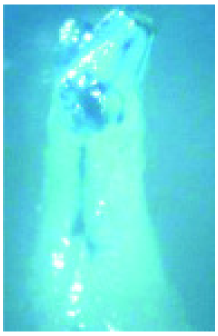


Fig. 47: *Gus* expression in *Vigna mungo* explants (Cotyledonary node) after 1 week in selection media

strongly affect the success of transformation. CN from two days old seedlings are suitable explants for transformation and 25^{0}C is the optimal co-cultivation temperature. It was found that transformation frequency after four weeks in selection medium was around 3.4%.

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

Total 70 F_1 seeds were generated in the cross Vijay x Pusa 256 and 27 in the cross WR 315 x Pusa 256. True F_1 plants confirmed by SSR markers were back crossed with recipient parent. Consequently, 6 BC_1F_1 seeds each were obtained in both the crosses. For background selection, 374 SSR markers were screened. Out of these 46 were found polymorphic between parents involved in the cross Vijay x Pusa 256, while 43 were polymorphic between the parents involved in the cross WR 315 x Pusa 256.

National Initiative on Climate Resilient Agriculture

Two trials (timely sown and late sown) of mungbean each comprising of 100 entries and 4 checks were conducted. Observations are being recorded on various morpho-physiological traits to find out the abiotic stress resistance level of the genotypes.

Breeding and Genetic Enhancement in Breaking Yield Barriers in *Kabuli* Chickpea and Lentil

The work was initiated for breaking yield barriers in lentil through introgression of desirable genes from landraces and wild species.

Procurement of lentil germplasm

Seeds of 150 wild accessions and 160 land races of Mediterranean region were received from ICARDA.

Pre-breeding

Thirty nine wild accessions from seeds obtained last year and 42 out of 160 races belonging to Iran, Turky, Ethopia and Egypt were grown in pots for obtained the cross with cultivated genotypes. F_1 seeds were harvested from 8 crosses made between cultivated (DPL 62 and DPL 58) and wild species (*L. culinaris* sp. *orientalis* and sp. *tomentosus*) and 4 crosses were made between cultivated (DPL 62 and DPL 58) and Mediterranean land races.

Evaluation for heat tolerance

A core collection of 237 accessions, 42 accessions of ICARDA drought nursery (LIDTN-2011) and 55 accessions of active germplasm were grown in late sown conditions (15 January) for heat tolerance evaluation. Out of these, 176 accessions flowered early and matured after 80-85 days of sowing. Among remaining 158 accessions, 62 accessions did not flower or flowered rarely and hence considered highly sensitive to heat. Ninety six accessions had flowering and podding after 85 days of sowing and were considered for recording the data on pod and seed development on the terminal of branches.

Quality Seed Production

Total 562 q breeder seed of chickpea, pigeonpea, mungbean, urdbean, lentil and fieldpea was produced during the year 2010-11. The details are given below:

(Figures in quintal)

Crop	Variety	GoI Indent	Production
Chickpea	DCP 92-3	7.00	69.00
	Shubhra	10.00	20.00
	Ujjawal	-	5.50
Total	-	**17.00**	**94.50**
Fieldpea	IPF 99-25 (Adarsh)	**8.00**	**53.00**
	IPFD 1-10 (Vikas)	11.00	84.00
	IPFD 99-13 (Prakash)	35.00	106.00
	IPF 5-9 (Aman)	2.00	8.00
Total		**56.00**	**251.00**
Lentil	DPL 62	15.00	32.00
	IPL 81	5.00	7.00
	DPL 15	4.00	14.75
	IPL 406	-	1.20
Total	-	**24.00**	**53.95**
Total Rabi	-	-	**400.45**

Crop	Variety	GoI Indent	Production
Pigeonpea	Bahar	8.00	15.00
	NDA 1	-	30.00
	UPAS 120	6.00	12.34
Total	-	**14.00**	**57.34**
Mungbean	IPM 99-125 (Meha)	10.00	11.16
	PDM 139 (Samrat)	43.00	50.00
	IPM 02-3	10.00	14.10
	IPM02-14	-	4.50
Total	-	**63.00**	**79.76**
Urdbean	IPU 94-1 (Uttara)	25.00	16.05
	IPU 02-43	5.00	8.52
Total	-	**30.00**	**24.57**
Total Kharif	-	**107.00**	**161.67**
Total Pulses	-	**204.00**	**562.12**

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

A field trial was conducted to fulfil the water need of the pigeonpea cv. Narendra Arhar 1 at the critical stages (including moisture stress period) through drip-irrigation and to compare the efficient nutrient use through drip *vis-a-vis* existing fertilizer use. Three planting patterns and 5 drip-fertigation treatments scheduled at branching and/or podding stages were tested. Planting patterns included (i) normal planting (M1, 90 x 20 cm), (ii) paired row system (M2, 60 x 20-120 cm) and (iii) wider planting (M3, 120 x 15 cm). The drip-fertigation schedules included (i) control (S1) no drip (rainfed - farmers' practice with full NPK at planting), (ii) drip (S2) at branching stage (20 mm) with ½ N+ ½ K (with full P + ½ NK at planting), (iii) drip (S3) at pod development stage (20 mm) with ½N+ ½K (with full P + ½ NK at planting), (iv) drip (S4) at branching and pod development stages (20+20 mm) with ¼ N + ¼ K at each stage (with full P + ½ NK at planting) and (v) furrow irrigation at branching and pod development stages (with full NPK at planting).

The plant emergence recorded at 30 DAS was 82% and optimum plant population (4.8 plants/m^2) was maintained. Drip-fertigation either at branching (S2) or at both branching and podding (S4) produced significantly higher (18%) seed yield over unirrigated control (farmers' practice). Drip-fertigation only at podding (S3) which was at par with furrow irrigation at both branching and podding (S5) had moderate level of yield (Fig. 48).

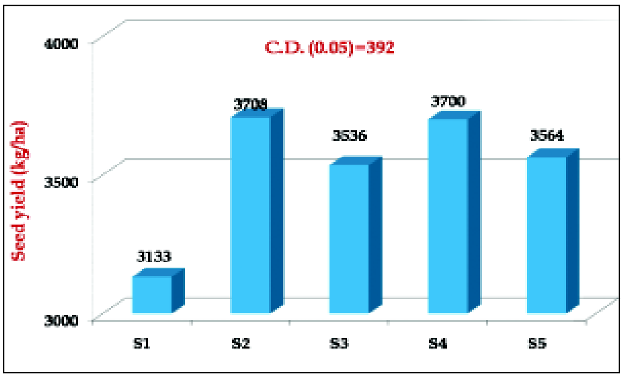


Fig. 48: Effect of drip-fertigation on pigeonpea productivity

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

Introgression of heat tolerance

Four crosses *viz*., DCP 92-3 x ICCV 92944 (16 seeds), DCP 92-3 x ICCV 07110 (6 seeds), KWR 108 x ICCV 07110 (10 seeds) and KWR 108 x ICCV 92944 (14 seeds) involving two heat tolerant genotypes (ICCV 92944 and ICCV 07110) were made to transfer genes imparting heat tolerance.

Evaluation of selected lines under field conditions

On the basis of evaluation data of last two years, 80 genotypes (20 tolerant, 20 sensitive and 40 middle ones) were grown on two dates of sowing to ensure normal and late sown condition. For late sown trial, sowing was done on 14th January following standard agronomic practices. Reproductive phase of most of the genotypes coincided with high temperature and crop faced heat stress. Large variations with respect to pods/plant, seed size, biomass and yield/plant was observed. Genotypes *viz*., ICCV 92944, ICC 3362, ICC 07117, JG 16, Vishal, ICC 1205, ICCL 81248 and ICC 14815 had both, higher grain yield and biomass, therefore can be considered as heat tolerant.

Physiological characterization for thermo-tolerance

Reference set consisting of 280 chickpea accessions were evaluated for two successive years for heat tolerance under late sown conditions. The selection for heat tolerance was made when day-time maximum temperature exceeded beyond 35^{0}C coinciding with reproductive phase. Genotypes exhibited significant variation in thermo-tolerance and grain yield. Selected genotypes were evaluated for thermo-tolerance based on photosynthetic ability involving photochemical quenching, membrane stability, pollen germination and stigma receptivity.

The photochemical quenching ($_{q}$p) indicating the ability of leaf to convert absorbed light into synthesis of ATP or carbohydrates, increased significantly in two heat tolerant lines ICCV 92944 and ICC 15614 as compared to heat sensitive genotype ICC 10685 (Fig. 49). The results suggested the high degree of thermo-tolerance in chickpea.

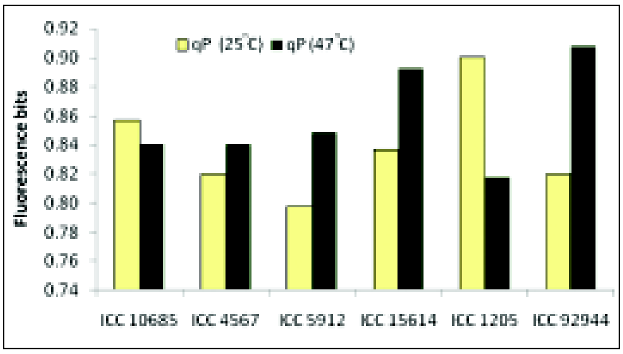


Fig. 49 : Photochemical quenching of different chickpea genotypes pretreated at 25 and 47^{0}C

A large shifting of fluorescence spectra was observed (Fig. 50) when leaves were subjected to high temperature (47^{0}C) that indicated a significant deviation of photosynthetic activity on changing the temperature.

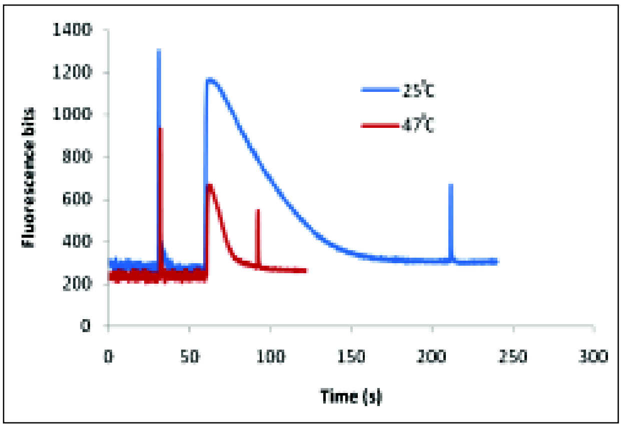


Fig. 50. Fluorescence spectra at two temperatures

Membrane stability index

Highest membrane stability was found in heat tolerant genotype ICCV 92944, while minimum was observed in heat sensitive genotype ICC 10685 (Table 16).

Table 16: Membrane stability index

	ICCV92944	ICC1205	ICC15614	ICC5912	ICC4567	ICC10685
MSI	87.5	82.0	81.2	83.8	83.4	79.9

Per cent pollen germination

At least 10 microscopic fields were scanned for assessing the per cent pollen germination pretreated at different temperature in a specific medium. The broad temperature range between 20-35^0 C was observed for optimum pollen germination. At high temperature beyond 35^{0}C, a drastic reduction in the pollen germination was seen in most of the genotypes. In general, the length of the pollen tubes decreases as the temperature increases from 20 to 43^{0}C. Comparative

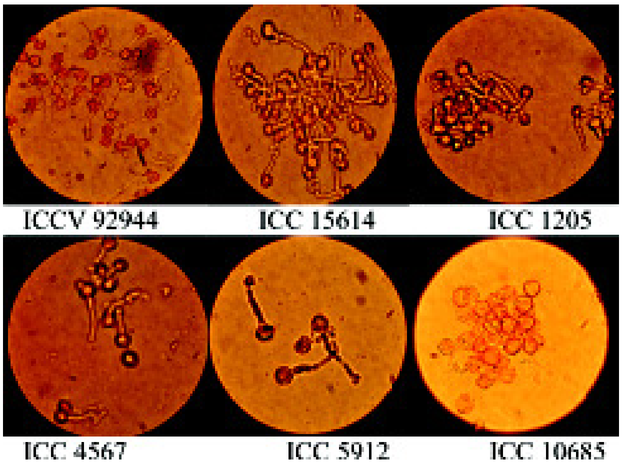


Fig. 51 : Pollen germination at 41^{0}C

studies showed that heat tolerant genotype ICCV 92944 and ICC 15614 had more than 60% pollen germination even at temperature 41^{0}C (Fig. 51).

Stigmal receptivity

In situ pollen germination was observed on stigma surface in heat tolerant genotype ICC 15614, while no germinating pollens were observed in sensitive line ICC 10685 (Fig. 52). The laboratory results confirmed the field trial conducted under late sown condition (Fig. 53).

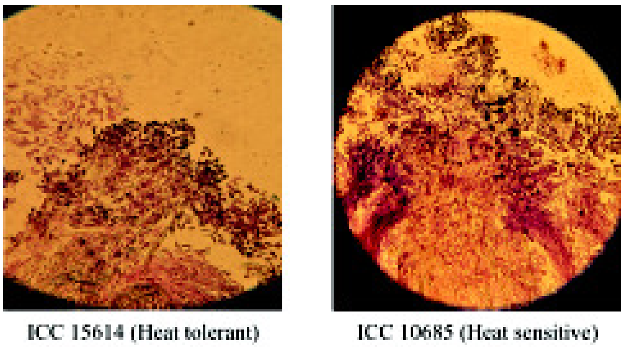
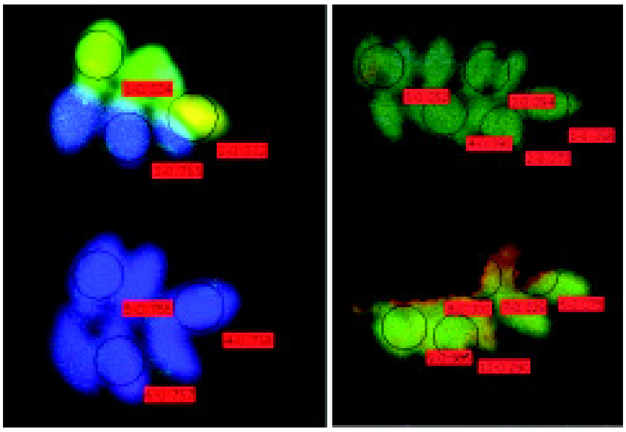


Fig. 52 : Stigmal receptivity in contrasting chickpea lines

Fig. 53 : Heat sensitive line ICC 10685 and tolerant line ICC 1205 under late sown condition

Fluorescence imaging of chickpea leaves subjected to high temperature

Partial inactivation of photosynthetic activity was observed in heat tolerant genotype ICCV 92944, while complete damage was observed in sensitive line ICC 10685 (Fig. 54).



Heat tolerant ICCV 92944 Top (46^{0}C) bottom (20^{0}C)

Heat sensitive ICC 10685 Top 20^{0}C, bottom 46^{0}C

Fig. 54 : Fluorescence imaging of leaves subjected to high temperature

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

Total 100 land races of chickpea procured from ICARDA, Syria were grown to multiply and evaluate the land races in Indian environments. Large amount of variability was observed for various quantitative traits. Out of 100 land races evaluated only one (ILC 10) was of prostrate type and others were semi-erect. The range for the various traits is given below:

Character	Genotype	
	Minimum	Maximum
Days to first flower	57 (ILC 142, ILC 148)	83 (ILC 137)
Days to 50% flower	64 (ILC 142, ILC 148)	89 (ILC 137)
Days to first pod initiation	70 (ILC 147)	91 (ILC 164)
Days to 50% podding	76 (ILC 148)	101 (ILC10, IL 52, ILC157, ILC 158)
Days to maturity	109 (ILC 40	125 (ILC 140,142, 144, 146)
Plant height (cm.)	32	68 (ILC156)
Pod per plant	7	60 (ILC 28)
Seed yield/ plant (g)	2.39	21.47 (ILC 161)
100 seed weight (g)	8.12	48.36 (ILC 149)
Plant type	Prostrate (ILC 10)	Semi-erect (99 acc.)

Maintenance of wild *Cicer* species

Total 78 accessions of 4 wild *Cicer* species (*C. reticulatum*: 51 acc., *C. judaicum*: 10 acc., *C. echinospermum*: 12 acc., C. pinnatifidum: 5 acc.) were maintained under green house condition. Morphological characterization of all the accessions was done. All accessions will be sown during 2011-12 to increase seeds for their screening against major biotic and abiotic stress.

Generation of breeding material

Six interspecific crosses involving *C. reticulatum* (Shubhra x ILWC 21, GNG 469 x ILWC 21 and ILWC 21 x IPC 2008-57) and *C. echinospermum* (IPC 2006-88 x ILWC 179 and IPCK 2002-29 x ILWC 245) were made to generate new variability and broaden the genetic base of cultivated types. Nine crosses made during 2009-10 were advanced and true to the type 9 F_2s were harvested.

Plant Growth Promoting Rhizobacteria for Chickpea and Pigeonpea

Micro-organisms colonizing the internal tissues of plant were isolated from chickpea and pigeonpea plant parts. These are termed as endophytic micro-organisms and isolated from seed, stem, leaves and roots of pigeonpea and chickpea. Two different media, one N-free semi-solid and 1/10 nutrient agar were used to isolate these micro-organisms after surface sterilization of tissues. Around 100 strains of different micro-organisms were isolated for further characterization. Isolated strains were subjected to various biochemical characterization *viz.*, nitrate reduction, catalase and oxidase, starch, gelatin and casein hydrolysis, arginin degradation, tween 80 hydrolysis, IAA production, HCN production, siderophore production, carbon utilization and

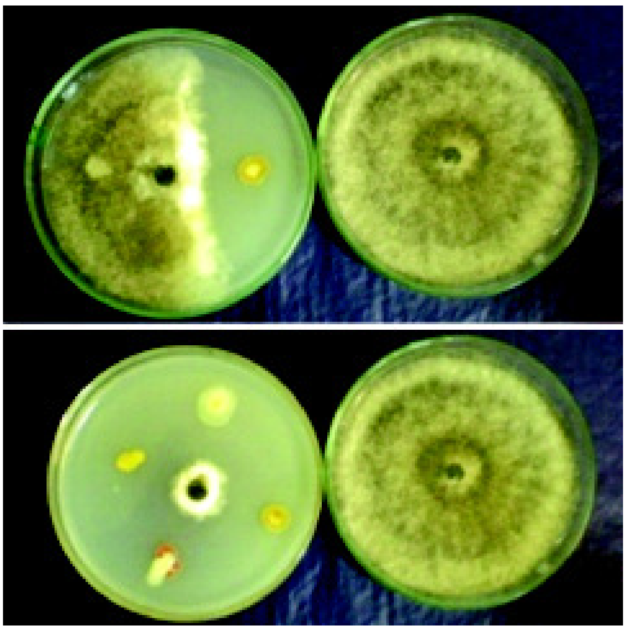


Fig. 55: Antibiosis against wilt pathogens by selected strains of endophytes from pigeonpea

antibiotic profiling and antagonistic activity with wilt pathogen of pigeonpea and chickpea (Fig. 55).

Sixteen endophytes were evaluated for their growth promoting effects in pots filled with vermiculite and soil. Out these, some efficient isolates were selected for further testing in pots filled with unsterilized soil (5 kg/pot). Endophyte showing growth promoting effects greater than 40% as compared to un-inoculated control were selected for field evaluation in micro-plots (Fig. 56).

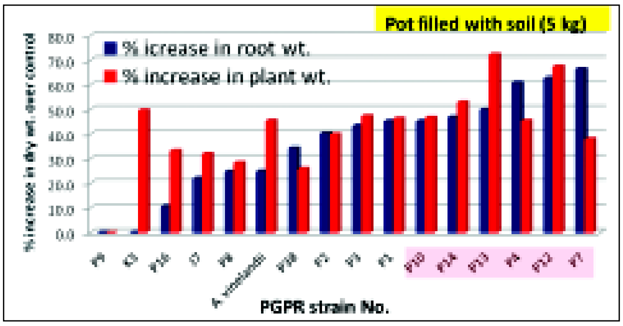


Fig. 56: Effect of endophytic bacteria on growth of pigeonpea seedlings grown in soil

Microbial identification using FAME analysis revealed that chickpea roots and stem were primarily colonized by *Pseudomonas aeruginosa*, while chickpea leaves were colonized by *Photorhabdus luminescens* as endophytic microorganism (Fig. 57). Pigeonpea roots endophytes belong to *Bacillus cereus* and *Stenotrophomonas maltophilia* and were distinct from the endophyte of chickpea roots (Fig. 58).

Third year of field inoculation trial with chickpea var. DCP 92-3 confirmed the growth response and increase in grain yield due to inoculation with different PGPR strains. There was differential response to inoculation ranging from 5 to 20 % increase (Fig. 59) over uninoculated control (19.23 q/ha). Higher increase in grain yield ranging from 14 to 20% over un-inoculated control was obtained with four PGPR strains *viz.*, P 66, CP 11, PSB 11 and J 7. Among these strains three strains *viz.*, CP 11, PSB 11 and J 7 showed consistent response in increasing the grain yield of chickpea under field conditions. These are potential PGPR strains for commercial use in chickpea crop.

