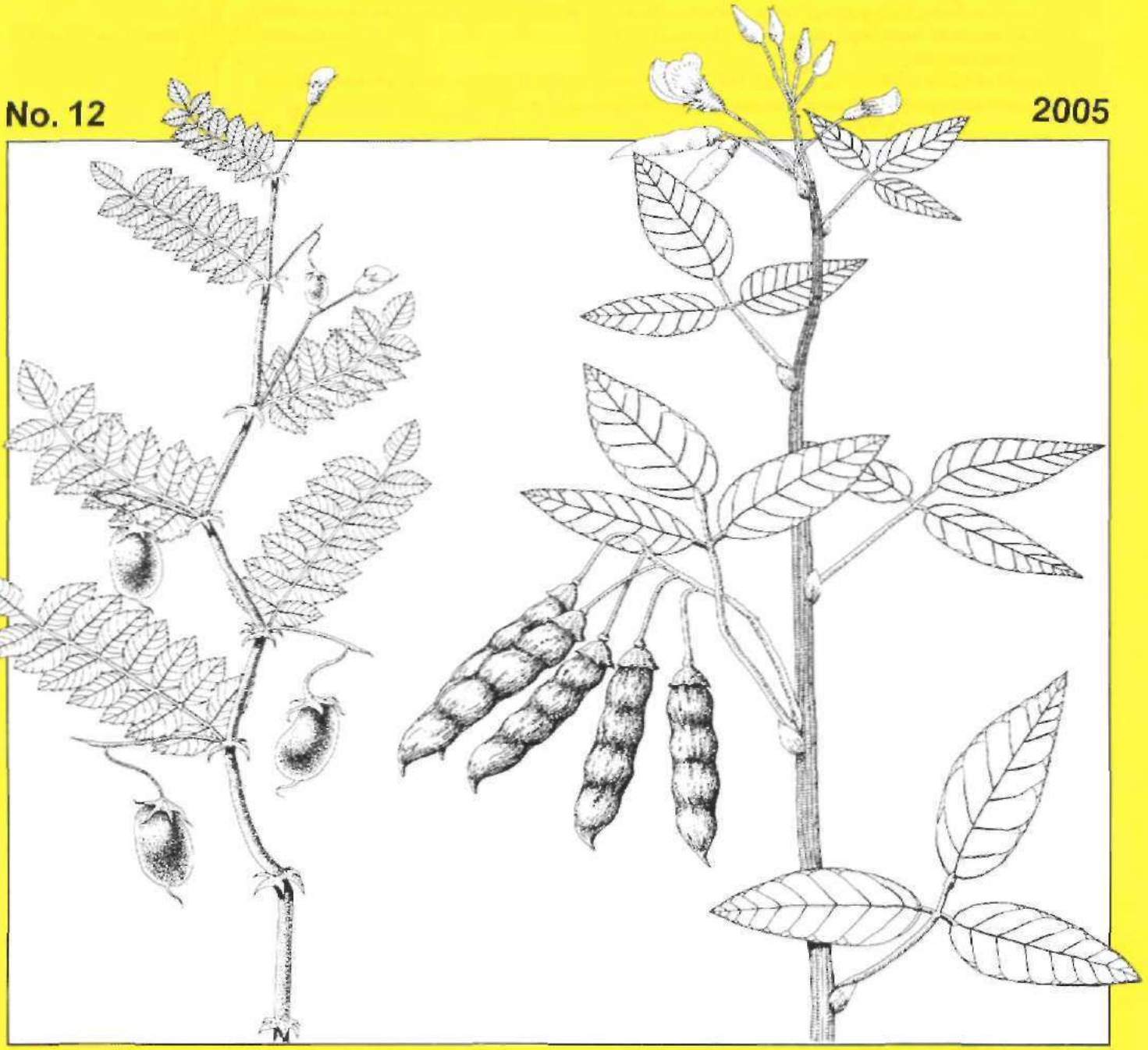
International Chickpea and Pigeonpea Newsletter

No. 12 2005



International Chickpea and Pigeonpea Newsletter

Publishing objectives

The International Chickpea and Pigeonpea Newsletter (ICPN) is published annually by ICRISAT. It is intended as a worldwide communication link for all those who are interested in the research and development of chickpea *(Cicer arietinum* L.), and pigeonpea *(Cajanus cajan* (L.) Millsp.), and their wild relatives. Though the contributions that appear in ICPN are peer-reviewed and edited, it is expected that the work reported will be developed further and formally published later in refereed journals. It is assumed that contributions in ICPN will not be cited unless no alternative reference is available.
ICPN welcomes short contributions (not exceeding 600 words) about matters of interest to its readers.

What to contribute?

Send us the kind of information you would like to see in ICPN.

- **Contributions should be current, scholarly, and their inclusion well-justified on the grounds of new information.**
- Results of recently concluded experiments, newly released varieties, recent additions to germplasm collections, etc.
- Genome maps and information on probe-availability and sequences, and populations synthesized for specific traits being mapped. Glossy black and white prints of maps should be included, if possible. Partial maps can also be submitted.
- Short reports of workshops, conferences, symposia, field days, meetings, tours, surveys, network activities, and recently launched or concluded projects.
- Details of recent publications, with full bibliographic information and 'mini reviews' whenever possible.
- Personal news (new appointments, awards, promotions, change of address, etc).

How to format contributions?

- Keep the items brief- remember, ICPN is a newsletter and not a primary journal. About 600 words is the upper limit (no more than two double-spaced pages). **As the newsletter is devoted to the chickpea and pigeonpea crops, authors should refrain from providing a general introduction to these crops, except if they are being grown in a new area.**
- If necessary, include one or two small tables (and no more). Supply only the essential information; round off the data-values to just one decimal place whenever appropriate; choose suitable units to keep the values small (eg, use tons instead of kg). Every table should fit within the normal typewritten area of a standard upright page (not a 'landscape' page).
- Black-and-white photographs and drawings (prepared in dense black ink on a white card or a heavy-duty tracing paper) are welcome - photocopies, color photographs, and 35-mm slides are not. Please send disk-files (with all the data) whenever you submit computer-generated illustrations.
- Keep the list of references short - not more than five references, all of which should have been seen in the original by the author. Provide all the details including author/s, year, title of the article, full title of the journal, volume, issue, and page numbers (for journal articles), and place of publication and publishers (for books and conference proceedings) for every reference.
- Express all the quantities only in SI units. Spell out in full every acronym you use.
- Give the correct Latin name of every crop, pest or pathogen at the first mention.
- Type the entire text in double spacing. Send a file, which should match the printout, on a double-sided/high density IBM-compatible disk using **Microsoft Applications.**
- Contact the Editor for detailed guidelines on how to format text and diskettes.
- **Include the full address with telephone, fax and email numbers of all authors.**

The Editors will carefully consider all submitted contributions and will include in the Newsletter those that are of acceptable scientific standard and conform to requirements. The language of the Newsletter is English, but where possible, articles submitted in other languages will be translated. Authors should closely follow the style of the reports in this issue. Contributions that deviate markedly from this style will be returned for revision, and could miss the publication date. Communications will be edited to preserve a uniform style throughout the Newsletter. This may shorten some contributions, but particular care will be taken to ensure that the editing will not change the meaning and scientific content of the article. Wherever substantial editing is required, a draft copy of the edited version will be sent to the contributor for approval before printing.

Contributions should be sent before 31 March to:

ICPN Editor
ICRlSAT
Patancheru 502 324
Andhra Pradesh, India
Fax +9140 30713074
Email newsletter@cgiar.org
Tel +9140 30713071

Contents

Agronomy/Physiology

Pathology

Entomology

Pigeonpea

Editorial

I wish to welcome all the ICPN readers. For this issue of ICPN, 34 manuscripts were received for consideration of which 25 have been accepted and included in this issue. Five manuscripts were found unsuitable for ICPN, and four corresponding authors did not review and respond to the remarks in time. I suggest that the contributors follow the guidelines (on the inside cover) while preparing the manuscript, and respond to the reviewing queries in time so as to bring out the newsletter issues conveniently and promptly. News about the researchers and the crops, and short research articles should be the focus of the newsletters, and I request the contributors to consider the same. It would give me immense satisfaction if all the personnel engaged with the research and development of chickpea and pigeonpea take interest in sharing and distributing the information using this newsletter.