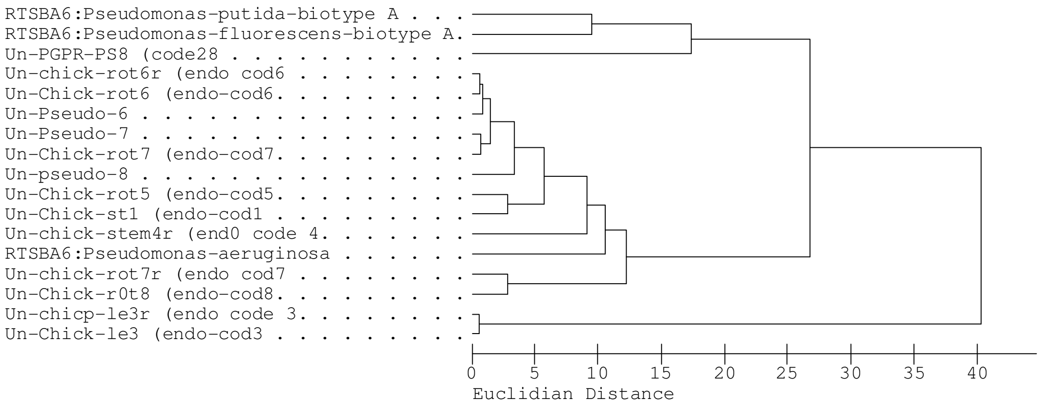


Fig. 57: Identification of endophytes of chickpea and their relationship with each other

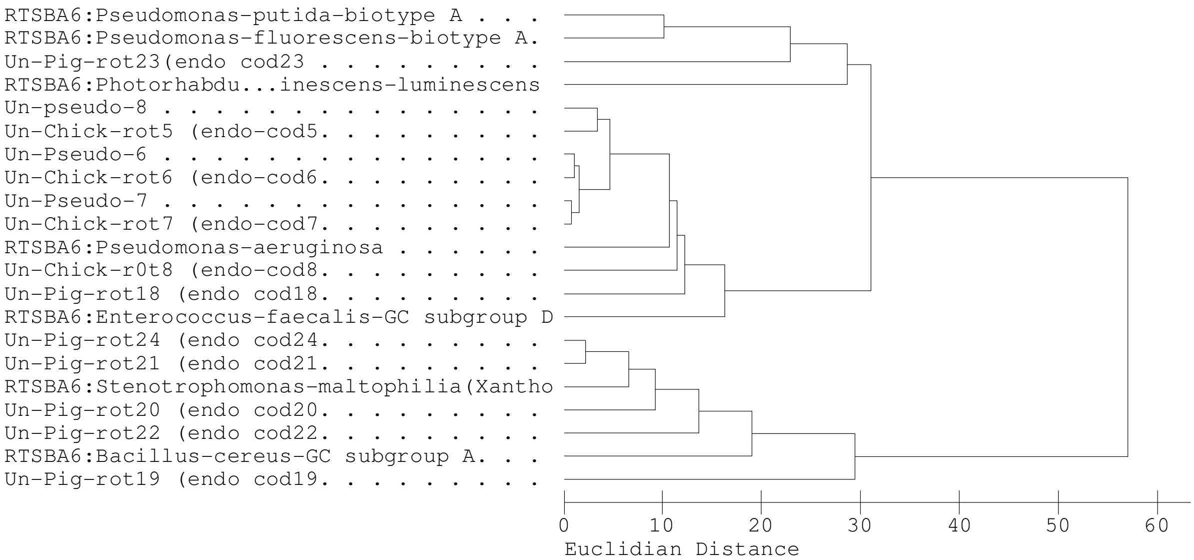


Fig. 58: Identification of endophytes of pigeonpea and their relationship with each other

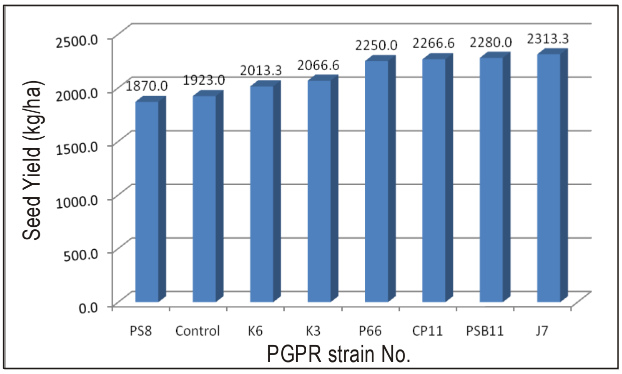


Fig. 59: Effect of chickpea inoculation with different PGPR strains

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

Fusarium Wilt of Pigeonpea

Screening for resistance

Total 455 pigeonpea genotypes comprising of breeding lines, promising selections and elite material were raised in wilt sick plot to screen for resistance to variant 2 of *Fusarium udum*. Wilt incidence in susceptible check was >90%. Seventy nine entries comprising of 27 donors for wilt resistance *viz*., ICP Nos. 8859, 8862, 8863, 9174, 89046, 89048, 89049, 93011, 93012, BWR 377, BDN 1, BDN 2, BSMR 736, BSMR 853, AWR 74/15, JAWS 5-6 A, GPS 33, KPBR 80-2-1, PI 397430, PDE 92-2E, KPL 43, KPL 44, KPL 49, IPA 38A, IPA 38B, IPA 40 and Banda Palera; two breeding lines *viz*., IPA 204, IPA 234; nine germplasm accessions *viz*., ICP 978A, DPPA 85-1, DPPA 85-13, BRG 3, BSMR 736, ICP 87119, IPA 16F, KPL 43 and ICP 8863 (R-Ch); two AICRP entries *viz*., ARCCV2 and ICP 8863, and 39 other promising lines were found resistant to wilt. Genotypes AWR 74/15, BDN 1, Banda Palera, MA 3, ICP 8858, ICP 8859, ICP8863, ICP 9174, KPL 43, KPL 44, PI 397430, IPF 9 and IPA 38 were resistant to variant 2 under artificial screening.

Variability in *Fusarium* in pigeonpea

Forty six isolates of *Fusarium udum* from 13 pigeonpea growing states of India were artificially inoculated on seven differential genotypes by sick soil method for identification of variants. Among seven differentials, reaction of genotypes C11, ICP 8863, ICP 9174 and Bahar could differentiate the isolates as five variants (variants 1, 2, 3, 4 and 5). Isolates from Uttar Pradesh revealed presence of variants 1, 2, 3, 4 and 5, among which variants 1 and 2 were predominant. Isolates from Bihar were identified as variant 2 and 3, from Jharkhand as variants 2 and 4, while West Bengal isolate was identified as variant 4. In central India, variant 1, 2, and 3 were found present in Madhya Pradesh and variants 1 and 4 in Maharashtra. Isolates from South India indicated presence of variants 1, 2, 3 and 5 in Karnataka, variants 1 and 2 in Andhra Pradesh and variant 2 in Tamilnadu. Based on previous and current results, a distribution map of *F. udum* variants in India has been prepared (Fig. 60).

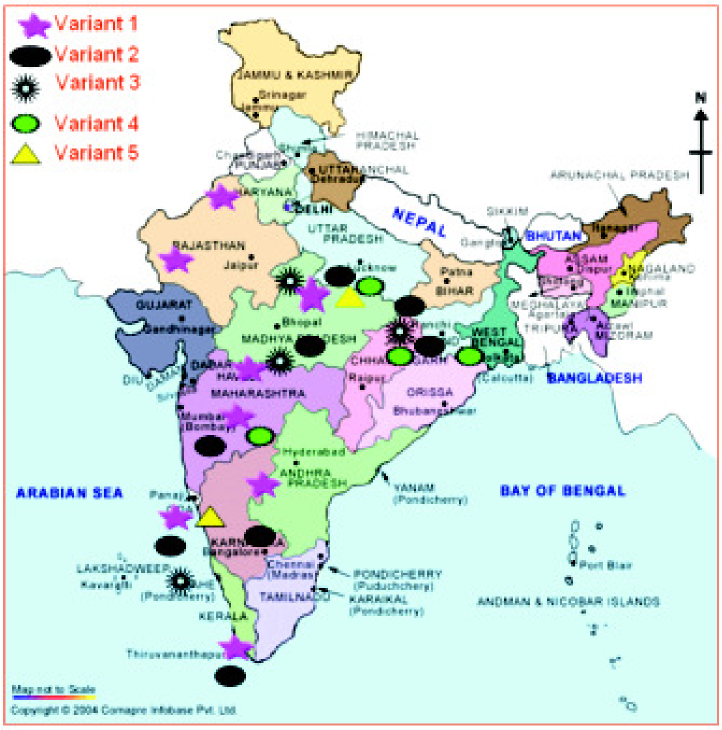


Fig. 60 : Distribution of *Fusarium udum* variants in India

Diversity analysis and diagnostic

DNA extracted from 50 isolates of *F. udum* representing distinct characters and of diverse ecological niches of the country was amplified with 29 *Fusarium* specific primers based on their diagnostic potential. Only four primers (FDP 3, FDP4, FDP 25 and FD5 29) produced single amplicon of diagnostic value in all the isolates. Amplicons from fourteen isolates amplified with primer FDP 29 have been sequenced. The sequencing and homology search result showed maximum similarity with translation elongation factor (TEF) 1 alpha of different species of *Fusarium*. The similarity was as high as 99% for isolate Fu 88 with *Fusarium udum* strain NRRL 22949 translation elongation factor 1 alpha gene, partial cds. This high homology indicates the potential of the new sequences to be designed for markers specific to *Fusarium udum*. In general, most of the sequences showed more than 90% homology and the 'e' value in Basic Local Alignment Search Tool (BLAST) was as low as $1e^{-180}$ indicating the robustness of the results. Multiple sequence alignment (MSA) of sequences amplified by FDP 29 primer in 14 isolates identified the conserved regions in the sequences, which perhaps indicate the essential 'coding sequences' of TEFs in *Fusarium*. The results from MSA and BLAST together will help to identify the conserved and flanking regions, respectively, in the TEF amplicons and therefore, will make it possible to design specific primers for *Fusarium udum*.

Cultures of 20 isolate each of *Fusarium udum* and *F. oxysporum* f. sp. *ciceri* from different pigeonpea and chickpea growing areas of the country have been deposited at NBAIM, Mau for long-term storage and maintenance. Details of morphological, cultural and pathogenic characters have also been provided.

Efficacy of promising bioagents

Seven effective antagonists were identified as promising during previous year (2009-10), comprising strains of *Trichoderma viride, T. harzianum* and *T. virens* (from RAU Dholi, UAS Bangalore and IIPR Kanpur). They were re-evaluated against *Fusarium* wilt of pigeonpea as seed treatment @ 10 g/kg seed to confirm the results. Seed treatment with fungicide carbendazim @ 2.0 g/kg was significantly most effective causing reduction of 73.5% wilt incidence over control. Among antagonists, *Trichoderma viride* (Kanpur) was at par with carbendazim. *T. virens* (Bangalore), *T. viride* (Dholi) and *T. harzianum* (Kanpur) reduced wilt incidence by 41-57% and were the next effective treatments (Fig. 61).

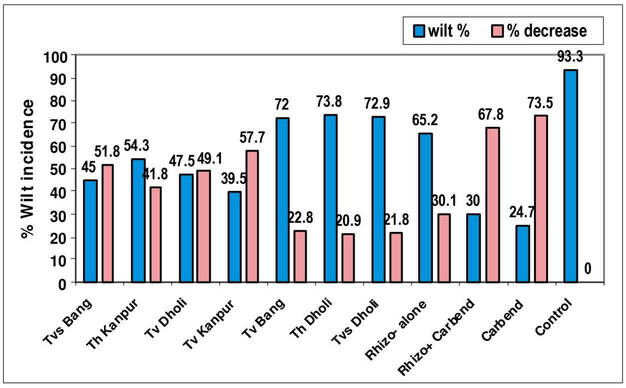


Fig. 61: Effect of antagonists and fungicide seed treatment on pigeonpea wilt

Elicitors in imparting systemic resistance

A pot experiment with soil application and seed soaking with salicylic acid, culture filtrate of *Trichoderma viride* (IIPRT 11), *T. virens* (TVS 12) and *T. harzianum* (IIPRT 31) was conducted to evaluate efficacy of these treatments in imparting resistance against wilt. Soil application of salicylic acid was done @ 20 ppm and seed soaking for 1 h @ 10 and 20 ppm. Seed soaking with culture filtrate of *Trichoderma* was done for 1 h in absolute concentration at the time of sowing. Under soil application treatment, the seed germination was very poor probably due to some toxic effect of salicylic acid at 20 ppm concentration. Seed soaking with culture filtrate of *T. viride* (Kanpur) was most effective in reducing the wilt disease by 81%, followed by *T. virens* (Bangalore). Soil drenching of salicylic acid was however, the next effective treatment reducing wilt incidence by 58% (Fig. 62).

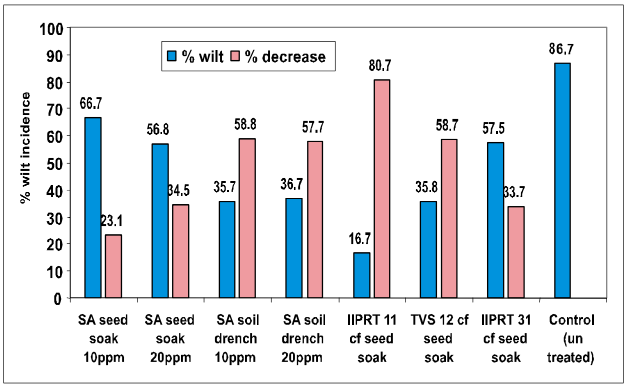


Fig. 62 : Effect of salicylic acid (SA) and culture filterate of antagonists on pigeonpea wilt

Outreach Project on Diagnosis and Management of Leaf Spot Diseases of Field and Horticultural Crops

Cercospora Leaf Spot of Mungbean and Urdbean

Screening for resistance

Thirty seven mungbean genotypes *viz*., BDYR 2, BGG 1, BM 111, CN 8090, CN 9042, DMG 1026, DMG 1030, DU 5-6, E-38, E 93161, GG 1980, GG 1990, GP 205, GP 275, GM 4, GEC 1921, GES 1-9-31, GML 70, IC 52061, IC 324025, IC 362096, INM 646, IPM 03-07, IPM 99-25, Jalgaon 1, Kopergaon 1, Kopergaon Mung 1, GM 99-25, LM 1, LM 12, LM 16, LM 43-1, LM 55, LM 97, LM 228, LM 236 and LM 237 were identified as moderately resistant.

Pathogencity tests of *Cercospora canescens* (ClS 34) was done on mungbean Cercospora leaf spot susceptible variety Kopergaon using 15 days old plants by inoculating detached leaves under pot conditions. Detached leaves inoculated with macerated mycelial suspension were incubated using blotters in petri plates at 26-29°C and 63-95% relative humidity with florescent light. Pin-head size spots appeared at the end of three days. Studies on 11 isolates of *Cercospora* were conducted for their growth rate after 15 days of incubation. Observations showed that isolates CLS 71, 74, 75, 79 and 87 were fast growing (>40 mm), 72, 77 as medium (>35 - 40 mm), 27, 34, 35 and 78 as slow growing (< 35 mm).

Influence of weather factors on development of cercospora leaf spot

First appearance of the disease on mungbean was noticed on 9th September, which gradually increased up to 22.1 and 22.2%, respectively on cvs. Kopergaon and NM 1 by mid-October. Maximum disease development was recorded in the third week of September, followed by first week of October. Minimum temperature showed significant negative relationship with % increase in the disease in subsequent week.

In vitro inhibitory effect of *Trichoderma* isolates on *C. canescens*

Thirty isolates of *Trichoderma* were evaluated for effect of their diffusible metabolites (non-volatile filtrate) on mungbean. Fifteen day old sterile culture filtrate containing non-volatile compounds of these 30 isolates were evaluated for their effect on seed germination, radicle and plumule length at seven days after sowing (DAS), root and shoot length and weight at 15 and 30 DAS. The experiment was conducted on variety Narendra Mung 1 by 1 h seed soaking. The results revealed that *Trichoderma* strain IPRT 2, 6 and 12 gave 100% germination, followed by >80-95% germination by IPRT 7, 11, 18, 23, 24, 26 and 28 as against 80% in untreated seed. Radicle length at 7 DAS was significantly higher due to treatment by metabolites of the isolates. However, IPRT 2, 3, 5, 6, 7, 13, 14, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27 and 28 increased it > double over check, while IPRT 22, 29, 30 and 31 increased by > three times. Similar was the growth improvement of plumule, root length at 15 DAS (IPRT 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 21, 23, 24, 27, 28, 29 and 30). Similarly, shoot length at 15 DAS was significantly better in IPRT 2, 4, 7, 8, 9, 12, 14, 15, 17, 26 and 28. Even at 30 DAS, higher root and shoot length was maintained by IPRT 2, 3, 6, 8, 11, 13, 14, 15, 16, 17, 19, 21 and 31. Higher dry root weight was exhibited by IPRT 3, 5, 6, 7, 8, 11, 13, 15, 16, 17, 25 and 26. At this stage, significantly higher shoot weight was also observed in the plants treated with the metabolites of IPRT 2, 3, 4, 6, 7, 8, 11, 13, 14, 15, 16, 17, 19, 25, 26 and 30. Thus, over all, IPRT 2, 3, 6, 7, 13, 17 and 26 were the best *Trichoderma* isolates which reduced the growth of *Cercospora canescens*, increased plant stand, promoted growth and vigour of mungbean. Inhibitory effect of salicylic acid @ 10 ppm was evident on all 14 isolates of *C. canescens*.

Effect of micronutrients on growth and sporulation of *C. canescens*

Zinc sulphate, copper sulphate, boron, magnesium sulphate and manganese sulphate each at 125, 250, 500 and 1000 ppm were evaluated *in vitro* for their effect on mycelial growth and sporulation of *C. canescens* isolates (27 and 34). Enhancement of mycelial growth of both isolates was observed by $MnSO_4$ @ 125 ppm. On the contrary $CuSO_4$ @ 1000 ppm reduced their growth over control.

Effect of insecticides on *C. canescens*

Eight insecticides mostly recommended for use in pulse eco-system were evaluated for their effect on mycelial growth of *C. canescens* each at 500 and 250 ppm using poisoned food technique. All insecticides at both concentrations significantly reduced mycelial growth of the pathogenic fungus over control. Emamectin benzoate @ 500 ppm was most effective showing 48.8% reduction over control, followed by endosulfan, dimethoate, novaluran, spinosad and rynaxypyr each at 500 ppm.

Evaluation of *Trichoderma* and non-target pesticides for CLS management

Ten *Trichoderma* strains and two non-target pesticides (endosulfan, dimethoate) based on *in vitro* studies were evaluated for their effect on Cercospora leaf spot (CLS, *Cercospora canescens*), anthracnose

(*Colletotrichum capsici*) and powdery mildew (*Erysiphe polygoni*) severity, growth parameters and yield. The experiment was conducted under field conditions on mungbean cv. NM-1. Seed treatment with all *Trichoderma* strains increased fresh and dry shoot weight significantly upto 30 days after sowing (DAS). At 45 DAS, however, the difference with control was non-significant. Among the diseases, anthracnose, Cercospora leaf spot and powdery mildew almost overlapped, hence the status of all three diseases was recorded. Two sprays of *Trichoderma* strains IIPRT 3, 7, 10, 31 and endosulfan significantly reduced anthracnose; IIPRT 10, 11, 2 1, 28 and dimethoate sprays reduced *Cercospora* leaf spot severity and IIPRT 10, 11, 18, 21, 22 and 31 reduced powdery mildew severity. Highest yield (778 kg/ha) was obtained with two spray of 0.07% endosulfan as this pesticide controlled defoliators, sucking pests and blister beetle besides reduction in anthracnose and powdery mildew disease severity. This was followed by spray of IIPRT 31, 11, 21 and dimethoate. As the crop was trapped in heavy rains at maturity, sprays of IIPRT 10, endosulfan, IIPRT 28, 31, 21, 3 and dimethoate gave significantly higher yield.

Integrated disease management

Ten treatments including control were evaluated for management of diseases in mungbean cv. Narendra Mung 1. Seed treatment either with carbendazim @ 2g/kg seed or *Trichoderma* (IIPRT 31) @ 6 g/kg seed was applied in all treatments expect control. Seed treatment (carbendazim or *Trichoderma*), two sprays of 0.05 % carbendazim or two sprays of insecticide (first: 0.07% endosulfan; second: 0.04% dimethoate) or one spray of 0.25% copper sulphate or *Trichoderma* significantly improved plant height and root–shoot biomass. Effective management of anthracnose and CLS was possible by either seed treatment+two sprays of carbendazim or seed treatment of carbendazim+first spray of 0.07% endosulfan, followed by second spray with 0.04% dimethoate. Significant reduction in powdery mildew was obtained by the sprays of carbendazim or *Trichoderma* IIPRT 31. Spraying with carbendazim or *Trichoderma* yielded >nine seeds /pod against 6.3 in control. Higher grain yield (778 kg/ha) was recorded in endosulfan, followed by dimethoate sprays because of the better management of insect pests, anthracnose and CLS as also the lower severity of powdery mildew. Thus, seed treatment with *Trichoderma* @ 6 g/kg seed+one spray of endosulfan (55 DAS) was found best. Replacement of insecticides by two sprays of carbendazim provided 351 kg/ha yield against 239 kg/ha in control.

Molecular Characterisation and Sequence Diversity of Tospoviruses Associated with Fabaceous and Solanaceous Crops

Status of *Groundnut bud necrosis virus*

Survey of Fabaceous and Solanaceous crops (pea, mungbean, urdbean, cowpea, groundnut, rajmash, pigeonpea, potato, tomato, chilli, brinjal) was conducted. Leaf curl/necrosis disease incidence was recorded in the range of 1-5% at Vamban. The incidence of the virus was higher in mungbean crop as compared to other crops. The symptoms of leaf curl or necrosis in urdbean crop were very different at Coimbatore from that at Kanpur. This variation in symptoms in urdbean was due to the infection of Ilarvirus (TSV) at Coimbatore [not the tospovirus (GBNV) as reported from Kanpur] (Fig. 63). The incidence of leaf curl or necrosis was 1-

Fig. 63: Symptoms of Ilarvirus in urdbean at Coimbatore

15% in mungbean and urdbean at Coimbatore. One field of cowpea crop was severely affected (90% incidence) by GBNV at TNAU, Coimbatore, showing typical chlorosis/ necrosis symptoms (Fig. 64). Pea (cv. Azad 1) crop was grown in a large area of Jaipur, which was very healthy. Only in a few fields we observed the tospovirus infection, which was <1%. However, in tomato crop, incidence of tospovirus (GBNV) was in the range of 1-10%. At Raipur, there was heavy attack of thrips in mungbean and urbean crops. Leaf curl incidence was in the range of 5-50% in

Fig. 64: Symptoms of GBNV on cowpea at Coimbatore

mungbean and urdbean (Fig. 65). At Aurangabad, incidence of GBNV in tomato crops was in the range of 10-90%. At Badnapur, heavy attack by thrips was recorded on urdbean crop.

Fig. 65: Symptoms of leaf curl and yellow mosaic on urdbean and infestation of thrips at Raipur

Variability in NP and NSm genes of GBNV infecting pea

NP, NSm genes of four different GBNV isolates of pea collected from different locations *viz*., Bareilly (BRY), Kanpur (KNP), Udham Singh Nagar (USN), Shahjahanpur (SJP) were cloned and sequenced to find out the variability in nucleotides, amino acid levels, which were designated as GBNV-[Pea_BRY], GBNV-[Pea_KNP], GBNV-[Pea_USN] and GBNV-[Pea_SJP]. The sequence data of each isolate were deposited at NCBI database. The complete nucleotide sequence of the NSm and NP genes of all the GBNV isolates had single open reading frame (ORF) of 924, 831 nucleotide base pairs and 307 and 278 amino acids, respectively. There was only 3% variability in the NP gene of GBNV isolates under study at nucleotide level and only 2% variation existed at amino acids level. Contrastingly, in the NSm gene of these isolates there was 8% variability at nucleotides level and 3% at amino acids level. This indicates that the nucleocapsid protein (NP) gene is highly conserved in the GBNV isolates, while the non-structural movement protein (NSm) gene has high variability.

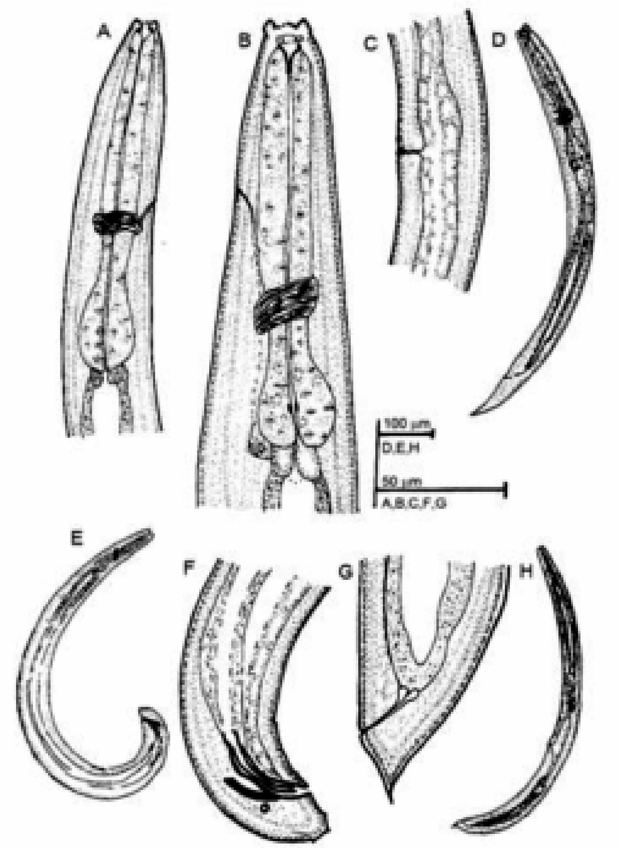
The amino acids of NSm gene of GBNV isolates under study differed from the type isolate of GBNV at 10 positions. Isolates, GBNV-[Pea_BRY] has leucine and asparagines at position 4 and 276. However, these positions were occupied by phenylalanine and serine in the GBNV type isolate. The amino acids at positions 4 (phenyalanine), 127 (serine), 291 and 298 (aspartic acid), and 299 (isoleucine) of GBNV type isolate were substituted by leucine, lysine, glycine, alanine and threonine, respectively in GBNV-[Pea_KNP] isolate. GBNV-[Pea_USN] isolate had differed at three positions *viz*., 4 (leucine), 127 (lysine) and 291 (glycine) from the type isolate. The GBNV-[Pea_SJP] has the maximum six substitutions of amino acids from GBNV type isolate at positions 4, 93, 127, 205, 283 and 292.

The amino acids of NP gene of GBNV isolates under study differed from the type isolate of GBNV at six positions only. The GBNV-[Pea_SJP] and type isolates are identical with respect to amino acid sequences. The amino acids at positions 17 (alanine), 42 (threonine) and 45 (asparagines) of GBNV type isolate were substituted by serine, alanine and serine in GBNV-[Pea_BRY] isolate. Similarly, the amino acid positions 42 (threonine), 45, 177 (asparagines) and 205 (glutamine) of GBNV type isolate were substituted by alanine, threonine, aspartic acid and glutamic acid, respectively in GBNV-[Pea_KNP] isolate. The GBNV-[Pea_USN] isolates differed at three positions *viz*., 42 (alanine), 45 (threonine) and 268 (proline) with GBNV type isolate. In general, the variability in amino acid of NSm gene of GBNV isolates of pea is high in comparison to the NP gene. The GBNV-[Pea_SJP] isolate has the highest variability in NSm gene at amino acid level. However, there is no variability in NP gene of this isolate in comparison to GBNV type isolate. This indicates that the NP gene of GBNV is highly conserved and variability exists in the NSm gene.

Management of Pests of Stored Grains/ Seeds of Cereals and Pulses through Entomopathogenic Nematodes (EPN)

Survey, collection and baiting of desiccation-tolerant (EPN) population

Among the 195 soil samples collected for identification of desiccation-tolerant EPN population, one new species, *Steinernema* strain IIPR 04 was identified from the soil collected from Shivrajpur of Kanpur district. *Steinernema* sp. n. IIPR 04 is unique in having two cuticularized pieces present at lip region, stoma forming a ring like structure with cheilorhabdions along with cuticularized pieces and presence of three caudal papillae instead of two in the genus. The new species is characterized by hair like mucron on tail tip and excretory pore present far anterior to nerve ring in female. Gubernaculum head bifurcate in male. The new species resembles *Steinernema abbasi* (Elawad *et al*., 1997), but *Steinernema* strain IIPR 04 has longer tail (40 µm) as compared to that in *S. abbasi* (17-20 µm) and shorter spicule. *Steinernema* sp. n. IIPR 04 has double epiptygma in vulval region. *S. abbasi* lacks mucron in first generation females, whereas in the new species, it is present in both generations of females. *Sterinernema* sp. n. IIPR 04 also resembles *Steinernema masoodi* (Ali *et al*., 2005), but differs in having greater d% value and has offset lip region, whereas in *S. masoodi* lip region is continuous. *Steinernema* sp. n. IIPR 04 can also be compared with all other species in having three caudal papillae whereas in genus *Steinernema* only two post-caudal papillae are seen (Fig. 66).



Female: B. Anterior region, C. Vulval region, G. Posterior region, H. Entire body, **Infective juvenile:** D. Entire body, **Male:** A. Anterior region, E. Entire body, F. Posterior region

Fig. 66: *Steinernema* sp. n. IIPR 04

Efficacy of EPN formulation against bruchids

Efficacy of talc-based formulation of EPN species *viz*., *Oscheius amsactae*, *Oscheius* strain IIPR 02, *Acrobeloides* strain IIPR 04 along with talc-powder and untreated control was tested against bruchids, *C. chinensis* in mungbean (cv. Meha) under laboratory conditions (30 ± 2°C, 65% RH). Samples of 500 g of mungbean seeds were taken in a mud pot (2 kg capacity) for each treatment and the talc-based EPN formulations (5 g; 5000 IJs per g) and talc-powder (5 g) were uniformly treated with the seeds. Five pairs of newly emerged adults of pulse beetle were released in each pot, covered with a piece of cloth, provided laboratory condition for bruchid oviposition and their multiplication. The data on the number of eggs laid and per cent damage were recorded at intervals of two, four and six months after the treatment. For recording oviposition, one hundred seeds from each replicate were taken randomly. The number of eggs laid per 100 seeds was calculated. Likewise, one hundred seeds of each replicate were randomly taken to sort out the insect-damaged, undamaged seeds and computed the percentage of damaged seeds. The talc-based formulation of *Oscheius* strain IIPR 02 recorded lower number of eggs (51 eggs/100 seeds) and per cent damage (16.6%) at two months after treatment as compared to other treatments (79.6 to 110 eggs/100 seeds; 18.8 to 27% damage) and untreated control (163 eggs/100 seeds; 32.8% damage). However, there was no significant difference in number of eggs laid and per cent damage among the EPN formulations, talc-powder and untreated control at four and six months after treatment.

Studies on target host finding by EPN

The ability of EPN species *viz*., *Steinernema masoodi* and *Oscheius* strain IIPR 02 to find target bruchid adults (*C. chinensis*) in soil, dust (talc-powder) and seeds (pigeonpea seeds) was studied. Cups were filled with sterile soil (15 to 25% moisture content), dust (15% moisture content), and seeds (8-10% moisture content). Ten adult bruchids within a perforated 5 ml microcentrifuge tube was inserted in the soil, dust and seed medium. A concentrated 0.5 ml suspension of 500 IJs in water was added to soil/dust/seed surface and compared with untreated check (without EPN inoculation). Cups were covered and incubated at room temperature for two days. Thereafter, dead or living bruchids were placed on moist filter paper in separate 60 mm dia petri dishes and transferred to 25ºC. The dead test insects were cut open and number of nematodes per target was counted. The results indicated recovery of more number of IJs from the target insect in the bottom of the cups having soil (35-40 IJs and 45-55 IJs per target insect) in *S. masoodi* and *Oscheius* strain IIPR 02, which was followed by dust with recovery of 22-28 IJs and 30-36 IJs per target insect in *S. masoodi* and *Oscheius* strain IIPR 02, respectively. In case of seed, there was no recovery of IJs from the target insect in both the EPN species.

Studies on Variability in *Fusarium oxysporum* f. sp. *ciceri* for Identification of Race-specific Donors for Resistance to Chickpea Wilt and its Management

Sixty isolates of *Fusarium oxysporum* f. sp. *ciceri* (*Foc*) were collected from 24 districts of Uttar Pradesh. Based on the observations on pathogenicity test, these 60 isolates were categorized into 3 distinct groups, in which, three isolates were found weak pathogenic causing <30.0% seedling mortality, while 17 isolates were characterized as moderately pathogenic causing 30.1 to 50.0% seedling mortality. Remaining 40 isolates were characterized as highly pathogenic with >50.1% wilt incidence.

Mycelial growth rate of 35 isolates of *Foc* was studied for 168 h at 25+1^{0}C, based on which, four isolates were found as slow growing (<60.0 mm growth), five isolates growing at medium pace (60.1 to

75.0 mm growth) and 16 isolates as fast growing (75.1 to 90.0 mm growth). In case of colony colour and mycelia growth pattern, most of the isolates were white in colour, exhibiting compact, fluffy and appressed growth.

Thirty five isolates of *Foc* were studied for their morphological characters. Based on the size of micro- and macro- conidia as well diameter of chlamydospores, 18 isolates were categorized with large sized macro-conidia (22.5-45.0 µ x 3.0-5.0 µ), 15 isolates with medium sized macro-conidia (15.0-25.0 µ x 2.5-3.0 µ), while two isolates with small-sized macro-conidia (12.5-17.5 µ x 2.5-3.0 µ).

Thirty isolates of *Trichoderma* were isolated from different crop niches, out of which 22 were *T. harizianum*, seven were *T. viride* and one was *T. virens.* All these isolates were evaluated for their potential against *Fusarium oxysporum* f. sp. *ciceri* race-2 (Kanpur isolate) by dual-culture technique. Effect of volatile and non-volatile compounds of *Trichoderma* on the growth of *Foc* as well as their tolerance to high temperature was also studied. Inhibition percentage of *Foc* by different isolates of *Trichoderma* ranged from 10.7 to 28.5 (at 72 h). Isolates most effective against *Foc* were IIPRT 2, 4 and 6, followed by 10, 17, 22 and 29. Inhibition of conidia production by different *Trichoderma* isolates ranged between 44.4-88.8%, wherein isolates IIPRT 4, 6, 8, 16, 25 and 28 were most effective against *Foc*. Non-volatile compounds in the culture filtrate of *Trichoderma* isolates IIPRT 5, 7, 11, 17, 19, 25 and 31 exhibited >52.1% mycelial growth inhibition of *Foc*. Culture filtrate of isolates IIPRT 5, 6, 9, 13, 14, 15, 16, 17, 18, 19, 22, 24 and 31 were highly detrimental to sporulation showing 85.7 to 100.0% inhibition of conidia production of the pathogen. Volatiles produced by the 30 isolates of *Trichoderma* showed 25.0-65.3% growth inhibition, in which IIPRT 24 and 28 were most inhibitory (50.0-65.3%), followed by IIPRT 2, 6, 9, 11, 20 and 31. Inhibition of conidia production ranged between 25.0 - 87.5%. IIPRT 3, 6, 9, 11, 16, 20, 24, 28 and 31 were most effective in reducing sporulation of *Foc*. All 30 *Trichoderma* isolates grown at high temperature (50+2^{0}C) exhibited mycelia growth ranging between 29.0-90.0 mm and 47.5-90.0 mm at optimum temperature (28+1^{0}C). Isolates IIPRT 4, 7, 11 and 31 showed no reduction in mycelial growth at high temperature regime thus showing tolerance towards high temperature.

Taxonomy, Distribution and Biology of Entomopathogenic Nematodes Infesting Insect Pests of Pulses in Uttar Pradesh

More than 70 soil samples were collected from different districts of UP. After processing of all samples, one new species of *Steinernema*, two of *Acrobeloides* and three of *Oscheius* were discovered. In the second year, mass multiplication of three species of *Oscheius* was carried out in the laboratory on different media. After a number of experiments it was found that media made of k*abuli* chickpea is good for *in vitro* culture and this medium is termed as IIPR medium. Simultaneously, virulence of these three species of nematodes was checked against *H. armigera* and *C. cephalonica.* All above mentioned species were heat tolerant and anti-dessicant. Nematodes samples were sent for scanning electron microscopy in order to confirm their exact taxonomic position and all three were found to be new species. Earlier, *Oscheius* was considered as necromenic, but after getting *endotokia matricida* stages, it is proved that they are entomo-pathogenic.

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 biorationals *viz.*, pheromone traps, NSKE, HaNPV and safer insecticide (Spinosad) for management of *Helicoverpa armigera* among the resource poor farmers, the project was initiated four villages *viz.*, Barai, Mungarol, Kashikera and Newari of Jalaun district. Awareness campaigns were organized in the project villages on *Helicoverpa*, its damage and management using bio products. To give on- hand experience to farmers in production and utilization of the biorationals, demonstrations were laid out in 20 ha area among 100 participating farmer. To build farmers capacity for production and utilization of the biorationals, on campus as well as on farm trainings were organized for the participating farmers.

Data on pod damage, yield enhancement and farmers perception about use of biorationals were gathered using personal interview method. It was observed that incidence of *H. armigera* crossed ETL in the month of February and it ranged between 6.0 to 8.68 larvae/row (an average of 7.37) in different fields. In most of the fields, Ist to 2nd instar larvae were recorded. Spray of antifeedant Neemarin resulted in reduction in population of larvae and it ranged between 3.8 to 7.53 larvae/row (an average of 5.69 /meter row). The HaNPV spray during pod formation stage resulted in further reduction in larval population after 5 days of spray and it ranged between 2.1 to 3.40/m. row(Av. 2.77) as compared to an average of 5.59/m. row (ranges between 4 to 7.25/m row) in the pre-treated count. The spinosad spray coinciding with the pod maturation stage, resulted in reduction in larval population below ETL *i.e.*, 0.3 to 0.65 with an average of 0.51/m. row as compared to 2.83 larvae/m. row (2.3 to 3.55) prior to spray (Fig. 67).

It was also recorded that the biorationals module used for *H. armigera* management along with improved variety (JG 16/DCP 92-3) recorded lower percent of pod damage (8.8%) as compared to biorationals module alone (11.3%). The percent pod damage was higher (20.1%) in the non participating farmers' fields, in which local varieties were used without any insecticidal spray. The combination of improved varieties and biorational pest management resulted in higher grain yield and gross returns (14.60 q/ha and Rs. 30,660/ha) as compared to biorational pest management alone (8.7 q/ha and Rs. 18,270/ha) and the fields of non participating farmers (Rs. 13,776/ha). Hence the incremental returns was highest in biorationals pest management along with improved variety (Rs. 16,884/ha) as compared to biorationals pest management alone (Rs 4,494/ha).

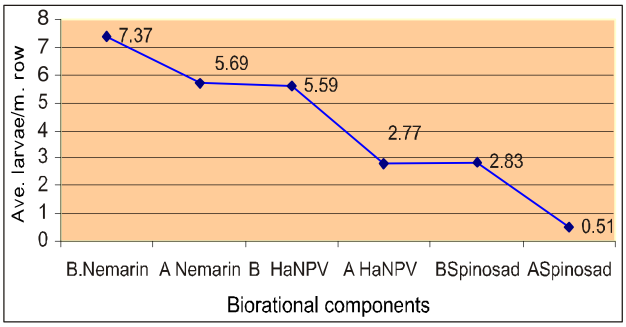


Fig. 67: Average larval count per meter row in chickpea before and after spray of biorationals

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

To improve rural livelihood and nutritional security through increased production of lentil especially in rice fallows and to evaluate the benefit of participatory technology, farmers participatory varietal selection trials on lentil were laid in 10 farmers' fields in Fatehpur and Ballia districts each. Farmers cultivated three improved varieties along with the local variety on the same field to evaluate and select the best suited variety. Among the three varieties NDL 1 gave highest yield (19.50 q/ha and 13.00 q/ha), followed by HUL 57 (17.00 q/ha and 10.00 q/ha), IPL 81 (14.50 q/ha and 11.00 q/ha), local (10.00 q/ha and 8.00 q/ha) in Fatehpur and Ballia districts (Fig. 68). Though all varieties were superior to the local variety, the majority of farmers preferred NDL 1 in rainfed monocropped situation of Ballia district and rice-lentil under irrigated situation of Fatehpur due to its high resistance against wilt, higher yield and remunerative price in market.

Six villages each in Ballia and Fatehpur districts were selected for seed production of lentil. Seed production of three varieties *viz.*, NDL 1, HUL 57 and IPL 81 wes undertaken in 16 ha area of 50 farmers' fields in Ballia and 12 ha area of 45 farmers' fields in Fatehpur. Total 136 quintals lentil seed was produced

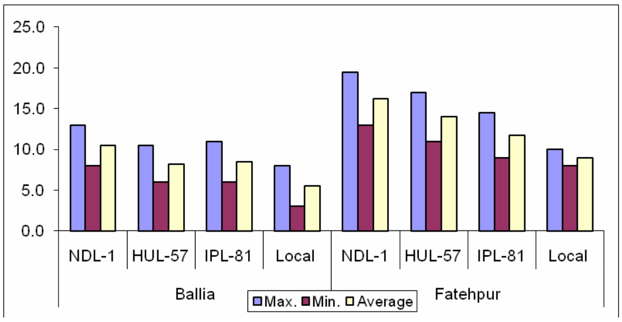


Fig. 68: Performance of farmer participatory varietals selection trial of lentil

in Ballia district and 148 quintals in Fatehpur districts during 2010-11. Details of disposal pattern of lentil is given in Table 17.

Table 17: Production and disposal pattern of lentil produced

District/ Village	Total production (q)	Quantity kept as seed for next year	Quantity sold in market	Quantity kept for own consumption
Ballia District				
Khathariya	30.0	12.0	8.0	-
Chaura	20.5	16.0	3.0	0.5
Laddupur	35.0	24.0	11.0	-
Ferojpur	20.5	13.0	5.0	2.5
Daulatpur	18.0	14.0	3.5	0.5
Subandha	12.0	09.0	2.5	1.0
Total	**136**	**88**	**33**	**4.5**
Fatehpur District				
Mauhar	48.00	20.00	26.00	2.00
Alipur	22.00	12.00	09.00	1.00
Pahur	27.50	14.00	12.50	1.00
Adampur	10.50	04.00	5.50	1.00
Selawan	34.00	22.00	10.00	-
Mandraw	6.00	2.00	3.50	0.50
Total	**148**	**74**	**66.5**	**5.5**

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

For demonstrating IPM modules in farmers' participatory mode to suit their cropping systems, three blocks *viz.*, Kamasin in Banda district, Kurara and Maudaha in Hamirpur district were identified for pigeonpea and Kamasin in Banda and Sumerpur in Hamirpur districts were selected for chickpea. Total 28 villages involving 997 farmers were covered under pigeonpea demonstration in Banda district, where as 18 villages involving 345 farmers in Kurara, 19 villages and 330 farmers in Maudaha unit of Hamirpur were covered under the programme. Seeds of improved variety of pigeonpea (Mal Arhar 13) @ 4 kg per farmer, pheromone trap, HaNPV and emamectin benzoate were demonstrated at each farmer's fields. Efficiency of different bio- as well as chemical insecticides was worked out against management of pod borer and pod fly in pigeonpea. Majority of farmers were fully convinced with effect of application of HaNPV at flowering stage and emamectin benzoate at pod formation stage against the pod borer in pigeonpea. The additional net return (profitability) due to management of pod borer by application of different insecticides is given in Fig. 69.

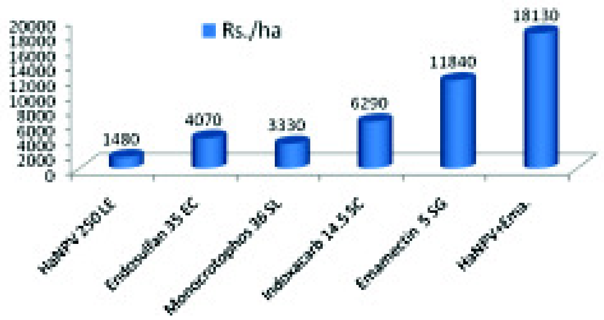


Fig. 69: Additional net return (Rs/ha) due to IPM in pigeonpea

For proper management of pod borer (*H. armigera*) in chickpea, two blocks *viz.*, Kamasin in Banda and Sumerpur in Hamirpur districts were selected by involving 76 and 491 farmers' fields, respectively. Pheromone traps and HaNPV were demonstrated in each field. Farmers were trained on use of pheromone traps and application of HaNPV. Farmers sprayed HaNPV @250 LE at different crop stages *viz.*, flower initiation, flowering, flowering and poding and poding. The effect of HaNPV indicated that spraying at flower initiation stage was very effective in reduction of larval population of pod borer in chickpea. Only 8.74 % pod damage was recorded in Kamasin, whereas 10.48 % pod damage was noticed in Sumerpur (Table 18). Majority of farmers were convinced with the effect of HaNPV against pod borer.

Table 18: Effect of HaNPV (250 L.E) against pod borer in chickpea

Stage of crop	Kamasin (Banda)		Sumerpur (Hamirpur)	
	% pod damage	Yield (q/ha)	% pod damage	Yield (q/ha)
Ist fortnight of January (Flower initiation)	8.74	14.60	10.48	13.70
2nd fortnight of January (Flowering)	12.80	12.10	16.10	12.50
Ist fortnight of February (flowering & podding)	18.87	10.40	19.49	9.80
2nd fortnight of February (Podding)	20.59	9.70	24.21	8.30

Promoting Use of *Trichoderma* sp.- An Eco-friendly Approach for Management of Wilt and Root Rot Complex in Major Pulse Crops in Bundelkhand Region

To promote the use of *Trichoderma* sp. in Hamirpur district of Bundlekhand three villages *viz.*, Naranpur, Soukhar and Nadehra were added during the year, besides earliar selected three villages *viz.*, Baank, Baanki, Bilahari of Bharuva Sumerpur block. Total 250 *Trichoderma* demonstrations on pigeonpea (50), chickpea (100) and lentil (100) were conducted in adopted villages. The efficient strain IPRT 31 of *Trichoderma harzianum* was used to make a formulation (6.8-7.2 X 10^9 CFU/g). The strain is effective under drought conditions. The formulation was used at farmers' fields as seed and soil inoculation @ 6.0 g/kg seed and 1.0 kg/acre, respectively. The results showed that decrease in average total plant mortality due to root rot and wilt over untreated was 17.82 % in lentil and 22.8 % in chickpea.

The average yield loos due to root rot and wilt in lentil was higher than chickpea. The major factors in disease management were identified as lack of knowledge on diseases, poor identification skills between insects and diseases affected symptoms, unavailability of quality bio-pesticide, lack of knowledge and skills in application bio-pesticides and poor cooperation from Govt. seed/pesticide store. Rejection of *Trichoderma* technology was observed due to lack of visible impact at first application because level of disease infestation in field was higher.

Farmers' Participatory Seed Production of Major Pulse Crops in Selected Villages of Hamirpur District in Bundelkhand Region

To improve seed replacement rate of major pulse crops, farmers' participatory seed production was carried out in two selected villages *viz.*, Baank and Baanki of Bharuwa Sumerpur block of Hamirpur district in Bundelkhand. Quality seed of pigeonpea var. Narandra Arhar 1(390 kg) and lentil var. DPL 62 (720 kg) was given to the farmers. The area covered in pigeonpea and lentil was 26 and 15 ha, respectively. Farmers shared half of seed cost as Rs. 17,550 for pigeonpea and Rs. 21,600 in lentil. The crop was sown under rainfed conditions and inspected and registered through Uttar Pradesh Seed Certification Agency, Jaloun. Improved varieties were observed better over local with more plant vigour, plant height, higher number of pods and less incidence of aphid in lentil. The maturity period of Narendra Arhar 1 was one week higher over the local. Lack of rains from December to February affected the yield. Broadcast sowing, higher plant population, high weed intensity, lack of irrigation facilities, and maintaining of segregation distance were the major problems in pigeonpea seed production.

The chickpea seed (DCP 92-3, JG 16 and KGD 1168) produced in previous season was diffused from two to eighteen villages. Out of 193 q chickpea seed produce 140 q (75%) was utilized in adopted villages and rest 53 q (25%) in other 18 villages in a radius of 24 km. The number of chickpea growers increased from 60 to119. The major channels in seed diffusion were farmers' club meetings, relatives, state department meetings, Newspapers, family members and neighbourers. An average of 23 percent gain was achieved in quality seed sell.

All India Coordinated Research Projects

CHICKPEA

Varieties Released and Notified

IPCK 2004-29 has been released for central zone comprising of Madhya Pradesh, Chattisgarh, Maharashtra, Gujarat, Bundelkhand tracts of U.P. and southern Rajasthan.

Phule G 0517 has been released for Maharashtra, Madhya Pradesh and Karnataka.

PKV *Kabuli* 4 has been released for Maharashtra and Madhya Pradesh.

MNK 1 has been released for south zone comprising of Karnataka, Andhra Pradesh, Tamil Nadu and Orissa.

Varieties Identified

IPCK 02 : This variety has been developed through selection and identified for Punjab, Haryana, Delhi, North Rajasthan, western U.P. and Jammu. It has semi-erect plants with light green foliage and large leaflets. Seeds are of white beige colour, extra large (56.0 g/100 seeds) and typically ram head shape. It matures in 151 days, with average yield of 14 q/ha. It is tolerant to wilt and dry root rot

WCGK 2000-16 : This variety has been developed from cross L 550 x ICCV 2 and identified for Punjab, Haryana, North Rajasthan, western U.P., Delhi and Jammu. It has semi-erect growth habit with light green foliage. The seed size is large (27.5 g/100 seeds) and of white beige colour. Its average yield is 23.0 q/ha and matures in 147 days. It is moderately resistant to *Fusarium* wilt.

Germplasm Evaluation

Total 10894 germplasm accessions were maintained at 13 centres. These accessions will be evaluated and rejuvenated in different years.

Breeder Seed Production

Total 8849.67q breeder seed of 84 varieties was produced against DAC Indent of 9380.75 q.

Research Achievements

- Under late sown conditions, the optimum plant population was found 44 plants/sqm (30 cm x 7.5 cm).
- Under rainfed conditions, deep sowing (10 cm) and seed priming (soaking of seed in water for 4-5 hours) proved beneficial.
- Applications of FYM @ 5t/ha and 20 kg S/ha increased the grain yield of chickpea.
- Two irrigations given at branching and pod development stage increased the grain yield. Under limited irrigation, one irrigation should be given at branching stage. Raised bed method of planting increases the grain yield over flat bed method.
- Based on field performance and drought susceptibility index (DSI), genotypes RSG 888, BGD 72, RSG 807, PG 96006, JG 315 and IPC 97-72 showed consistenly higher drought tolerance which was at par with RSG 143-1.
- Genotypes *viz*., ICCV 10, IPC 97-72, RSG 888, RSG 931, RSG 143-1 and SAKI 9516 were identified for higher water use efficiency.
- Membrane injury index was found significantly less in high temperature tolerant genotypes ICCV 92944 and ICC 4958 as compared to sensitive ones such as PBG 5 and C 214. Per cent Pollen germination was also higher in tolerant lines.
- Traits like early flowering combined with high biomass accumulation and higher foliar resistance were identified for cold tolerance. These characteristics features were observed in genotypes *viz*., ICCV 92944, ICCV 88506, IPC 94-94, PG 96006, IPC 97-72 and ICCV 88506. However, ICCV 96030, ICCV 96029, ICCV 88503, ICCV 88505, ICCV 88506 and PG 96006 yielded high under low temperature condition.
- Screening of rhizobia at Bangalore and Sehore under field conditions showed that strains 10 and RVSGRS 117 were more efficient at these centres. Out of 31 isolates screened under sterilized condition at Hisar, two isolates CH 2009-42 and CH 2009-507 were found more efficient than the reference strains.
- Rhizobial isolates from Bangalore, Sehore, Coimbatore, Ludhiana and Hisar were sent to Delhi Centre. Molecular diversity of rhizobia from Pantnagar and Delhi was assessed and isolates from Pantnagar were found molecularly divergent from IARI isolates.

- Application of 1.0 kg/ha ammonium molybdate (Mo) as soil or seed treatment significantly enhanced the effect of microbial inoculants (*Rhizobium*+PSB) inoculation and an significant increased the nodulation, N and grain yield of chickpea (26%) at 4 locations in M.P.
- Based on three years data, entries *viz*., JSC 35, GL 23094 and IPC 2004-52 are recommended as donors to incorporate resistance against wilt, ascochyta blight and stunt, respectively in breeding programme.
- Reaction of 14 chickpea differential genotypes against races of *F. oxysporum* f. sp. *ciceri* was evaluated at 9 locations and when compared with the Phillips reaction (1988), indicated the existence of race 2 at ICRISAT, Junagadh, Sehore and Jabalpur as JG 315 only exhibited resistant reaction which matches with the reaction of race 2 against these genotypes.
- Genotype BG 3002 exhibited dual resistance against wilt and dry root rot, and GL 26054 against wilt and ascochyta blight diseases.
- Entries *viz*., IPC 2004-52, JG 2000-14, JG 2004-03, PG 9425-9 and H 82-2 have shown stable resistance/moderately resistance against wilt across the locations and over the years. Similarly, entries *viz*., IPC 2000-6 and H-01-80 have shown stable resistance/moderately resistance against stunt and ascochyta blight, respectively across the locations and over the years.

Front Line Demonstrations

Total 1307 front line demonstrations were conducted in different zones. In 532 demonstrations conducted with high yielding varieties, the overall mean grain yield of high yielding varieties was 1670 kg/ha, which 21.1% higher than old/traditional varieties. The mean yield of sulphur and zinc applied demonstrations was 10.6 and 11.8% higher, respectively. Seventy five demonstrations on foliar application of 2% urea solution gave 13.5% higher yield and 13.2% higher returns. Ninety demonstrations on insect-pest management gave 25% higher yield. Three hundred forty demonstrations conducted with improved package of technology gave 1510 kg/ha of mean yield. Demonstrations on impact of Rhizobium inoculation resulted in 12.4% higher yield. Forty six demonstrations on weed control gave 1461 kg/ha of grain yield, which was 21.5% higher than the control.

Official Website for AICRP on Chickpea

AICRP on Chickpea added a feather to its cap after getting its official website with domain name **www.aicrpchickpea.res.in** launched by Smt. Abha Asthana, Additional Chief Secretary & APC, Govt. of Madhya Pradesh during 15th Annual Chickpea Group Meet 2010. The website is interactive having the detailed information about centres, research achievements, varieties and technologies developed, crop statistics and updated information of activities of the coordinated project.

PIGEONPEA

Promising Entries

Entries *viz*., RVKV 260, BRG 10-2, RPKV 261, BRG 10-01, PT 0012, PT 04-31 and GJP 0901were found promising.

Breeder Seed Production

Total 1097.95 q breeder seed (36 varieties) was produced against the DAC indent of 373.46 q.

Research Achievements

- Planting on raised bed ensured optimum plant population and 19% more grain yield.
- Genotypes TJT 501 and BDN 2 were found compatible for inter cropping with groundnut and JKM 189 with mungbean.
- Five weeks old seedling of pigeonpea recorded almost double yield in transplanting method than direct seeded pigeonpea both under sole and intercropping with perlmillet.
- Integrated nutrient management PSB+vermi-compost+RDF or PSB+FYM+RDF was found superior.
- Combined application of *Rhizobium*+ PSB+ PGPR showed superiority over their sole application.
- Dry sowing of pigeonpea before on-set of monsoon supplemented with 20 kg N and 50 kg P_2O_5 (RDF) recorded 59% higher grain yield than normal sowing after on-set of monsoon.
- Pre-emergence spary of Pendimethalin @ 0.75 kg/ha, followed by spray of Paraquat @ 0.40 kg/ha at 6 WAS or post-emergence spray of Imazathapyr @ 0.75g/ha (15-20 DAS), followed by Paraquat @ 0.40 kg/ha at 6 WAS was found as efficient as that of Pendimethalin+ one hand weeding.

- Closer plant spacing (20 cm) was advantageous for hybrid.
- The strains CPR 9, AKPR 101, GRR 8-10, LAR 06 and RA 09-6 were found better for increasing the yield.
- Plant growth promoting rhizobacterial strain K 133, WGF 1Ps-327 (2), CRB 2 and CRB 4 performed well.
- Combined inoculation of *Rhizobium* strain GRR 3-8 and PGPR enhanced the nodulation and grain yield irrespective of varieties.
- Application of *Rhizobium* (CPR 9), AM Fungi (*Glomus sp*.) and P_2O_5 enhanced the nodulation and grain yield.
- Combined use of biofertilizers (Rhizobium, PSB and PGPR) increased the yield levels at farmers' fields which ranged from 11.16% to 37.22%.
- Under terminal moisture stress at Bangalore JKM 204 and Maruthi recorded highest yield.
- $ZnSO_4$ @ 1% spray during flowering, followed by another spray 15 days after the first spray increased the seed yield.
- Among the newly tested insecticides, Flubendiamide 20 WG at 50 g a.i./ha, Emmamectin benzoate 5% SG @ 11 g a.i./ha and spinosad 45% SC @ 73 g a.i. /ha gave better control of pod borer.
- Among insecticides, Acetamiprid 20SP @ 20 g a.i./ha, Thiacloprid 21.7 SC @ 75 g a.i./ha and Fipronil 25 EC @ 8 g a. i./ha gave better control of pod fly.
- Among the microbials tested for management of pod borer, DOR Bt.1, 1.5 kg/ ha and *Beauveria bassiana* 300 mg/lit were found promising.
- Entries AKT 08-2 and Phule T 0012 were found promising against wilt, and IPA 8-1 and NTL 554 against sterility mosaic.
- Entries AKT HR 2001-12, AL 1593, AL 1702, PA 382, Phule T 0012, Phule T 04-31, Phule T 00-012-1, RVKP 249, RVKP 260, RVKP 261, SKNP 0706, SKNP 718, SKNP 845, WRG 168, RVSA 07-24 and RVSA 07-31 were found promising against phytophthora blight.
- Entries AL 1778, IPA 8-1, RVSA 07-29, Bahar, AKT 08-2 and AL 1593 were found promising against macrophomina blight/stem canker.
- Entries KPL 43, IPA 16 F, ICPL 87119, IPA 204, BSMR 736 and BSMR 853 showed stable resistance against wilt. Stable resistance against SMD was observed in IPA 8F, followed by Hy3C, IPA 16F, BRG 3, Bahar and IPA 15 F .
- Entries SKNP 0706, PT 0012, PT 04-149, NTL 520 and PA 382 were found promising against *Meloidogyne incognita.*
- Entries PT 00-012-1, SKNP 0706 and H 05-62 were found promising against *Meloidogyne javanica.*
- Entry H 05-62 was found resistant against pigeonpea cyst nematode, *Heterodera cajani.*

Front Line Demonstrations

Total 1103 demonstrations were conducted. Improved varieties early, medium and late recorded 22.7% , 20.7% and 25.8% higher grain yield than local varieties. Application of 20 kg/ha sulphur with 100 kg DAP/ha enhanced the productivity of pigeonpea by 19.8 % and recorded 17.24% higher net returns over 100 kg DAP /ha alone in 94 demonstrations. Insect pest management was found most beneficial and recorded 49.2% higher grain yield with 35.5% higher net returns in 140 demonstrations. Planting on ridges recorded 24% higher grain yield with 28.2% higher net returns in 32 demonstrations. Integration of all components of production technology enhanced the productivity of pigeonpea by 22.25% with 34.2 % higher net returns in 396 demonstrations.

MULLaRP

Varieties Identified

IPM 02-3: This mungbean variety developed by IIPR, Kanpur from the cross IPM 99-125 x Pusa bold 2 gives an average yield of 1128 kg/ha with yield superiority of about 19 % over the best check Pusa 9531 and is resistant to MYMV. It has been identified for spring season in Rajasthan, Punjab, Haryana, Delhi, plains of Himachal Pradesh and Uttarakhand and Jammu region of J & K. The variety has been already notified for *kharif* season in NWPZ.

IPM 02-14: This mungbean variety developed from the cross PDM 139 x EC 398884 has shown yield superiority of 9 % over the best check with an average yield of 737 kg/ha. It has been identified for spring/ summer season in Andhra Pradesh, Karnataka, Tamilnadu and Orissa.

LU 391: This urdbean variety developed from the cross KUG 92 x UG 841 gives an average yield of 768 kg/ha and has resistance to MYMV. It has been identified for spring season in Andhra Pradesh, Karnatka, Tamilnadu and Orissa.

KUG 479: This urdbean variety developed from the cross UG 562 x Pant 419 gives an average yield of 1177 kg/ha and possesses resistance to MYMV. It has been identified for spring season in Rajasthan, Punjab, Haryana, plains of Himachal Pradesh and Uttarakhand and Jammu region of J&K.

IPL 315: This lentil variety developed from PL 4 x DPL 62 gives an average yield of 1487 kg/ha with yield superiority of 13.2% over the best check DPL 62. It is resistant to rust and moderately tolerant to wilt and has been identified for Madhya Pradesh, Chhatisgarh and Bundelkhand region of U.P.

SKNP 04-09: This dwarf fieldpea variety developed as selection from germplasm line DDR 49 gives yield of 1711 kg/ha with 15.5% more than the best check VL 42 and is resistant to powdery mildew. It has been identified for eastern U.P., Bihar, Jharkhand, West Bangal and Assam.

HFP 529: This dwarf fieldpea variety developed from the cross (HUDP 9 x Arkel) x (HUDP 12 x Arkel) gives an average yield of 2555 kg/ha with superiority of 20.6% over the best check DMR 7. It is resistant to powdery mildew disease. It has been identified for Punjab, Haryana, plains of Uttarakhand, western U.P., Delhi and parts of Rajasthan.

Research Ahievements

Mungbean

- Post-emergence application of Imazathapyr @75 g/ha and Fenoxaproppethl @ 50 g/ha at 5-20 DAS effectively managed weeds.
- Mungbean *Rhizobium* MOR 1 was identified as an effective strain, significantly increasing the grain yield (11.6%) over 20 kg N/ha.
- Genotype NDM 09-33 showed multiple resistance to anthracnose, powdery mildew, Cercospora leaf spot and root rot. Genotype SG 63-14 showed multiple resistance to MYMV and powdery mildew.
- Pant Mung 1 and COGG 912 were found resistant to cyst nematode

Urdbean

- Imazethapyr @ 40 g/ha applied at 15-20 DAS effectively managed weeds.
- Urdbean *Rhizobium* strain AUBR 10 was found promising, increasing yield by 26.2% and 12.3% over uninoculated control and 20 kg N/ha, respectively.
- PU 31 showed multiple resistance against MYMV, *Cercospora* and anthracnose
- UKG 469 was promising against root knot nematode, *Meloidogyne incognita* and *M. javanica.*

Lentil

- Imazethapyr @ 37.5 g/ha or Quizalfop ethyl @50 g/ha, applied at 30 DAS managed weeds.
- LR 35B-01 is identified as an efficient *Rhizobium* strain, increasing grain yield by 18.1, 2.9 and 2.6% over uninoculated control, check strain and 40 kg N/ha, respectively.
- DPL 65 showed combined resistance to wilt, rust and Ascochyta blight.
- Genotypes *viz*., VL 519 and RLG 101were found promising against *Meloidogyne incognita* and PL 084 and HUL 57 were found promising against *Meloidogyne javanica.*

Fieldpea

- Imazethapyr @ 50 g/ha applied at 20-30 DAS effectively managed the weeds.
- *Rhizobium* strain P-9 was found most efficient, showing maximum grain yield (2230 kg/ha) being 4.7% higher than 60 kg N/ha application.
- KPMR 886 showed multiple resistance to rust, powdery mildew and Ascochyta blight.
- Genotypes *viz*., IPFD 08-1, Pant P 125, NDP 9-401 and VL 52 were found promising against *Meloidogyne incognita.*

Rajmash

- RDF and three sprays of 2% urea (pre-flowering, pod initiation and pod development) significantly increased the yield.
- The response of *Rhizobium* inoculation was highly effective in combination with 60 kg N/ha, increasing grain yield by 9.0 % over *Rhizobium* treatment alone.
- VRJ 157 was found tolerant to root knot nematode, *M. incognita* and VRJ 125 was found tolerant to *M. Javanica.*

Breeder Seed Production

Breeder seed 1168.65 of mungbean (62 varieties), 617.15 q of urdbean (44 varieties), 515.96 q of lentil (33 varieties) and 1303.60 q of fieldpea (30 varieties) was produced against the DAC indent of 797.58 q, 500.98 q, 346.55 q and1774.80 q, respectively.

Front Line Demonstrations

Under front line demonstrations, significant increase in grain yield and in net returns were recorded through use of improved genotypes and package technologies in different pulse crops. Result are given in table below.

Crop	% Increase in grain yield over local practices		% Increase in net return over local practices	
	Genotypes	Package Technology	Genotypes	Package Technology
Mungbean	16.35	35.78	21.18	37.19
Urdbean	19.10	33.05	25.22	37.74
Lentil	21.82	24.62	28.48	27.38
Fieldpea	20.82	25.40	27.02	30.87
Rajmash	21.83	27.93	19.70	33.86
Rabi mungbean	13.75	19.49	13.55	20.57
Rabi urdbean	15.44	22.48	13.26	25.39
Lathyrus	32.30	-	45.47	-

Transfer of Technology

Cultivation of Summer Mungbean Improved Rural Livelihood of Farmers in Fatehpur District

Indian Institute of Pulses Research, Kanpur implemented a project on Model Seed System(s) in district Fatehpur, Uttar Pradesh to empower farmers in production of chickpea and pigeonpea seed in the year 2007. This provided a platform to Institute scientists and farmers to interact about improved pulse production and value of pulses in sustainable crop production. During formal and informal meetings with farmers in the target villages, where rice - wheat was the predominant cropping system, most of the farmers had the opinion that after the harvest of wheat mungbean can not be grown during summer season. IIPR arranged visit of farmers to the Institute farm and showed them summer mungbean in the year 2007.

The visit to Institute demonstrations and discussions with scientists sensitized the farmers and consequently few farmers from Mauhar and Alipur Villages of Malwan block of Fatehpur came forward to start mungbean cultivation in summer. Ten kg. seed of short duration varieties Meha and Samrat developed by IIPR, Kanpur was supplied to six farmers namely, Mr. Rajesh Patel, Baburam Prajapati, Deshraj Singh, Shiv Pratap Singh, Ram Prakash Singh and Ram Sajeevan Patel. In the year 2008 the mungbean was grown after mustard under the guidance of Institute scientists. Farmers harvested 12-14 q mungbean per ha and earned Rs. 50-60 thousand per ha. The crop was harvested in 65 days. Picking of pods was not required as both the varieties have synchronous maturity. Such large profit within 65 days enthused many farmers to take up spring/summer mungbean cultivation in 2009. Farmers also realized that the yield of succeeding rice crop was higher with preceeding mungbean.

During spring/summer 2009, Mr. Rajesh Patel from village Alipur took up mungbean cultivation in 3.5 ha land after harvest of wheat. He planted mungbean variety Meha in 2.0 ha and Samrat in 1.5 ha on 7-9 April 2009 after pre-plant irrigation. He used 25 kg seed (treated with fungicide thiram @ 3g/kg seed) per ha and applied 100 kg DAP and 20 kg Sulpher per ha as basal dose. He applied two irrigations at 32 and 43 DAS and sprayed insecticide Metasystox 0.03 % solution at podding stage to control thrips. The crop was harvested on 12-15 June 2009. The yield of variety Samrat was 13.5 q/ha and Meha was 14.0 q /ha. From the total produce of 48 q Mr. Patel earned Rs. 1,76,000 with an investment of Rs. 28,000/- only. Similarly Mr. Baburam Prajapati earned. Rs. 42,000 from 0.8 ha and Shiv Pratap Singh earned Rs. 54,000 from 0.9 ha, Deshraj Singh earned Rs. 80,000 from 1.6 ha. This improves the income of farmers and changed their fortune.

Now most of the farmers of Mauhar and Alipur villages have started cultivation of summer mungbean as they are fully confident of bonus yield and monetary gains from summer mungbean without affecting their prevailing rice-wheat cropping system. This innovative message has spread in neighboring villages and around 375 ha spring/summer mungbean is being cultivated during current season in cluster of 20-25 villages in Malwan block of Fatehpur Districts. During summer 2010, majority of farmers earned net return between Rs. 5500-6000/ha as the very remunerative market rate (Rs. 6000/q). Farmer's also sold 31.50 q seed of Samrat and IPM 2-3 during 2011@Rs. 7000/per q. Now farmers have introduced mungbean under different cropping system *viz.*, rice-chickpea-mungbean, rice-mustard-mungbean and *kharif* fallow-mustard–mungbean in Fatehpur district.

Broadcasting of Pulses Technology through All India Radio

A joint programme "*Dalhan Kisan Ke Liye*" was developed on contract basis with IIPR and All India Radio, Kanpur. Total 23 Episode related to pulses improvement, production, protection and post-harvest managements were broadcast on weekly basis (20 October, 2010 to 22 March, 2011). On every Monday recording was done and broadcasting of same message was done on every Wednesday at 06:05 to 06:35 P.M. by AIR, Kanpur.

Training and Extension Activities

Activity	Date	No. of participants	Background of participants	Venue/Place
National Training under NFSM-P	09 March to 11 March 2011	23	Joint Director (Agriculture) Deputy Director (Agriculture) Distt. Agril. Officers of different states	IIPR, Kanpur
Training for KVK Scientists	10-11 May 2010	42	Programme Coordinator (s) and Subject Mater Specialists of KVKs of U. P., Bihar, Odissa, West Bengal	IIPR, Kanpur
	3-4 June 2010	45	Programme Coordinator (s) and Subject Mater Specialists of KVKs of A. P., Tamilnadu, Karnataka and Maharashtra	MPKVV, Rahuri (Maharashtra)
	16-17 June 2010	50	Programme Coordinator (s) and Subject Mater Specialists of KVKs of M.P., Gujarat and Rajasthan	JNKVV, Jabalpur (MP)
Model Training Course	14-21 Sep, 2010	16	-do-	IIPR, Kanpur
State level Training Course under NFSM-P	28-29 July, 2010	52	State/Division/District level consultants, Technical Assistants of U.P.	IIPR, Kanpur
	16 Dec, 2010	65	-do-	IIPR, Kanpur
Collaborative Training 1. NCIPM, New Delhi	14-15 January 2011	24	State/Division/District level consultants, Technical Assistants of U.P., Jharkhand and M. P.	IIPR, Kanpur
ICARDA, New Delhi	27-28 Feb 2011	23	SMSs from KVKs, DDA and project staff from U. P. Assam, West Bengal	IIPR, Kanpur
Training of farmers				
Other States	20-23 Oct, 2010	24	Farmers of Bihar	IIPR, Kanpur
	24-28 Dec, 2010	33	Farmers of Bihar	
	10-12 Jan, 2011	17	Farmers of Jharkhand	
	23-24 Jan, 2011	21	Farmers of Bihar	
	4 March, 2011	40	Farmers of Bihar	
	20 Jan 2011	06	Farmers of M. P.	
Uttar Pradesh	24-25 April 2010	10	Farmers of Allahabad	
	22-23 May 2010	25	Farmers of Kannauj	
	21-24 June, 2010	22	Farmers of Kannauj	
	10 Nov, 2010	31	Farmers of Santkabir Nagar	
	1 Dec 2010	3	Farmers of Basti	
	16 Dec 2010	45	Farmers of Lucknow	
	4 Jan 2011	29	Farmers of Gonda	
	17 Jan 2011	56	Farmers of Farrukhabad	
	18 Jan 2011	21	Farmers of Varanasi	
	17-18 Feb 2011	32	Farmers of Allahabad	
	23-24 Feb 2011	36	Farmers of Jaloun	
	12 March 2011	29	Farmers of Jhansi	
	14-15 March	40	Farmers of Hamirpur	
	16 March 2011	37	Farmers of Hamirpur	
	24-25 March 2011	20	Farmers of Kannauj	
Field days	7.06.2010	88	ICRISAT and IIPR scientists and farmers	Mauhar ,Fatehpur
	8.06.2010	78	ICRISAT and IIPR scientists and farmers	Kuitkheda, Kanpur Dehat
	14.08.2010	72	Farmers and IIPR Scientist	Dharampur, Hamirpur

Activity	Date	No. of participants	Background of participants	Venue/Place
	1.11.2010	85	Farmers and IIPR scientists	Kethariya, Ballia
	13.11.2010	48	Farmers and IIPR scientists	Mauhar & Alipur, Fatehpur
	21.12.2010	54	ICRISAT and IIPR scientists and farmers	Mauhar & Alipur, Fatehpur
	28.02.2010	62	ICARDA and IIPR scientists	Mauhar & Alipur, Fatehpur
Farmer's day	17.03.2011	58	Farmers of Kanpur Dehat, Fatehpur and Jaloun and officials of NSC	IIPR, Kanpur
Organisation of farmers fair	29.01.2011	448	Farmers of different distts. of U.P. & M.P. officials of Govt. semi. Govt., Private and NGOs	IIPR, Kanpur
Participation in Kisan Mela and other	3-5 feb, 2011	-	-do-	Bhopal M. P.
	3-5 March, 2011	-	Participants of KVKs of the country	CSAU&T, Kanpur
Exposure visit	6/09/2010	50	Farmers of Sitapur, U. P.	IIPR, Kanpur
	8/09/2010	45	Farmers of Kannauj, U.P.	
	11/09/2010	15	IAS Trainees, U.P.	
	25/09/2010	60	Farmers of Auriya, U.P.	
	19/10/2010	40	Farmers of Basti, U.P.	
	27/10/2010	45	Students of U.P.	
	07/12/2010	95	Farmers of Sitapur, U.P.	
	13/12/2011	56	Farmers of Mau, U.P.	
	14/12/2010	70	Farmers of Hamirpur, U. P.	
	15/12/2010	100	Farmers of Muraina, M.P.	
	22/12/2010	20	Farmers of Hamirpur, U.P	
	16/01/2011	30	Farmers of Bhind, M.P.	
	20/01/2011	45	Farmers of Baran, Rajasthan	
	21/01/2011	45	Farmers of Raibareli, U.P.	
	22/01/2011	80	Farmers of Kannauj, U. P.	
	03/02/2011	90	Farmers of Rath, Hamirpur, U.P.	
	4/02/2011	60	Student of NDUA&T, Faizabad, U.P.	
	4/02/2011	40	Farmers of Gwaliar, M. P.	
	4/02/2011	6	ATMA, Datia, M.P.	
	17/02/2011	50	Farmers of Banda, U. P.	
	21/02/2011	20	Farmers of Etawa U. P.	
	23/02/2011	40	Farmers of Dhoulpur, M. P.	
	26/02/2011	54	Farmers of Hamirpur, U. P.	
	3/03/2011	60	Farmers of Sitapur, U. P.	
	3/03/2011	17	Farmers of Ashok Nagar, M.P.	
	07/03/2011	20	Farmers of Guna, M. P.	
	12/03/2011	60	Farmers of Jaunpur, U. P.	
	16/03/2011	40	Farmers of Damoh, M. P.	
	18/03/2011	30	Farmers of Maudaha, Hamirpur, U. P.	
	23/03/2011	43	Female Farmers of Ajmer, Rajasthan	

Publications

Research Papers

Akram, M. and Naimuddin (2010). First report of natural infection of *Vigna mungo* var. *silvestris* L. by *Groundnut bud necrosis virus,* a tospovirus. *Phytopathologia Mediterrranea* **46**: 249-252.

Akram, M. and Naimuddin (2010). First report of *Groundnut bud necrosis virus* infecting pea (*Pisum sativum*) in India. *New Disease Reports* [doi:10.5197/j.2044-0588.2010.021.010].

Anjum, T.K., Gupta, S. and Datta, S. (2010). Mapping of mungbean yellow mosaic India virus (MYMIV) and powdery mildew resistant gene in black gram [*Vigna mungo*(L.) Hepper]. *Electronic Journal of Plant Breeding* **1**(4): 1148-1152.

Bandopadhyay, K.K., Mishra, A.K., Ghosh, P.K. and Hati, K.M. (2010). Effect of integrated use of farm yard manure and chemical fertilization on soil physical properties and production of soybean. *Soil and Tillage Research* **110**:115-125.

Chaturvedi, S.K. and Nadarajan, N. (2010). Revisiting chickpea research in India. *Electronic Journal of Plant Breeding* **1**(4): 611-615.

Chaturvedi, S.K., Gaur, P.M., Sandhu, J.S. and Mishra, Neelu (2010). Efforts for improving seed size and yield of *kabuli* chickpea. *Progressive Agriculture-An International Journal* **5**(2): 5-8.

Chaudhary, R.G., Saxena, D.R., Dhar Vishwa, Singh, R.K. and Namdev, J.K. (2010). Prevalence of wilt root rots and their associated pathogen at reproductive phase in lentil. *Archives of Phytopathology and Plant Protection* **43**: 996-1000.

Choudhary, A.K. **(**2010). A wilt resistant line 'IPA 204' of long-duration pigeonpea (*Cajanus cajan*). *Indian J. Agric. Sci.* **80** (10): 907–909.

Choudhary, A.K. (2011). Effects of pollination control in pigeonpea and their implication. *Journal of Food Legumes* **24**: 50-53.

Choudhary, A.K., Kumar, N., Singh, Bansa and Khan, A. (2010). Dodder – A fatal parasitic weed of pigeonpea. *Journal Food Legumes* **23**: 238-239.

Choudhary, A.K., Singh, D. and Iquebal, M. A. (2011). Selection of pigeonpea genotypes for tolerance to aluminum toxicity. *Plant Breeding* [doi:10.1111/j.1439-0523.2010.01833.x].

Datta, S., Choudhary, R.G., Shamim, Md. and Dhar V. (2011). Polymorphism in the internal transcribed spacer (ITS) region of the ribosomal DNA among different *Fusarium* species. *Archives of Phytopathology and Plant Protection* **44** (6): 558–566.

Datta, S., Kaashyap, M. and Kumar S. (2010). Amplification of chickpea SSR primers in *Cajanus* species and their validity in diversity analysis. *Plant Breeding* **129** (3): 334-340.

Datta, S., Mahfooz, S., Singh, P., Choudhary, A.K., Singh, F. and Kumar, S. (2010). Cross-genera amplification of informative microsatellite markers from common bean and lentil for the assessment of genetic diversity in pigeonpea. *Physiology and Molecular Biology of Plants* **16** (2): 123-134.

Devraj and Renu Jain (2011). PulsExpert: An Expert System for the Diagnosis and Control of Diseases in Pulse crops. *Expert Systems With Applications: An International Journal* **38**: 11463-11471.

Dixit, G.P. and Katiyar, P. K. (2010). Morphological characterization of Indian pea varieties. *Journal of Food Legumes* **23**(1) : 25-29.

Dubey, Shantanu Kumar, Sah, Uma and Singh, S.K. (2010). Participatory impact assessment of technological interventions disseminated in Bundelkhand region of Uttar Pradesh. *Journal of Food Legumes* **24** (1): 36-39.

Duraimurugan, P., Raja, K. and Regupathy, A. (2011). An eco-friendly approach for management of pulse beetle, *Callosobruchus maculatus* through neem formulations assisted with pitfall trap. *Journal of Food Legumes* **24**(1): 23-27.

Dutta, S., Kumawat, G., Singh, B.P., Gupta, D.K., Singh, S., Dogra, V., Gaikwad, K., Sharma, T.R., Raje, R.S., Bandhopadhya, T., Datta, S., Singh, M.N., Fakrudin, B., Kulwal, P., Varshney, R.K., Cook, D.R. and Singh, N.K. (2011). Development of EST-SSR markers by deep transcriptome sequencing in pigeonpea (*Cajanus Cajan* [L.] Millspaugh). *BMC Plant Biology* **11**:17.

Ghosh, P.K., Das, A., Saha, R., Kharkrang, E., Tripathi, A.K., Munda, G.C. and Ngachan, S.V. (2010). Conservation agriculture towards achieving food security in North-East India. *Current Science* **99**(7) : 915-921.

Hasan Tanveer, Choudhury, P.R., Dixit, G.P and Jha, G.K. (2010). Detection of molecular divergence and development of DNA fingerprints in fieldpea cultivars. *Indian Journal of Genetics and Plant Breeding* **70**(2) : 132-139.

Kamta Prasad, Rajesh Kumar, N. Prakash, A.K. Sah and R.P. Verma (2010). Indigenous soil and water conservation practices prevalling among the tribal farmers of Mizoram. *Indian J. Soil Cons.* **38**(1): 31-36.

Katiyar, P.K., and Dixit, G.P. (2010). Genetic divergence in Indian blackgram (*Vigna mungo*) cultivars. *Indian J. Agric. Sci.* **80**(3) : 242- 243.

Katiyar, P.K., and Dixit, G.P. (2011). Assessment of genetic divergence in greengram (*Vigna radiata*) germplasm. *Indian J. Agric. Sci.* **81**(1): 79-81.

Krishnamurthy, L., Gaur, P.M., Basu, P.S., Chaturvedi, S.K., Tripathi, S., Vadez, V., Rathore, A., Varshney, R.K. and Gowda, C.L.L. (2011). Large genetic variation for heat tolerance in the reference collection of chickpea (*Cicer arietinum* L.) germplasm. *Plant Genetic Resources: Characterization and Utilization* **9**(1): 59-69.

Kumar, J., Choudhary, A.K., Solanki, R. and Pratap, A. **(**2011). Towards marker assisted selection in pulses – A review. *Plant Breeding*. [doi:10.1111/j.1439-0523.2011.01851.x.]

Kumar, L., Chaudhary, R.G., Shukla, Neetu and Prajapati, R.K. (2010). Isolation of sorghum allelochemicals and their efficacy against crops pathogens. *Allelopathy Journal* **25**(2) 369-382.

Kumar, L., Varshney, Jay G. and Bhattacharya, A. (2011). Bioefficacy of formulations of different allelofractions of sesame (*Sesamum indicum*) against purple nutsedge (*Cyprus rotundus*). *Indian J. Agri. Sci*. **81**(1): 67-73.

Kumar, Shantanu, Sah, Uma, Singh, S.K. and Singh, A.K. (2010). Impact of technological innovation for sustainable pulse development in Bundelkhand region of Uttar Pradesh. *Agricultural Situation in India* Vol. LXVI No. **11**: 649-654.

Nadarajan, N. and Chaturvedi, S.K. (2010). Genetic options for enhancing productivity of major pulses- Retrospect, issues and strategies. *Journal of Food Legumes* **23** (1): 1-7.

Naimuddin and Akram, M. (2010). Detection of mixed infection of begomoviruses in cowpea and their molecular characterization based on CP gene sequences. *Journal of Food Legumes* **23**: 191-195.

Naimuddin, Akram, M., Pratap, Aditya, Chaubey, B. R. and John, J. K. (2011). PCR based identification of the virus causing yellow mosaic disease in wild *Vigna* accessions. *Journal of Food Legumes* **24**: 14-17.

Naimudin, Mohd. Akram and Pratap, A. (2011). First report of natural infection of *Mungbean yellow mosaic India virus* in two wild species of *Vigna. New Disease Reports* **23**: 21

Narasimhan, A., Patil, B.R., Datta, S. and Kaashyap, M. (2010). Genetic diversity assessment across different genotypes of mungbean and urdbean using molecular markers. *Electronic Journal of Plant Breeding* **1**(4): 379-383.

Narendra Kumar, K. Srinivas, B.L. Mina, Mukesh Kumar and A.K. Srivastva (2010). System productivity, profitability and competition indices of horsegram intercropping under rainfed condition. *Journal of Food Legumes* **23** (3&4): 196-200.

Narendra Kumar, Ved Prakash, B. L. Mina, K. A. Gopinath and A. K. Srivastva (2010). Effect of sowing methods, growth retardant and intercropping on horsegram (*Microtyloma uniflorum*) productivity. *Indian J of Agricultural Sciences* **80**(4):335-337.

Pratap, A., Choudhary, A.K. and Kumar, J. (2010). *In vitro* techniques towards genetic enhancement of food legumes – A review. *J. Food Legumes* **23**: 169-185

Roy Burman, R., Singh, S.K. and Singh A. K. (2010). Gap in adoption of improved pulse production technologies in Uttar Pradesh. *Indian Res. J. Ext. Edu*. **10** (1): 99-104.

Sah, Uma , Kumar, Shantanu, Singh, S.K. and Kumar Rajesh (2010). Gender role analysis of pulse production- A study from Uttar Pradesh. *Journal of food Legumes* **23** (3&4): 230-233.

Sankaranarayanan, K., C.S. Praharaj, P. Nalayini and N. Gopalakrishnan (2011). Grain legume as a doable remunerative intercrop in rainfed cotton (*Gossypium hirsutum)*. *Journal of Food Legumes* **24** (1): 18-22.

Singh, D. and Choudhary, A. K**.** (2010). Inheritance pattern of aluminum tolerance in pea (*Pisum sativum* L). *Plant Breeding* **129**: 688-692.

Singh, R.K., Hasan, A. and Chaudhary, R.G. (2010). Variability in *Fusarium oxysporum ciceri* causing vascular wilt in chickpea. *Archives of Phytopathology and Plant Protection* **43**: 987-995.

SN, Zhu H., Varghese, N., Datta, S., Choi, H.K., Horres, R., Jüngling, R., Singh, J., Kavi Kishor, P.B., Sivaramakrishnan, S., Hoisington, D.A., Kahl, G., Winter, P., Cook, D.R. and Varshney, R.K. (2010). Integration of novel SSR and gene-based marker loci in the chickpea genetic map and establishment of new anchor points with *Medicago truncatula* genome. *Theoretical and Applied Genetics* **120**: 1415- 1441.

Solanki, R.K., Singh, S. and Kumar, J. (2010) Molecular marker assisted testing of hybridity of F_1 plants in lentil. *Journal of Food Legumes* **23**:21-24

Tiwari, S. and Vishwa Dhar (2010). Identification of broad base and stable sources of resistance to *Fusarium* wilt in pigeonpea. *Indian Phytopathology* **63**: 165-167.

Zhu, S.N.H., Varghese, N., Datta, S., Choi, H.K., Horres, R., Jüngling, R., Singh, J., Kavi Kishor, P.B., Sivaramakrishnan, S., Hoisington, D.A., Kahl, G., Winter, P., Cook, D.R. and Varshney, R.K. (2010). Integration of novel SSR and gene-based marker loci in the chickpea genetic map and establishment of new anchor points with *Medicago truncatula* genome. *Theoretical and Applied Genetics,* **120:** 1415- 1441.

Papers Presented in Symposia/Conferences

Basu, P. S. and Jagdish Singh (2010). Onset of flowering and source-sink imbalance are major determinants of grain yield in chickpea under high temperature. National Conference of Plant Physiology: Physiological and Molecular Approaches for Crop Improvement under Changing Environment, held on 25-27 November, 2010 at BHU, Varanasi

Chattopadhyay, C. and Mohapatra, S.D. (2010). Perception of constraints in chickpea cultivation among extension scientists of *KVK*s. 32nd Annual Conference & Symposium on Innovations in Plant Pathology Research and Human Resource Development, held on 24-26 November, 2010 at JAU, Junagadh.

Chaturvedi, S.K., Nadarajan, N. and Mishra, Neelu (2011). Chickpea research in India-Accomplishments, issues and perspective. International Conference on Managing Sustainable Development of Rural Economy and Agri Business, held on 21-23 January 2011 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

Chaturvedi, S.K. and Nadarajan, N. (2010). Revisiting chickpea research in India. 3rd National Plant Breeding Congress, held on July 7-9, 2010 at Tamil Nadu Agricultural University, Coimbatore.

Chaudhary, R.G., Dhar, Vishwa, Trivedi, Subha and Gurha, S.N. (2011). Current status of pathogenic variability and host resistance in chickpea wilt in India. IXth National Symposium on Crop Health Management for Sustainable Agri-Horticultural Cropping Systems, held on 17-19 February, 2011 at CARI, Port Blair.

Chaudhary, R.G., Naimuddin, V.D. Singh and Neetu Trivedi (2011). Influence of weather factor on epidemics of *Cercospora* leaf spot of mungbean. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Chaudhary, R.G., Trivedi, Neetu, Singh, V.D. and Trivedi, Subha (2010). Potential *Trichoderma* strains against *Cercospora canescens* infecting greengram and blackgram. National Symposium on Molecular Approaches for Management of Fungal Diseases of Crop Plant, held on 27-30 December, 2010 at IIHR, Bangalore.

Dhar, Vishwa and Chaudhary, R.G. (2010). Current scenario of Fusarium wilt resistance in pigeonpea. 32nd Annual Conference & Symposium on Innovations in Plant Pathology Research and Human Resource Development, held on 24-26 November, 2010 at JAU, Junagadh.

Duraimurugan, P. and Singh, S.K. (2011). Review of pest complex and its succession on mungbean and urdbean in the scenario of climate change. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Ghosh P.K., Narendra Kumar and Hazra, K.K. (2010). Role of resource conserving technologies in mitigating climate change. National Symposium on Food Security in Context of Changing Climate, held on 30 October - 01 November, 2010 at Kanpur.

Ghosh, P.K., Venkatesh, M.S., Singh, K.K., Narendra Kumar, Praharaj, C.S. and Hazra, K.K. (2011). Changes in soil organic carbon content under long-term fertilizer experiement of pulse based production systems. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Kumar, Narendra, Hazra, K.K., Singh, K.K., Ghosh, P.K. and Praharaj, C.S. (2011). Evaluation of post-emergence herbicides in chickpea + mustard intercropping system. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Kumar, Narendra, N.B. Singh, M.S. Venkatesh, K.K. Singh, C.S. Praharaj and P.K. Ghosh (2010). Effect of FIRB planting, P and S nutrition on lentil (*Lens culinaris*) productivity in rice (*Oryza sativa*)-lentil system. National Symposium on Resource Management Approaches Towards Livelihood

Security, held on 2-4 December, 2010 at UAS, Bengaluru, Karnataka.

Kumar, S., Kumar, J., Singh, R.G., Sarker, A. and Baum, M. (2011), Lentils for dryland agriculture: Present status and future strategy. National Symposium on Integrated Farming Systems for Sustainable Agriculture – Challenges and opportunities, held on 19-21 February, 2011, at Institute of Agricultural Sciences, Bundelkhand University, Jhansi.

Mishra, Neelu; Chaturvedi, S.K. and Gaur, P.M. (2010). Mitigating impacts of climatic change on chickpea yield. 4th International Conference on Plants and Environmental Pollution, held on 8-11 December, 2010 at National Botanical Research Institute, Lucknow.

Mohapatra, S.D. and Chattopadhyay, C. (2011). Constraint analysis in pigeonpea: Implications for stabilising productivity in India. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Mohan Singh, M.P. Singh, S.S. Bhadauria and Archna Mishra (2011). Carbon sequestration and improvement in soil quality under organic chickpea production. Xhe Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

M.P. Singh, S.S. Bhadauria and Archna Mishra (2010). Soil quality improvement and productivity of chickpea and mustard under organic production system. National Symposium on Food Security in Context of Changing Climate, held on 30 October-1 November, 2010 at CSAUA&T, Kanpur,

Praharaj, C.S., J.P. Mishra, Narendra Kumar, K.K. Singh, and P.K. Ghosh (2011). Improving crop productivity and water use efficiency in chickpea genotypes through *in situ* water conservation practices in EGPZ. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Praharaj, C.S., Mishra, J.P., Kumar Narendra, Singh, K.K. and Ghosh, P.K. (2010). Production potential, water use and its efficiency of chickpea (*Cicer arietinum*) and fieldpea (*Pisum sativum*) under different seed bed configurations and irrigations. XIX National Symposium on Resource Management Approaches Towards Livelihood Security, held on 2-4 December, 2010 at UAS, Bangaluru, Karnataka.

Praharaj, C.S., Sankarnarayanan, K., Narendra Kumar, Singh K.K. and Ghosh, P.K. (2010). Low-input technologies for increasing crop productivity and sustainability. National Symposium on Food Security in Context of Changing Climate, held on 30 October - 01 November, 2010 at CSAUA&T, Kanpur.

Rajesh Kumar, N. Prakash and Kamta Prasad (2011). Development of extension modules for production of demand driven commodities. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Rajesh Kumar, S. K. Singh, Uma Sah and Purushottam (2011). Role of extension workers in enhancing pulse production in Uttar Pradesh. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

S.K. Singh, Rajesh Kumar and Ambreesh Singh Yadav (2011). Strengthening participatory seed production of pulses through farmers' association/society. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Saxena, Hem and Duraimurugan, P. (2010). Biopesticides in pest management in pulses: Progress and potential. Third Conference on Biopesticides: Emerging Trends (BET 2010) - Biopesticides in Food and Environment Security, held on 20-22 October, 2010 at CCSHAU, Hisar.

Saxena, Hem, Duraimurugan, P. and Sachan, Ashoo (2011). Screening of safer insecticides against *Bracon hebetor* Say (Hymenoptera:Braconidae), a potential parasite of *Helicoverpa armigera*. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Singh, Bansa and Singh, K.K. (2011). Effect of different urdbean based cropping sequences on root-knot nematode, *Meloidogyne javanica* population. Xth Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Singh, K.K., Singh, S.K., Singh, Bansa, Naimuddin, Ghosh, P.K., Kumar, Narendra, Venkatesh, M.S., Praharaj, C.S. and Hazra, K.K. (2011). Effect of crop residue and NPKS on crop productivity and soil fertility in rice-lentil cropping system. X[th] Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Singh, M. K. and Prasoon Verma (2011). Line sowing of pulses by suitable equipments for better crop production. X[th] Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Trivedi, Neetu and Chaudhary, R.G. (2011). Efficacy of *Trichoderma* isolates for the management of pigeonpea (*Cajanus cajan*) wilt. X[th] Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Trivedi, Shubha, Chaudhary, R.G., Gurha, S.N. and Dutta, S. (2011). Diversity in the isolates of *Fusarium oxysporum* f. sp. *ciceri* from Bundelkhand region of U.P. X[th] Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Vasishtha, H. and Srivastava, R.P. (2011). Effect of milling and cooking on sapogenols of pigeonpea. International Conference on Innovations in Food Processing and Ingredients towards Healthy India, held on 4-5 January, 2011 at ICT, Mumbai.

Venkatesh, M.S., Ghosh, P.K., Mishra, J.P., Singh, K.K. and Mathur, R.S. (2010. Pulse genotypes rich in micronutrient content for addressing nutritional security for vegetarian population. X[th] Agricultural Science Congress on Soil, Plant and Animal Health for Enhanced and Sustained Agricultural Productivity, held on 10-12 February, 2011 at NBFGR, Lucknow.

Venkatesh, M.S., Mishra, J.P. and Ghosh, P.K. (2010). Integrated phosphorus management in maize-chickpea cropping sequence in inceptisol under central Uttar Pradesh conditions. National Symposium on Development in Soil Science, held on 14-17 November, 2010 at Indian Institute of Soil Science, Bhopal.

Vijay Laxmi and Bhattacharya, A. (2010). Physiological traits associated with seed yield in early maturing pigeonpea. National Conference of Plant Physiology: Physiological and Molecular Approaches for Crop Improvement under Changing Environment, held on 25-27 November, 2010 at BHU, Varanasi.

Vijay Laxmi and Bhattacharya, A. (2010). Association of physio-chemical traits with seed yield in early pigeonpea. National Conference of Plant Physiology: Physiological and Molecular Approaches for Crop Improvement under Changing Environment, held on 25-27 November, 2010 at BHU, Varanasi.

Book Chapters

Ahmad, R., Duraimurugan, P., Arjuna Rao, P. and Clement, S.L. (2011). Armyworms. **In:** Compendium of Chickpea and Lentil Diseases and Pests (Eds. : Weidong Chen, H.C. Sharma and Fred J. Muehlbauer). APS Press, The American Phytopathological Society, USA. pp. 99-101.

Bhattacharya, A. and Vijaylaxmi (2010). Physiological Responses of Grain of Legumes to Stress Environments. **In:** Climate Change and Management of Cool Season Grain Legumes Crops. Springer, London New York, pp.35-86

Chaturvedi, S.K. (2010). Quality Seed Production of Chickpea. **In:** Manual on Breeder Seed Production. Directorate of Seed Research (ICAR), Mau (U.P.).

Pratap, A., Gupta, S.K., Kumar, J. and Solanki, R.K. (2011). Soybean. **In:** Technological Innovations in Major World Oil Crops. Vol.1 Breeding (Ed. Gupta, S.K.). Springer Science + Business Media, Netherland.

Upadhyaya, H.D., Kashiwagi, J., Varshney, R.K., Gaur, P.M., Saxena, K.B., Krishnamurthy, L., Chaturvedi, S.K., Basu, P.S., Singh, I.P., Gowda, C.L.L., and Pundir, R.P.S. (2010). Drought Phenotyping in Chickpea and Pigeonpea. **In:** Drought Phenotyping in Crops: From Theory to Practice (Eds. Ribaut, J.M. and Monneveux, P.). Published by Generation Challenge Programme, Mexico. pp. 337-346.

Popular Articles

A. K. Choudhary and Narendra Kumar (2010). Pigeonpea in North-Eastern Plain Zone: Problems, remedy and prospects. *Kheti* **48**(3): 5-8.

Aditya Pratap, Debjyoti and S.K. Chaturvedi (2010). *Mung ki unnat kheti. Krishi Karya*. Lucknow.

Kanhaiya Lal (2010). *Dalhani faslon me gudvattayaukt beejon ki uplabdhata. Unnat Krishi* **48** (3) : 9-10.

Kumar, J. (2010). *Bare dane vali masoor ke niryat ki sambhavnaye. Unnat Krishi* **44** (3): 22.

Mohapatra, S.D., Singh, S.K. and Sachan, A.S. (2010). *Arhar ke pramukh keeton ka ekikrat prabandhan. Unnat Krishi* **48** (3): 26-28.

Radha Kishan, Rajesh Kumar, Ambreesh Singh Yadav and S. K. Singh (2010). *Kharif urd ki utpadan taknik. Krishi Gyaneshwri* SBBPUAT, Meerut. Vol- II: 48-51.

S.K. Singh, Rajesh Kumar, Mohd. Iqbal and Jeewesh Kumar (2011). *Basant kalin mung ki kheti. Krishi Gyaneshwri* SBBPUAT, Meerut. Vol- I: 48-51.

Saxena, Hem and Duraimurugan, P. (2010). *Chana phali bhadak ka samekit keet prabhandan. Unnat Krishi* **48**(3): 15-17.

Singh, M.K. and Prasoon Verma (2010). *Dalhan utpadan me unnat krishi yantro ka upyog. Unnat Krishi* **48**(3): 18.

Soren, K.R., Das, A., Patil, P.G. and Datta, S. (2010). *Dalhani phasalon ka utpadan badane mein jaiv pardyogiki ki bhumika. Unnat Krishi* **48**(3): 23-25.

Srinivasan, T., Duraimurugan, P., Singh, S.K. and Chattopadhyay, C. (2010). Bruchid infestation in pulses and its management. *Indian Farming* **60** (4): 13-16.

Verma, Prasoon (2010). Milling technologies from IIPR, Kanpur, www.CommodityIndia.com October 2010.

Verma, Prasoon (2011). Pulses : Increasing availability. *Yojna* January, 2011.

Book

Purushottam and Baldeo Singh (2010): Extension and management in watershed development. Concept Publishing Company Pvt. Ltd.

Institute Publications

- Annual Report 2009-10
- Pulses Newsletter Vol. 21 Nos. 1, 2, 3 and 4
- *Dalhan Samachar* –Vol. 4 Nos. 1and 2 (Hindi)
- *Dalhan Alok – Raj Bhasha Patrika* 2010 (Hindi)
- An Annotated Bibliography of Bihar Hairy Caterpillar *S. obliqa* (Walkar)
- *Bhartiya Dalhan Anusandhan Sansthan : Ek Parichay* (Hindi)
- *Dalhan Utpadan Badhane Ki Taknik* (Hindi)
- *Dalhan Prashnottari : Samanya* (Revised)
- *Dalhan Prashnottari : Chana* (Revised)
- *Dalhan Prashnottari : Arhar* (Revised)
- *Dalhan Prashnottari : Urd* (Revised)
- *Dalhan Prashnottari : Mung* (Revised)
- *Dalhan Prashnottari : Matar* (Revised)
- *Dalhan Prashnottari : Masoor* (Revised)
- *Chana Phali Bhedak : Ek Parichay* (Hindi)
- *Chana Phali Bhedak Ka Prabandhan* (Hindi)
- NPV: *Chana Phali Bhedak Ke Niyantran Ki Ek Jaivik Vidhi* (Hindi)
- *Yon Rasayan Akarshan Jaal* (Feromon Trap) : *Chana Phali Bhedak Ke Prakop Ke Purva Gyan Ki Vidhi* (Hindi)

Human Resource Development

Deputation Abroad

Dr. N. Nadarajan, Director and Dr. Sanjeev Gupta, Principal Scientist wer deputed to attend the International Food Legumes Research Conference held at Antalya (Turkey) on April 26-30, 2010. As post-conference visit, they visited ICARDA, Syria on May 1-5, 2010. During the visit, interections were held with Dr. Kamal, ADG, International Coordination and other pulse scientists of ICARDA.

Dr. P.S. Basu, Principal Scientist, was deputed to visit JIRCAS, Tsukuba, Japan during May 24-30, 2010 under Generation Challenge programme of ICRISAT on " Linking genetic diversity with phenotype for drought tolerance traits through molecular and physiological characterization of a diverse reference collection of chickpea".

Dr. Subhojit Datta, Senior Scientist was deputed to attend the Vth International Congress on Legume Genetics and Genomics (ICLGG) held on July 2-8, 2010 at Asilomar Conference Grounds, Pacific Grove, California, USA. Dr. Datta presented a paper "Conservation of microsatellite regions across legume genera enhances marker repertoire and genomic resources in indigenous food legumes".

Participation in Trainings/Workshops, *etc.*

Drs. N. Nadarajan and S.K. Chaturvedi attended Brain storming meeting on Enhancing Pulses Production in India, held on 22 March, 2011 at New Delhi. The meeting was organized by ICRISAT.

Mr. Prasoon Verma attended Brain storming session on Post Harvest Technology, held at CIPHET, Ludhiana on 1-3 May, 2010.

Mr. Prasoon Verma attended ZTM-BPD Entrepreneurship Development & Business Opportunity Workshop, held at IVRI, Izatnagar on 8-9 July, 2010.

Mr. Prasoon Verma attended and delivered lecture in Winter School on Noval Techniques in Food Processing, held at CIPHET, Ludhiana on 7 September, 2010.

Dr. M. K. Singh attended Interaction Meet on Agricultural Mechanization, held at CIAE Bhopal on 23-24 July, 2010.

Dr. P.K. Ghosh attended Brainstorming session on Exploring Untapped Potential of Acid Soils of India, held on 22-23 July, 2010 at New Delhi.

Dr. P.K Ghosh attended the QRT meetings held at CIAE Bhopal and TNAU, Coimbatore, on 27-28 February, 2011 and 5-6 March, 2011, respectively.

Dr. M.S. Venkatesh attended National Seminar on Developments in Soil Science: 2010 at Indian Institute of Soil Science, Bhopal on 14-17 November, 2010.

Dr. M.S. Venkatesh attended Results Frame work Document (RFD) meeting held on 11-14 March, 2011 at NASC Complex N. Delhi.

Dr. R.G. Chaudhary participated in the training programme on Vigilance and Disciplinary Proceedings held on 2-4 June, 2010 at PISR, Bangalore.

Drs. C. Chattopadhyay and Dr Jagdish Singh attended the ICAR Sponsored 15th Management Development Programme in Agricultural Research, held on 2-7 December, 2010 at NAARM, Hyderabad.

Drs. S. Datta and A. Das attended Sixth review meeting of Network Project on Transgenics in Crops, held on 19-20 May, 2010 at NRCPB, New Delhi.

Dr. S. Datta attended Vth International Congress on Legume Genetics and Genomics (ICLGG) on July 2-8, 2010 at Asilomar Conference Grounds, Pacific Grove, California, USA.

Dr. S. Datta attended Consultation on Biotechnology Research in ICAR, held on 26-27 July, 2010 at NASC, New Delhi.

Dr. S. Datta attended Consultation on project on 'Development of pod borer resistance in pulse crops', held on 10 August, 2010 at KAB, ICAR, New Delhi.

Dr. S. Datta attended International Consultation on DNA Barcoding, held on 6-7 November, 2010 at NASC, New Delhi.

Dr. S. Datta attended Special meeting of NFBSFARA on 'Transgenics development in pulses for pod borer resistance', held on 13 December, 2010 at ICAR, New Delhi.

Dr. S. Datta attended Second annual review meeting of 'Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops', held on 17-18 February, 2011 at IISR, Calicut.

Drs. S. Datta, S.K. Chaturvedi and A. Das attended First meeting of partners of National Fund for Basic, Strategic and, Frontier Application Research in Agriculture (NFBSFARA) project on 'Development of pod borer resistant transgenic pigeonpea and chickpea' held on 21 February, 2011 at NRC on Plant Biotechnology (NRCPB), New Delhi.

Dr. Jagdish Singh participated in the Harvest Plus-ICAR-DBT meeting on "Crop Biofortification Research and Development" held at NASC Complex, New Delhi on 6-9 November, 2011.

Dr. Mohan Singh participated as resource person and delivered a lecture in the Winter School on System based INM for sustainable productivity of soil health on Integrated Nutrient Management in pulse based system, held at PDFSR, Modipuram, Meerut on 1 October, 2010.

Dr. Mohan Singh participated as resource person in the Faculty Exchange Programme on 'Role of microorganisms for improving soil health and productivity', at GBPUA&T, Pantnagar on 5 February, 2011.

Dr. Mohan Singh attended the Annual Review Meeting of AMAAS Project, held on 17-18 August, 2010 at NASC Complex, New Delhi.

Dr. Mohan Singh attended Workshop on PGPR for chickpea and pigeonpea at NBAIM, Mau on February, 21, 2011.

Mr. Devraj attended Interactive meet on "Information and Communication Technology in ICAR" held at NASC Complex, Pusa, New Delhi on 3-4 November, 2010.

Mr. Devraj attended Sensitisation-cum-training workshop for the Nodal Officers of PIMS-ICAR held at CIAE, Bhopal on 11-11-2010.

Mr. Devraj attended Interface meeting of data sharing, management, strengthening and integration of databases, held at NASC Complex, New Delhi on 23-11-2010.

On-going Research Projects

S.N.	Title of the project	Principal Investigator	Associate
	CROP IMPROVEMENT		
1	Genetic resources of chickpea: Collection, evaluation and conservation	Dr. Shiv Sewak	-
2.	Genetic resources of pigeonpea: Collection, evaluation and conservation	Dr. Farinder Singh	Dr. Vishwa Dhar Dr. A.K. Choudhary
3.	Genetic resource of urdbean: Collection, evaluation and conservation	Dr. Sanjeev Gupta	Mr. Naimuddin Dr. Bansa Singh
4.	Genetic resources of lentil: Collection, evaluation and conservation	Dr. Jitendra Kumar	Dr. Sanjeev Gupta Mr. Naimuddin
5.	Genetic resources of fieldpea: Collection, evaluation and conservation	Dr. P.K. Katiyar	Dr. G.P. Dixit
6.	Genetic resources of mungbean: Collection, evaluation and conservation	Dr. P.K. Katiyar	Dr. B.B. Singh Dr. G.P. Dixit
7.	Genetic enhancement of *desi* chickpea for improved plant type and multiple disease resistance	Dr. S.K. Chaturvedi	Dr. R.G. Chaudhary Mr. U.C. Jha Dr. P.S. Basu
8.	Genetic enhancement of *kabuli* chickpea for improved plant type and multiple disease resistance	Dr. R.K. Solanki	Dr. S.K. Chaturvedi Dr. R.G. Chaudhary Mr. M. Algo Mr. U.C. Jha
9.	Genetic enhancement of lentil for improved plant type and multiple disease resistance	Dr. Jitendra Kumar	Dr. R. K. Solanki Mr. Naimuddin
10.	Genetic enhancement of fieldpea for improved plant type and multiple disease resistance	Dr. G.P. Dixit	Dr. P.K. Katiyar
11.	Genetic enhancement of long duration pigeonpea for improved plant type and multiple disease resistance	Dr. A.K. Choudhary	Dr. Vishwa Dhar Dr. I.P. Singh
12.	Genetic enhancement of short duration pigeonpea for improved plant type and multiple disease resistance	Dr. A.K. Choudhury	Dr. I.P. Singh Dr. C. Chattopadhyay
13.	Development of suitable plant type of mungbean for different seasons	Dr. Aditya Pratap	Dr. B.B. Singh Mr. Naimuddin
14.	Breeding for varieties of urdbean with improved plant type and multiple disease resistance	Dr. Sanjeev Gupta	Mr. Naimuddin Dr. Bansa Singh Dr. P. Duraimurgan Mr. D. Sen Gupta
15.	Isolation of protease inhibitor genes against *Helicoverpa* pod borer	Dr. S. Datta	Dr. P. Nandeesha
16.	Identification of molecular markers linked to *Fusarium* wilt resistance gene in pigeonpea	Mr. Prakash G. Patil	Dr. I. P. Singh Dr. S. Datta Dr. Vishwa Dhar
17.	Development of chickpea transgenic for drought tolerance	Dr. Alok Das	Dr. S. Datta Dr. P.S. Basu
18.	Identification of donors and QTL associated with traits imparting drought tolerance in lentil	Dr. Jitendra Kumar	Dr. R.K. Solanki Dr. P.S. Basu Dr. K.R. Soren
19.	Identification of molecular markers link to *F. oxysporum* race 2 resistance genes in chickpea	Dr. K.R. Soren	Dr. R.K. Solanki Dr. R.G. Chaudhary
20.	Genetic improvement of pulses through distant hybridization	Dr. Aditya Pratap	Dr. S.K. Chaturvedi Dr. I.P. Singh Dr. Jitendra Kumar Dr. Alok Das

S.N.	Title of the project	Principal Investigator	Associate
21.	Quality breeding in lentil	Dr. R.K. Solanki	Dr. M.S. Venkatesh
22.	Pre-breeding in pigeonpea for yield enhancement	Dr. Dibendu Datta	Dr. A.K. Choudhary
23.	Development of cytoplasmic genetic male sterility based hybrids for enhancement of productivity and stability of yield in pigeonpea	Dr. I. P. Singh	Dr. Vishwadhar Dr. Dibendu Dutta Dr. Prakash G.Patil
	CROP PRODUCTION		
1.	Development of efficient water management practices for higher productivity in pulses	Dr. C.S. Praharaj	Dr. M.S. Venkatesh Dr. K.K. Singh Mr. Prasoon Verma
2.	Residue management in cropping systems involving pulses	Dr. K.K. Singh	Dr. S.K. Singh (Ent.) Dr. Bansa Singh Mr. Naimuddin Dr. Narendra Kumar
3.	Long term effect of pulses in cropping systems on soil health and crop productivity	Dr. C.S. Praharaj	Dr. P.K. Ghosh Dr. M.S. Venkatesh Dr. Bansa Singh Mr. Naimuddin Dr. P. Duraimurgan Mr. K.K. Hazra
4.	Establishing critical levels of nutrients in pulse crop	Dr. M.S. Venkatesh	Dr. P.S. Basu
5.	Enhancing phosphorus use efficiency in pulse based cropping system	Dr. M.S. Venkatesh	Dr. P.K. Ghosh
6.	Soil test and crop response studies for site-specific integrated nutrient management in maize-lentil cropping sequence	Dr. M.S. Venkatesh	Dr. K.K. Singh
7.	Studies on post-emergence herbicides in pulse based cropping system	Dr. Narendra Kumar	Mr. K.K. Hazra
8.	Resource conservation technology in pulse based cropping system	Dr. Narendra Kumar	Dr. K.K. Singh Mr. S. Poul Raj Dr. M.K.Singh
9.	Assessment of quality parameters and mineral content in popular varieties of pulses	Dr. K.K. Singh	Dr. P.K. Ghosh Dr. M.S. Venkatesh Mr. Prasoon Verma Dr. Shiv Sewak Dr. G.P. Dixit Dr. P.K.Katiyar Dr. Farinder Singh
10.	Carbon dynamics and carbon sequestration potential in pulse based production system under long term experiment	Dr. P.K. Ghosh	Dr. M.S. Venkatesh Dr. K.K. Singh Dr. C.S. Praharaj Dr. Mohan Singh
	CROP PROTECTION		
1.	Changing scenario of insect pests and diseases of pulse crops due to climate change	Dr. C. Chattopadhyay	Dr. S.K. Singh Dr. Sarika
2.	Identification of sources of resistance to wet rot and Botrytis gray mold of chickpea and variability in *Sclerotium rolfsii*	Dr. C. Chattopadhyay	Dr. R.G. Chaudhary Dr. Mohd. Akram

S.N.	Title of the project	Principal Investigator	Associate
3.	Identification of resistant donors in mungbean and urdbean against Cercospora leaf spot and its management	Dr. R. A. Singh	Mr. Naimuddin
4.	Studies on variability in *Rhizoctonia bataticola* and identification of race specific and multi-race donors for wilt and dry root rot resistance in chickpea	Dr. R.G. Chaudhary	Dr. Vishwa Dhar Dr. S.K. Chaturvedi
5.	Basic and molecular characterization of virus(es) associated with leaf curl necrosis of urdbean and mungbean	Dr. Mohd. Akram	Mr. Naimuddin Dr. P. Duraimurugan
6.	Variability in mungbean yellow mosaic virus isolates infecting mungbean and urdbean in different agroeclogical zones	Mr. Naimuddin	Dr. Mohd. Akram
7.	Investigations on urdbean leaf crinkle disease – An emerging threat to urdbean	Mr. Naimuddin	Dr. P. Duraimurgan Dr. Sanjeev Gupta Dr. Mohd. Akram
8.	Sources of resistance against wilt and root rots in lentil and their molecular characterization	Mr. Naimuddin	Dr. R.G. Chaudhary Dr. Jitendra Kumar
9.	Evaluation of potential bioagents against *Helicoverpa armigera* in chickpea and pigeonpea	Dr. Hem Saxena	Dr. P. Duraimurgan
10.	Identification of source(s) of resistance to pod fly, *Melanagromyza obtusa* Malloch and its management in late pigeonpea	Dr. Shiva Kant Singh	Dr. I.P. Singh
11.	Development of forecasting module for pod fly, *M. obtusa* Malloch in late pigeonpea	Dr. Shiva Kant Singh	Ms. Ranjna Agrawal Mr. Amrendara Kumar Dr. C.P. Srivastava Mr. D.C. Singh Mr. Hemant Kumar
12.	Current status of plant parasitic nematodes infesting pulses in Bundelkhand	Dr. Bansa Singh	-
13.	Identification of sources of resistance/ tolerance against root knot nematodes in pulses	Dr. Bansa Singh	-
14.	Temporal and spatial variation of population in *Helicoverpa armigera* (Hubner)	Dr. S.D. Mohapatra	Dr. P. Duraimurugan
15.	Bioecology of legume pod borer, *Maruca vitrate* (Geyer) in short duration pigeonpea and its management	Dr. S.D. Mohapatra	Dr. F. Singh Dr. S.K. Singh
16.	Identification of sources of resistance to bruchids in mungbean and urdbean	Dr. P. Duraimurugan	Dr. S.K. Singh Dr. Lalit Kumar
17.	Bioecological studies of lesion nematodes, *Pratylenchus* spp. in chickpea and their management	Dr. Bansa Singh	Dr. R.G. Chaudhary
18.	Bioefficacy, scale up production and formulation of EPN for management of pod borer of chickpea	Dr. P. Duraimurgan	-
19.	Development of management strategies against thrips infesting mungbean	Dr. S.D. Mohapatra	Dr. Mohd. Akram Dr. Amalendu Ghosh
20.	Identification of sources of resistance against phytophthora blight of pigeonpea and its management	Dr. C. Chattopadhyay	Dr. Mohd. Akram
21.	Management of viral disease of mungbean	Dr. Mohd. Akram	Dr. Naimuddin Dr. P. Duraimurugan

S.N.	Title of the project	Principal Investigator	Associate
PLANT PHYSIOLOGY, BIOCHEMISTRY AND MICROBIOLOGY			
1.	Development of screening techniques and physiological characterization of heat tolerance in chickpea	Dr. P.S. Basu	Dr. S.K. Chaturvedi Dr. Jagdish Singh
2.	Effect of high temperature and low soil moisture on different morphological, physiological and biochemical parameter(s) in relation to total dry matter and seed yield of lentil	Dr. Vijaya Laxmi	-
3.	Physiological studies on pre-harvest sprouting in mungbean	Dr. Vijaya Laxmi	Dr. Sanjeev Gupta
4.	Screening of fieldpea genotypes against heat stress and morphophysiological traits associated with heat tolerance	Dr. Vijaya Laxmi	Dr. G.P. Dixit
5.	Biochemical basis of wilt resistance in pigeonpea	Dr. R.P. Srivastava	Dr. Vishwa Dhar
6.	Increasing nodulation and nitrogen fixation in chickpea under moisture stress	Dr. Mohan Singh	-
7.	Isolation and screening of efficient AM fungi for lentil and chickpea	Mr. S. Paulraj / Dr. M. Senthil Kumar	-
8.	Development of production technology for organic production system for lentil and *kabuli* chickpea	Dr. Mohan Singh	-
9.	Allelopathic effect of root exudates of sorghum, linseed and biocidal compounds of calotropis latex on diseases and nematodes of pulses	Dr. Lalit Kumar	Dr. R.G. Chaudhary Dr. Bansa Singh
10.	Identification and characterization of biochemical compounds imparting resistance to fungal pathogens and *Helicoverpa armigera* in chickpea	Dr. Lalit Kumar	Dr. R.G. Choudhary Dr. S.D. Mohapatra Dr. Jagdish Singh
AGRICULTURAL EXTENSION, ENGINEERING & STATISTICS			
1.	Validation of farmer-to-farmer model of extension for dissemination of pulse production technology	Dr. Uma Sah	Dr. S.K. Singh Dr. Hem Saxena Dr. Narendra Kumar
2.	Analysis of pulse production technologies disseminated in U.P.	Dr. Rajesh Kumar	Dr. S.K. Singh
3.	Development of efficient machines for pulse production system : Pulse threshers	Mr. Prasoon Verma	-
4.	Value addition to milling by-product of pigeonpea - Development of *dal* analog	Mr. Prasoon Verma	Dr. R.P. Srivastava
5	Improvement in IIPR mini *Dal Mill* and development of allied milling machinery	Mr. Prasoon Verma	Dr. M.K. Singh Mr. S.K. Garg
6	Development and evaluation of suitable sowing equipment for pulses	Dr. M.K. Singh	Dr. Narendra Kumar Mr. Prasoon Verma Mr. S.K. Garg
7.	Modeling and forecasting of pulse production using auto regressive integrated moving average and artificial neural network methodology	Dr. Sarika	Dr. M.A. Iquebal

S.N.	Title of the project	Principal Investigator	Associate
8.	Development of prototype expert system for identification and control of insect pests/diseases in chickpea and pigeonpea	Mr. Devraj	Dr. R.G. Chaudhary Dr. Vishwa Dhar Dr. P. Duraimurugan
9,	Development of online information retrieval system of AICRP on chickpea breeding trials	Dr. M.A. Iquebal	Dr. N.P. Singh Dr. Shiv Sewak Dr. Sarika Dr. Savita Kolhe
10.	Development of efficient estimation procedures for computation of compound growth rates in pulses	Dr. M.A. Iquebal	Dr. Sarika Mr. Devraj
11.	Online development of database and information system for mungbean coordinated trial	Mr. Devraj	Dr. G.P. Dixit Dr. P.K. Katiyar
12.	Analysis of gender roles in pulses production and processing in Bundelkhand region	Dr. Rajesh Kumar	Dr. S.K. Singh Dr. Uma Sah

Externally Funded Projects

Crop Improvement

Sl.	Name of the project	Funding agency	Principal Investigator	Associate
1.	Development of pod borer resistant transgenic chickpea and pigeonpea	NPTC (ICAR)	Dr. S. Datta	Dr. Alok Das Dr. P. Duraimurugan
2.	Functional genomics in chickpea	NPTC (ICAR)	Dr. S. Datta	Dr. S.K. Chaturvedi Dr. K.R. Soren Dr. Prakash G. Patil
3.	Understanding plant nematode interactions using RNAi	NAIP (ICAR)	Dr. S. Datta	Dr. Bansa Singh Dr. Alok Das
4.	Pigeonpea genomics initiative	Indo-US AKI	Dr. S. Datta	Dr. A.K.Chaudhary Dr. Prakash G. Patil
5.	Development of pod borer resistant transgenic pigeonpea and chickpea	NFBSFARA (ICAR)	Dr. N. Nadarajan	Dr. S.K. Chaturvedi Dr. A.K. Chaudhary Dr. S.D. Mohapatra Dr. S. Datta Dr. P. Duraimurugan Dr. Prakash G. Patil Dr. K.R. Soren Dr. Alok Das
6.	Centre of Excellence for high throughput allele determination for molecular breeding	DBT	Dr. S. Datta	Dr. S.K. Chaturvedi Dr. A.K. Chaudhary Dr. Prakash G.Patil Dr. K.R. Soren
7.	Seed production in agricultural crops	DAC	Dr. S.K. Chaturvedi	-
8.	Enhancing yield and stability of pigeonpea through heterosis breeding	DAC/ISOPOM	Dr. I.P. Singh	Dr. N.P. Singh
9.	To develop MYMV resistant transgenics legumes by incorporating hairpin ribozyme gene targeted to viral rep mRNA	DST	Dr. Annika Singh	-
10.	Implementation of PVP legislation of chickpea (DUS)	DAC	Dr. N.P. Singh	Dr. Shiv Sewak Dr. M.A. Iquabal
11.	Implementation of PVP legislation of pigeonpea (DUS)	DAC	Dr. N.D. Majumder	-
12.	Implementation of PVP legislation of MULLaRP (DUS)	DAC	Dr. B. B. Singh	Dr. G.P. Dixit Dr. P.K. Katiyar
13.	Strengthening of breeder seed production	DAC	Dr. S.K. Chaturvedi	-
14.	Construction of a linkage map and tagging of resistance to MYMV and powdery mildew in urdbean (*Vigna mungo* (L.) Hepper)	DBT	Dr. Sanjeev Gupta	-
15.	Shuttle breeding for development and identification of high yielding varieties of pulses for sustainable agriculture in South Asia (SAARC)	SAARC	Dr. B.B. Singh	Dr. G.P. Dixit Dr. Sanjeev Gupta Dr. R.K. Solanki

Sl.	Name of the project	Funding agency	Principal Investigator	Associate
16.	Improving heat tolerance in chickpea for enhancing its productivity in warm growing conditions and mitigating impact of climate change	DAC/TMOP	Dr. S.K. Chaturvedi	Dr. P.S. Basu Dr. S.K. Singh (Ext.)
17.	Deployment of molecular markers in chickpea breeding for developing superior cultivars with enhanced disease resistance	DBT	Dr. Aditya Pratap	Dr. S.K. Chaturvedi Dr. S. Datta Dr. R.G. Chaudhary
18.	Breeding and genetic enhancement in breaking yield barriers in *kabuli* chickpea and lentil	DAC-ICARDA-ICAR	Dr. S.K. Chaturvedi	Dr. Jitendra Kumar Mr. Udai Chand Jha
19.	National initiative on climate resilient agriculture	ICAR	Dr. Sanjeev Gupta	Dr. P.S. Basu Dr. Aditya Pratap Dr. Dibendu Datta Mr. D. Sen Gupta Mr. Alagu M.
Crop Production				
1.	Efficient management of water and nutrients for enhancing productivity of pigeonpea through drip-fertigation	Jain Irrig. Sys. Ltd.	Dr. C.S. Praharaj	Dr. P.K.Ghosh Dr. K.K. Singh Dr. Narendra Kumar
Crop Protection				
1.	Outreach Project on *Phytophthora, Fusarium* and Ralstonia diseases of horticultural and field crops – Fusarium wilt of pigeonpea and chickpea	ICAR	Dr. Vishwa Dhar	Dr. R.G. Chaudhary Dr. S. Datta
2.	Management of pests in stored seeds/grain of cereals and pulses through EPN	DBT	Dr. P. Duraimurugan	-
3.	Diagnosis and management of leaf spot diseases of field and horticultural crops – Cercospora leaf spot of mungbean and urdbean	ICAR	Dr. R.G. Chaudhary	Mr. Naimuddin
4.	Molecular characterization and sequences diversity of tospovirus associated with fabaceous and setaceous crop	ICAR	Dr. Mohd. Akram	-
5.	Scale up production and development of cost effective formulation of entomo-pathogenic nematodes (EPN) based bio-pesticides for pod borer of chickpea	CSIR	Dr. S.S. Ali	-

Sl.	Name of the project	Funding agency	Principal Investigator	Associate
6.	Studies on the variability in *Fusarium oxysporum* f.sp. *ciceri* for identification of race-specific donors for resistance to chickpea wilt and its management	DST	Dr. Subha Trivedi	-
7.	Taxonomy, distribution and biology of entomopathogenic nematodes infesting insect pests of pulses in Uttar Pradesh	DST	Dr. Azra Shaheen	-
Crop Physiology, Biochemistry and Microbiology				
1.	Plant growth promoting rhizobacteria (PGPR) for chickpea and pigeonpea	ICAR	Dr. Mohan Singh	Dr. R.G. Chaudhary
Agricultural Extension				
1.	Increasing chickpea and pigeonpea production through intensive application of integrated pest management (A3P project)	DAC	Dr. S.K. Singh	-
2.	Enhancing Lentil Production for food, nutritional security and rural livelihoods.	DAC	Dr. S.K. Singh	-
3.	Promoting use of *Trichoderma* sp. and ecofriendly approach for management of wilt and root rot complex in major pulse crops in Bundelkhand region	DBT	Dr. Purushottam	Dr. R.G. Chaudhary
4..	Farmer participatory seed production of major pulse crops in selected villages of Hamirpur district of Bundelkhand	NABARD	Dr. Purushottam	Dr. S.K. Singh
5.	Strengthening of breeder seed production and training infrastructure and organization of training under NFSM	DAC	Dr. S.K. Singh	Dr. Uam Sah
6.	Popularization of biorationals for management of *H. armigera* for improving chickpea productivity in Jalaun district of Bundelkhand region of U.P.	DBT	Dr. Uma Sah	Dr. Hem Saxena Dr. Rajesh Kumar Dr. P. Duraimurugan

Panorama

Union Minister of Agriculture Visited IIPR

Hon'ble Union Minister of Agriculture Shri Sharad Pawar visited Indian Institute of Pulses Research, Kanpur on January 29, 2011 along with Mr. P.K. Basu, Secretary, DAC, Ministry of Agriculture, GoI

and Dr. S. Ayyappan, Secretary DARE and Director General, ICAR, New Delhi. Mr. Raja Ram Pal, Hon'ble Member of Parliament, Dr. T.P. Rajendran, Asstt. Director General (PP) and Dr. B.B. Singh, Asstt. Director General (O&P) also accompanied the Minister during the visit.

Hon'ble Minister inaugurated the Pulse Genetic Resource Centre. He visited Genetic Stock Management Farm and experimental fields of the Institute and took keen interest in the development of new varieties and hybrids. The dignitaries appreciated the upkeep and maintenance of the experimental plots and the farm.

In the interaction meeting, Dr. Nadarajan, Director highlighted the achievements of the Institute in development of new high yielding varieties and matching crop production technologies. In his address the Hon'ble Minister called upon the scientists to develop short duration varieties of pulse crops to foster multiple cropping system. He stressed upon developing high yielding varieties insulated with pest and disease resistance, with matching crop production and protection technologies keeping in mind the anticipated changes in climate and seasons. He called for minimizing the post-harvest losses. He provided the road map for increasing pulse production through short, medium and long term research efforts.

Addressing the pulse growers the Hon'ble Minister expressed his concern over shrinking cultivable area due to rapid urbanisation and industrialization, followed by ever increasing population of the country. He called upon the scientists for close interaction with farmers to produce sufficient food for the growing population. In this endeavour Govt. will provide all help and support to make the country self sufficient in pulses. The Hon'ble Minister honoured five progressive farmers of the area at this occasion.

Institute Foundation Day Celebrated

The 18th Foundation Day of Indian Institute of Pulses Research was celebrated on September 5, 2010 with great fervour and gaiety. The Vice-Chancellor of CSA University of Agriculture & Technology, Kanpur Dr. G.C. Tiwari was the Chief Guest and Dr. A.K. Singh, Zonal Project Director was special guest on the occasion. While appreciating the Institute's achievements, Dr. Tiwari in his address called upon the scientists to put their synergetic efforts to combat the vagaries of changing seasons, environment and ecology. He stressed on developing varieties capable to give high yield in extreme high and low temperature. He called for harnessing the rich biodiversity with modern tools of biotechnology for gene transfer and genetic improvement.

Dr. N. Nadarajan, Director of the Institute presented a detailed resume of research programmes, activities and achievements made during 2009-10. He informed the house that during the year four new varieties of *kabuli* chickpea, mungbean and urdbean developed by the Institute have been released for cultivation in different parts of the country. A new pulse thresher has been developed by the Institute. He commended the progress made in transgenic research and developing multiple resistance against major diseases. In his address Dr. A.K. Singh called for faster dissemination of new technologies and varieties to the farmers, so that the research results are visible at farmers' fields. He suggested for developing programmes with farmers' participation to address their needs and problems.

On this occasion, Dr. R.G. Chaudhary was given 'Best Scientist Award 2009'. Mr. M.R. Tripathi, Mr. K.A. Chaturvedi and Mr. Babu Lal and Mr. Jaswant Singh were conferred with 'Best Worker Award' in technical, administrative and supporing staff category, respectively. A new Institute publication 'An Anotated Bibliography of Bihar Hairy Caterpillar *S. obliqua* (Walkar)' was also released on the occasion.

Quinquennial Review Team Meeting

The Institute Quinquennial Review Team (QRT) meeting was held at IIPR on January 30-31, 2011 under the Chairmanship of Dr. V.S. Tomar, Vice-Chancellor, RVS KVV, Gwalior. The other members Dr. R.P. Sharma, Dr. K.B. Wanjari, Dr. P.S. Deshmukh, Dr. N.B. Pawar, Dr. O.M. Bambawale and Dr. I.P.S. Ahlawat also attended the meeting. Research activities of the Institute, particularly development of transgenics and good number of varieties released coupled with matching production technologies were appreciated by the members. The team suggested many important researchable issues which will be taken care during XIIth plan. This was followed by review meeting of all AICRPs on MULLaRP, Chickpea, Pigeonpea and Arid Legumes centres of Central Zone on February 27-28, 2011 at CIAE, Bhopal and of South Zone on March 5-6, 2011 at TNAU, Coimbatore.

Research Advisory Committee Meetings

The 16th Research Advisory Committee (RAC) meeting of the Institute was held on October 27-28, 2010 under the chairmanship of Dr. S.C. Modgal, Former Vice Chancellor of G.B. Pant University of Agriculture and Technology, Pantnagar. Dr. V.D. Patil, Assistant Director General (O&P), Dr. O.P. Dubey, Ex. ADG (O&P) ICAR, Dr. Shanker Lal, Ex. Director IIPR, Dr. M.N. Khare, Ex. Dean, JNKVV, Jabalpur, Dr. N. Nadarajan, Director, IIPR and Dr. Mohan Singh, Member Secretary participated in the meeting along with all HoDs, PCs and I/C Sections of the Institute.

The 17th meeting of Research Advisory Committee (RAC) was held on February 14-15, 2011 under the chairmanship of Dr. S.A. Patil, Former Director IARI, New Delhi. The meeting was attended by Dr. B.B. Singh, ADG (O&P), ICAR; Dr. D.P. Singh, former Director Research, GBPUA&T, Pantnagar; Dr. S.V. Sarode, Director Research, PDKV, Akola; Dr. Karabi Datta, Coordinator, Biotechnology Support Programme (DBT), Calcutta University, Kolkata; Dr. N. Nadarajan, Director, IIPR and Dr. Mohan Singh, Member Secretary. All Project Coordinators, Heads of Divisions and Sectional Incharges took part in this meeting. Dr. N. Nadarajan, while welcoming the Chairman and members of RAC apprised the house about the progress in R&D activities, new initiatives, major achievements and developments in collaborative programmes with national and international organizations. The RAC appreciated the on-going programmes and congratulated the scientists for successful demonstration of technologies on farmers' fields.

After critical review of the on-going research programmes and thorough deliberations, major focus of the RAC was on development of transgenics in pigeonpea and chickpea against pod borer and development of hybrids in pigeonpea to break the yield plateau. The RAC stressed upon DNA finger printing of all newly evolved varieties and gene pyramiding for tolerance against abiotic and biotic stresses. Research on photo-insensitivity, introduction of moisture conservarion technologies, improving C-sequestration in soils of pulse growing areas and nutritional biofortification of pulses with essential minerals was stressed upon by the RAC.

Annual Group Meet of AICRPs

- Annual Group Meet on Chickpea was held on 29-31 August, 2010 at College of Agriculture, Indore, Rajmata Vijayraje Scindia Krishi Vishwavidyalaya, Gwalior. The group meet was inaugurated by Smt. Abha Asthana, Additional Chief Secretary & APC, Govt. of MP and the inaugural session was chaired by Dr. Swapan K. Datta, DDG (CS), ICAR. Dr. Datta, in his chairman's remarks said that productivity must be enhanced to 15q/ha by next 10 years. He stressed that pre-breeding should be initiated to generate desired variability in chickpea which will help in breaking the yield barriers to some extent.

In different sessions achievements of last year's programme were reviewed and technical programmes of different disciplines were formulated for the next season. During the meet, three varieties *viz.*, IPCK 02, MNK 1 and WCGK 2000-16 were identified for notification and release.

- Annual Group Meet on MULLaRP (*Rabi*) crops was held on 22-23 September, 2010 at IIPR. While inaugurating the group meet, Dr. Swapan K. Datta, DDG (CS), ICAR called upon the scientists to develop plant types with suitable architecture, insulated with resistance against diseases and tolerance against various abiotic stresses and popularize the pulses cultivation in non-traditional areas.

Dr. V.D. Patil, ADG (O&P) in his remarks, suggested to popularize the proven technologies among farmers. Dr. N. Nadarajan, Director, while welcoming the dignitaries and delegates, described the potential of lentil and *rabi* urdbean and mungbean and called upon to develop appropriate technologies to promote these crops.

In the technical sessions, research accomplishments of previous season were reviewed and technical programme for the next season was finalized. One new variety of lentil IPL 315 and two varieties of fieldpea *viz.*, SKNP 04-09 and HFP 520 were identified in the Group Meet.

Training programme for KVK's Scientists

To acquaint the KVK Scientists about the latest production, protection and crop improvement technologies of pulses, three training programmes were organised under "Technology Demonstra-tion for Harnessing Pulses Productivity". For Ist batch, training programme on Improved Production Technology for Pulses was organised at IIPR, Kanpur on May 10-11, 2010. Dr. K. D. Kokate, DDG (A.E.), inaugurated the programme. Dr. Kokate presented brief about scenario of KVKs and emphasized on incorporation of pulses under different cropping system. Dr. N. Nadarajan, Director, IIPR, presented the problems and prospects of pulses especially for U.P., Bihar, Orissa and West Bengal. Total 40 participants including Programme Coordinators and Subject Matter Specialists of these states actively participated in the training.

ICAR Zonal Sports Tournament (North Zone)

ICAR Zonal Sports Tournament (North Zone) 2010 was organized by IIPR Kanpur from 6-9 April, 2010. In this Tournament 750 men and women from 23 Institutes located in states of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttrakhand and Uttar Pradesh participated. The tournament was inaugurated by Prof. Partha Chakraborty, Dean of Students Affair, IIT, Kanpur. IIPR contingent of 65 players including 7 women participated in all the events of the tournament. The performance of the sport contingent was very good. Mr. Jaswant Singh stood first in the shot put men event. Dr. Uma Sah was runner up in the badminton women singles event. Mrs. Meenakshi Varshney was runner up in TT women singles. Mrs. Meenakshi Varshney and Dr. Vijay Laxmi were runner up in TT women doubles event. The Basket ball team played the final against NDRI, Karnal and was runner up in the tournament. Dr. S.K. Mitra, Director National Sugar Institute, Kanpur was the chief Guest for closing ceremony and distributed the medals and certificates to the winners.

हिन्दी दिवस का आयोजन

भारतीय दलहन अनुसंधान संस्थान में दिनांक 30 सितम्बर, 2010 को हिन्दी दिवस समारोह पूर्वक मनाया गया। समारोह में गौरहरि सिंहानिया इंस्टीट्यूट ऑफ मैनेजमेन्ट एण्ड रिसर्च के निदेशक प्रो. पथ्वी यादव, मुख्य अतिथि थे। समारोह की अध्यक्षता संस्थान के निदेशक डा. एन. नदराजन ने की। अपने उद्बोधन में प्रो. यादव 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। यह मिथक भी अब टूट चुका है कि विज्ञान और प्रबंधन के क्षेत्र में केवल अंग्रेजी के बल पर आगे बढ़ा जा सकता है। इन क्षेत्रों में हिन्दी की सफलता का परचम लहरा रहा है। अध्यक्षीय उद्बोधन में निदेषक डा. नदराजन ने कहा कि हिन्दी दिवस के आयोजन से हम हिन्दी के प्रति अपना सम्मान और निष्ठा व्यक्त करते हैं और हिन्दी के उत्थान के लिए संकल्प लेते हैं। उन्होंने वैज्ञानिकों का आवाह्न किया कि नई तकनीकी जानकारी किसानों तक पहुँचाने के लिए उन्ही की भाषा में सतत प्रयास करें और हिन्दी के नये प्रकाषनों पर बल दिया। संस्थान की राजभाषा समिति के सचिव श्री दिवाकर उपाध्याय ने संस्थान में राजभाषा की प्रगति आख्या प्रस्तुत की। अतिथियों का स्वागत डा. एन.डी. मजूमदार ने किया।

हिन्दी पखवाड़े में आयोजित विभिन्न प्रतियोगिताओं के विजयी प्रतिभागियों सर्वश्री कन्हैया लाल, राजेन्द्र कुमार, आलोक सक्सेना, षिव शरण, शुकदेव महतो, हरगोविन्द राठौर, अनिल कुमार सोनकर, प्रोमित डायस, श्रीमती मीनाक्षी वार्ष्णेय और श्रीमती रीता मिश्रा तथा कार्यालयीन कामकाज में हिन्दी के प्रचार–प्रसार में उत्कृष्ट सहयोग देने वाले अधिकारियों सर्वश्री दिवाकर उपाध्याय एवं बृजकिषोर वर्मा को मुख्य अतिथि ने पुरस्कार और प्रमाण पत्र प्रदान किए। कार्यक्रम का संचालन डा. संजीव गुप्ता ने किया ।

Institute Management Committee

As on 31.3.2011

Dr. N. Nadarajan Director IIPR, 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 ADG (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. C.S. Rao Principal Scientist (Soils) CRIDA,Hyderabad	Member
Dr. P.K. Agrawal Principal Scientist (Biotechnology) VPKAS, Almora	Member
Dr. O.P. Sharma, Principal Scientist (Pathology) NRC on IPM, Pusa Campus New Delhi	Member
Finance & Accounts officer IIPR, Kanpur	Member
Sh. Rajendra Singh Administrative Officer IIPR, Kanpur	Member Secretary

Quinquennial (2006-2010) Review Team

As on 31.3.2011

Dr. V.S. Tomar, Vice Chancellor Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.)	Chairman
Dr. K.B. Wanjari, Emeritus Scientist Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola	Member
Dr. I.P.S. Ahlawat, Ex. Head, Division of Agronomy, IARI, New Delhi	Member
Dr. O.M. Bambawale, Director NCIPM, Lal Bahadur Shastri Building, Pusa Campus, New Delhi	Member
Dr. N.B. Pawar , Ex. Professor, Plant Pathology College of Agricultue, Baner, Pune	Member
Dr. P.S. Deshmukh, Emeritus Scientist Division of Plant Physiology, IARI, New Delhi	Member
Dr. R.P. Sharma, Ex. Director, NRCPB, New Delhi	Member

Research Advisory Committee

As on 31.3.2011

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

Institute Research Council

As on 31.3.2011

Dr. N. Nadarajan Director IIPR,Kanpur	Chairman
Dr. B.B. Singh Assistant Director General (O&P), ICAR, Krishi Bhavan, New Delhi	Member
All Scientists of the Institute	Member
Dr. C. Chattopadhyay Head, Division of Crop Protection IIPR,Kanpur	Member Secretary

Important Committees of the Institute

As on 31.3.2011

1. Monthly Review Committee

Dr. N. Nadarajan, Director, Chairman
All Project Cordinators
All Heads of Divisions
All Scientists
Farm Manager
Editor
Incharge Electricals
Finance & Accounts Officer
Administrative Officer
Asstt. Admin. Officer (Admin.)
Asstt. Admin. Officer (Stores)
Chairmen of Various Committees
Architect
Caretaker, Guest House
Secretary, IJSC
Dr. P.K. Ghosh, Member Secretary

2. Farm Advisory and Produce Price Fixation Committee

Dr. P.K. Ghosh, Chairman
All HoD's
I/c Engineering
I/c Security
Farm Manager
Dr. S.K. Chaturvedi, Member Secretary

3. Estate Managamant Committee

Dr. Mohan Singh, Chairman
Dr. Bansa Singh
Dr. S.K. Singh (Extn.)
Mr. Prsoon Verma
Administrative Officer
Finance & Accounts Officer
Mr. D.N. Awasthi, Member Secretary (Civil)
Mr. S.K. Garg, Member Secretary (Electrical)

4. Publication Committee

Dr. N. Nadarajan, Director, Chairman
Dr. C. Chattopadhyay
Dr. P.S. Basu
Dr. M.S. Venkatesh
Dr. Aditya Pratap
Mr. Diwakar Upadhyaya, Member Secretary

5. Purchase Committee

Dr. Vishwa Dhar, Chairman
Dr. R.G. Chaudhary
Dr. J.P. Mishra
Mr. Prsoon Verma
Finance & Accounts Officer
Administrative Officer, Member Secretary

6. Institute Technology Management Committee

Dr. C. Chattopadhyay, Chairman
Dr. Mohan Singh
Dr. P.S. Basu
Dr. Lalit Kumar
Dr. M.S. Venkatesh
Mr. Prasoon Verma
Dr. J.P. Saxena, IARI, New Delhi
Dr. Sanjeev Gupta, Member Secretary

7. Resource Generation Committee

Dr. S.K. Chaturvedi, Chairman
Dr. S.K. Singh (Extn.)
Dr. Farindra Singh
Farm Manager
Finance & Accounts Officer
Administrative Officer
I/c Library
Dr. A.K. Choudhary, Member Secretary

8. Project Monitoring and Evaluation Committee

Dr. Mohan Singh, Chairman
Dr. P.K. Ghosh
Dr. S.K. Chaturvedi
Dr. S.K. Singh (Extn.)

Dr. C. Chattopadhyay, Member Secretary

9. Library Committee

Dr. N. Nadarajan, Director, Chairman
All HoDs
Finance & Accounts Officer
Administrative Officer
Dr. Sanjeev Gupta, Member Secretary

10. Institute Biosafety Committee

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

11. Academic Committee

Dr. Vishwa Dhar, Chairman
Dr. (Mrs.) Hem Saxena
Dr. P.S. Basu
Dr. Aditya Pratap
Dr. K.K. Singh
Mr. Naimuddin, Member Secretary

12. Germplasm Identification Committee

Dr. Sanjeev Gupta, Chairman
Dr. Shiv Sewak
Dr. I.P. Singh
Dr. S.K. Singh (Ento.)
Dr. Md. Akram
Dr. G.P. Dixit, Member Secretary

13. HRD Cell

Dr. R.P. Srivastava, Chairman
Dr. Rajesh Kumar
Dr. I.P. Singh
Dr. R.A. Singh, Member Secretary

14. Consultancy Processing Cell

Dr. R.G. Chaudhary, Chairman
Dr. Rajesh Kumar
Dr. Narendra Kumar
Mr. Prasoon Verma, Member Secretary

15. Institute Joint Staff Council

Dr. N. Nadarajan, Director, Chairman
Dr. G.P. Dixit
Dr. (Mrs.) Vijay Laxmi
Finance & Accounts Officer
Administrative Officer (Member Secretary)
Mr. G.S. Pandey
Mr. Rajesh Kumar
Mr. Kailash
Mr. Harbans
Mr. Yashwant, Secretary (Staff side)

16. Grievance Cell

Dr. R.G. Chaudhary, Chairman
Dr. Jitendra Kumar
Dr. G.K. Srivastava
Mrs. Rita Mishra
Mr. Satish Chandra, Secretary, IJSC
Administrative Officer, Member Secretary

17. Vehicle Maintenance Committee

Mr. Prasoon Verma, Chairman
Dr. Lalit Kumar
Finance & Accounts Officer
Administrative Officer
Mr. Anil Kumar Saxena, Member Secretary

18. Computer/ARIS Cell & Instrumentation Committee

Dr. P.S. Basu, Chairman
Er. Prasoon Verma
Dr. M.S. Venkatesh
Dr. S.D. Mohapatra
Mr. Devraj, Member Secretary (Computer)
Mr. G.S. Pandey, Member Secretary (Instrumentation)

19. Guest House Management Committee

Dr. S. K. Singh (Extn.), Chairman
Dr. K.K. Singh
Dr. (Mrs.) Vijay Laxmi
Administrative Officer, Member Secretary

20. Sports Committee

Dr. Bansa Singh, Chairman

Dr. A.K. Choudhary

Dr. M.P. Singh

Mr. Yashyant Singh, Secretary, IJSC

Dr. K.R. Soren, Member Secretary

21. *Rajbhasha* Implementation Committee

Dr. N. Nadarajan, Director, Chairman

All HoDs

Dr. S.K. Singh (Extn.)

Dr. R.K. Srivastava

Mr. Diwakar Upadhyaya, Member Secretary

22. Women's Cell & Sexual Harassment Committee

Dr. (Mrs.) Hem Saxena, Chairperson

Dr. (Mrs.) Vijay Laxmi

Mr. Naimuddin

Dr. (Mrs.) Uma Sah

23. Research Coordination & Management Unit

Dr. Sanjeev Gupta, I/c

Dr. P.S. Basu

Mr. Naimuddin

Mr. Diwakar Upadhyaya

Mr. D.K. Sharma

Dr. R.K. srivastava

Mr. Kanhaiya Lal

Mr. H.G. Rathore

24. Incharges

Dr. Mohan Singh, Member Secretary, RAC

Dr. C. Chattopadhyay, Member Secretary, IRC

Dr. Vishwa Dhar, Convener, Seminars

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

Dr. S.K.Chaturvedi, I/c Farms

Dr. Sanjeev Gupta, Nodal Scientist, IPR

Mr. D.N.Awasthi, I/c Civil Works

Mr. S.K. Garg, I/c EMW

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

Mr. A.B. Singh, I/c Gardening

Mr. Anil Kumar Saxena, I/c Vehicles

Mr. R.K. Singh, I/c Security

Mr. R.K.S. Yadav, Care Taker, Guest House

Personnel

A. Research Management

1.	Dr. N. Nadarajan		Director

B. Scientific

Crop Improvement

2.	Dr. S.K. Chaturvedi	Plant Breeding	Head of the Division
3.	Dr. Asit B. Mandal	Plant Breeding	Principal Scientist
4.	Dr. Sanjeev Gupta	Plant Breeding	Principal Scientist
5.	Dr. I.P. Singh	Plant Breeding	Principal Scientist
6.	Dr. Dibendu Datta	Plant Breeding	Principal Scientist
7.	Dr. A.K. Choudhary	Plant Breeding	Senior Scientist
8.	Dr. S. Datta	Biotechnology	Senior Scientist
9.	Dr. Aditya Pratap	Plant Breeding	Senior Scientist
10.	Dr. Jitendra Kumar	Plant Breeding	Senior Scientist
11.	Dr. P. Nandeesha	Biotechnology	Scientist
12.	Dr. R. K. Solanki	Plant Breeding	Scientist
13.	Mr. Prakash G. Patil	Biotechnology	Scientist
14.	Dr. Khela Ram Soren	Biotechnology	Scientist
15.	Dr. Alok Das	Biotechnology	Scientist
16.	Mr. Udai Chand Jha	Plant Breeding	Scientist
17.	Mr. Debjyoti Sen Gupta	Plant Breeding	Scientist
18.	Dr. Murleedhar S. Aksi	Plant Breeding	Scientist
19.	Dr. Ashok Kumar Parihar	Plant Breeding	Scientist

Crop Production

20.	Dr. P.K. Ghosh	Agronomy	Head of the Division
21.	Dr. C.S. Praharaj	Agronomy	Principal Scientist
22.	Dr. J.P. Mishra	Agronomy	Senior Scientist (Upto 14.5.2010)
23.	Dr. K.K. Singh	Agronomy	Principal Scientist
24.	Dr. M.S. Venkatesh	Soil Science	Senior Scientist
25.	Dr. Narendra Kumar	Agronomy	Senior Scientist
26.	Mr. Kali Krishna Hajara	Agronomy	Scientist

Crop Protection

27.	Dr. C. Chattopadhyay	Plant Pathology	Head of Division
28.	Dr. Vishwa Dhar	Plant Pathology	Principal Scientist
29.	Dr. R.A. Singh	Plant Pathology	Principal Scientist (Upto31.8.2010)
30.	Dr. R.G. Chaudhary	Plant Pathology	Principal Scientist
31.	Dr. (Mrs.) Hem Saxena	Entomology	Principal Scientist

32.	Dr. Bansa Singh	Nematology	Principal Scientist
33.	Dr. Shiva Kant Singh	Entomology	Principal Scientist
34.	Dr. S.D. Mohapatra	Entomology	Senior Scientist
35.	Dr. Mohd. Akram	Plant Pathology	Senior Scientist
36.	Mr. Naimuddin	Plant Pathology	Scientist (SG)
37.	Dr. P. Duraimurugan	Entomology	Scientist
38.	Dr. R. Jagdeeswaran	Nematology	Scientist
39.	Dr. P. Lakshmi Soujanya	Entomology	Scientist (11.5.2010)
40.	Dr. Amalendu Ghosh	Entomology	Scientist
	Physiology, Biochemistry & Microbiology		
41.	Dr. Jagadish Singh	Plant Physiology	Head of the Division
42.	Dr. Mohan Singh	Microbiology	Principal Scientist
43.	Dr. R.P. Srivastava	Biochemistry	Principal Scientist
44.	Dr. P.S. Basu	Plant Physiology	Principal Scientist
45.	Dr. (Mrs.) Vijay Laxmi	Plant Physiology	Senior Scientist
46.	Dr. Lalit Kumar	Agril. Chemistry	Senior Scientist
47.	Dr. M. Senthilkumar	Microbiology	Senior Scientist
48.	Mr. S. Paul Raj	Microbiology	Scientist
49.	Mr. Alagupalamuthir Solai	Plant Physiology	Scientist
	Agricultural Extension		
50.	Dr. S.K. Singh	Agril. Extension	Principal Scientist
51.	Dr. Rajesh Kumar	Agril. Extension	Principal Scientist
52.	Dr. (Mrs.) Uma Sah	Agril. Extension	Senior Scientist
53.	Dr. Purushottam	Agril. Extension	Senior Scientist
	Agricultural Statistics and Computer Application		
54.	Mr. Devraj	Computer Application	Scientist (SG)
55.	Dr. Sarika	Agril. Statistics	Scientist
	Agricultural Engineering		
56.	Mr. Prasoon Verma	Agril. Engineering	Scientist (SG)
57.	Dr. M.K. Singh	Agril. Engineering	Scientist

C. AICRP on Pigeonpea

58.	Dr. N.D. Majumder	Project Coordinator
59.	Dr. Farindra Singh	Senior Scientist

D. AICRP on Chickpea

60.	Dr. N.P. Singh	Project Coordinator
61.	Dr. Shiv Sewak	Principal Scientist
62.	Dr. Mir Asif Iquebal	Scientist

E. AICRP on MULLaRP

63.	Dr. B.B. Singh	Project Coordinator (Upto 25.1.2011)
64.	Dr. G.P. Dixit	Principal Scientist
65.	Dr. P.K. Katiyar	Senior Scientist
66.	Mr. Hemant Kumar	Scientist (Sr. Scale)

F. Technical

67.	Mr. Diwakar Upadhyaya	Editor (T-9)
68.	Mr. D.N. Awasthi	Architect (T-7/8)
69.	Dr. T.N. Tiwari	Technical Officer (T-7/8)
70.	Mr. Lallan Yadav	Technical Officer (T-7/8)
71.	Mr. D.K. Sharma	Technical Officer (T-7/8)
72.	Mr. M.R. Tripathi	Technical Officer (T-7/8)
73.	Mr. Desh Raj	Technical Officer (T-7/8)
74.	Mr. Brahm Prakash	Technical Officer (T-7/8) (Upto 3.8.2010)
75.	Dr. M.P. Singh	Technical Officer (T-7/8)
76.	Mr. Vijendra Singh	Technical Officer (T-7/8)
77.	Mr. S.P.S. Chauhan	Technical Officer (T-7/8)
78.	Dr. A.S. Sachan	Technical Officer (T-6)
79.	Mr. Jokhu Ram	Technical Officer (T-6)
80.	Dr. Aditya Prakash	Technical Officer (T-6)
81.	Dr. G.K. Srivastava	Technical Officer (T-6)
82.	Mr. A.B. Singh	Technical Officer (T-6)
83.	Dr. Ved Ram	Technical Officer (T-6)
84.	Mr. R.S. Mathur	Technical Officer (T-6)
85.	Mr. Radha Krishan	Technical Officer (T-6)
86.	Mr. Omkar Nath	Technical Officer (T-6)
87.	Mr. Ramesh Chandra	Technical Officer (T-5)
88.	Mr. S.K. Garg	Technical Officer (T-5)
89.	Mr. Govind Ram	Technical Officer (T-5)
90.	Mr. Ved Prakash	Technical Officer (T-5)
91.	Mr. Rajendra Prasad	Technical Officer (T-5)
92.	Mr. A.P. Singh	Technical Officer (T-5)

G. Administrative

93.	Mr. P.R. Sharma	Finance & Accounts Officer (Upto 30.4.2010)
94.	Mr. K.N. Gupta	Finance & Accounts Officer
95.	Mr. Rajendra Singh	Administrative Officer
96.	Mr. A. K. Saxena	Assistant Administrative Officer
97.	Mrs. A. Abraham	Assistant Administrative Officer
98.	Mr. B.K.Verma	P.S. to Director

Appointments, Promotions, Transfers, *etc.*

Appointments

Name	Designation	Date of joining
Mr. Udai Chand Jha	Scientist (Plant Breeding)	23.4.2010
Mr. M. Alagupalamuthirsolai	Scientist (Plant Physiology)	3.5.2010
Mr. Debjyoti Sen Gupta	Scientist (Plant Breeding)	3.5.2010
Dr. S.K. Chaturvedi	Head, Division of Crop Improvement	11.8.2010
Mr. Kali Krishna Hajara	Scientist (Agronomy)	27.8.2010
Dr. R. Jagadeeswaran	Scientist (Nematology)	30.8.2010
Dr. Muraleedhar S. Aski	Scientist (Plant Breeding)	17.9.2010
Dr. Jagdish Singh	Head, Division of Crop Physiology, Biochemistry and Microbiology	12.10.2010
Sh. Deen Dayal Kumar	Technical Assistant (T-3)	01.11.2010
Dr. M. Senthilkumar	Sr. Scientist (Microbiology)	03.1.2011
Dr. Amalendu Ghosh	Scientist (Entomology)	10.1.2011
Dr. Ashok Kumar Parihar	Scientist (Plant Breeding)	10.1.2011
Mr. K.N. Gupta	Finance & Accounts Officer	15.3.2011

Promotions

Name	Promoted to	w.e.f.
Dr. G.P. Dixit	Principal Scientist	05.8.2008
Dr. I.P. Singh	Principal Scientist	05.8.2008
Dr. K.K. Singh	Principal Scientist	03.12.2008
Dr. Shiva Kant Singh	Principal Scientist	14.11.2008
Dr. Lalit Kumar	Senior Scientist	30.6.2008
Dr. (Mrs.) Uma Sah	Senior Scientist	08.11.2008
Dr. Purushottam	Senior Scientist	30.7.2007
Mr. Devraj	Scientist (SG)	16.12.2008
Mr. Hemant Kumar	Scientist (Sr. Scale)	10.1.2008
Sh. Shiv Saran Singh	Assistant	04.11.2010
Smt. Reeta Mishra	Senior Clerk	04.11.2010
Mr. Vijendra Singh	Technical Officer (T-7/8)	01.1.2009
Mr. Satish Chandra	Assistant	30.3.2011

Transfers

Name	Designation	From	To	Date
Dr. (Mrs.) P. Laxmi Soujanya	Scientist (Entomology)	IIPR, Kanpur	DMR Regional Station, Hyderabad	11.5.2010
Dr. J.P. Mishra	Principal Scientist (Agronomy)	IIPR, Kanpur	ICAR, New Delhi	14.5.2010
Mr. Shiv Pal Singh Chauhan	Technical Officer (T- 7/8)	NRC for Agro-forestry, Jhansi	IIPR, Kanpur	21.7.2010
Mr. Brahm Prakash	Technical Officer (T-7/8)	IIPR, Kanpur	IISR,Lucknow	03.8.2010
Dr. Asit B. Mandal	Principal Scientist (Plant Breeding)	DSR, Mau	IIPR, Kanpur	11.2.2011

- Dr. B.B. Singh, Project Coordinator (MULLaRP) was relieved from the Institute on 25.1.2011 to join as Asstt. Director General (Oilseeds & Pulses) at ICAR, New Delhi.
- Sh. Rajeev Nigam was relieved from the Institute on 04.12.2010 to join as Asstt. Administrative Officer at Zonal Project Directorate, Kanpur.

Retirements

Name	Post held	Date of retirement
Mr. P.R. Sharma	Finance & Accounts Officer	30.4.2010
Mrs. Shanti	Supporting Staff	30.6.2010
Dr. R.A. Singh	Principal Scientist (Plant Pathology)	31.8.2010
Mr. Narain Singh	Technical Assistant (T-2)	31.8.2010

Obitury

Sh. Lalta Prasad, Supporting Staff left for his heavenly abode on 22.5.2010. May his soul rest in Peace.

Indian Institute of Pulses Research, Kanpur-208 024

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

Email: director@iipr.ernet.in

Website: http://iipr.res.in

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