I thank the contributors and the authors of this issue, and particularly the reviewers of the manuscripts, namely, SL Dwivedi, PM Gaur, L Krishnamurthy, K Krishnappa, JVDK Kumar Rao, N Mallikarjuna, S Pande, RPS Pundir, LJ Reddy, OP Rupela, KL Sahrawat, DVSSR Sastry, KB Saxena, HC Sharma, P Singh, Sube Singh, V Vadez (ICRISAT), PK Agrawal, SC Goswami, GT Gujar, J Kumar (1ARI, New Delhi), Shiv Kumar (IIPR, Kanpur), and SB Sharma (Department of Agriculture, Australia), and the Library at ICRISAT compiling SATCRIS listing.

We are updating the mailing list of ICPN. Therefore, kindly furnish the particulars in the attached form and send it back to us before 30 November 2005 or email your response to newsletter@cgiar.org. It may be difficult to process any request after the deadline.

ICPN team wishes its readers a very happy Christmas and a healthy, productive and prosperous 2006.

HD Upadhyaya

News

CGIAR Award to ICRISAT Scientist

P Lava Kumar, Special Project Scientist - Virology, of ICRISAT, received the "CGIAR Young Scientist Award 2004", for his contribution to identification of the causal agent of pigeonpea sterility mosaic disease (SMD), a widespread problem in the Indian subcontinent that drastically cuts the pigeonpea yields, causing over US$300 million worth of grain loss. His work lead to the development of disease diagnostic tools and improved methods of controlling it. He was also the recipient of "Millennium ICRISAT Science Award 2004" as promising young scientist for contribution to the sustainable management of SMD.

Chickpea Scientists' Meet Held at ICRISAT-Patancheru

A one-day Chickpea Scientists' Meet was organized at ICRISAT on 6 January 2005 for the scientists of National Agricultural Research System (NARS), India. The meeting was attended by 45 scientists that included 28 Indian NARS scientists from 12 states and 17 ICRISAT scientists. The objective of the meeting was to facilitate interaction between ICRISAT and NARS scientists and provide opportunity to NARS scientists to see ICRISAT's chickpea experiments and select breeding lines and germplasm of their interests.

The meeting was inaugurated by JDH Keatinge, the Deputy Director General (Research) of ICRISAT, after a formal welcome by CLL Gowda, the Leader for Global Theme - Crop Improvement. Masood Ali, Director, Indian Institute of Pulses Research, Kanpur, made a presentation on significant achievements and future opportunities for lCRISAT-Indian NARS collaboration in chickpea research. PM Gaur, ICRISAT's Chickpea Breeder, presented highlights of the recent developments in chickpea research at ICRISAT. It was emphasized that ICRISAT-Indian NARS partnership has been very fruitful in chickpea research as 25 varieties, including some very popular varieties such as ICCV 2, ICCV 10, ICCC 37, JG 11, JG 16, JG 130, KAK 2, JGK 1, Vishal, and BG 1053, have been developed through this partnership. The ICRISAT-Indian NARS collaborative varieties had 37% share in the total indent of chickpea breeder seed in the country for 2004/05.

The participants witnessed various experiments on physiology, pathology, entomology, genetic resources, wide hybridization, genetics and breeding of chickpea, and had interactions with the scientists. They selected germplasm and breeding materials of their interests and submitted indents to ICR1SAT for the supply of seed.

Contributed by PM Gaur
lCRISAT, Patancheru, India

Marigold: A Diagnostic Tool for BGM Forecasting and Management in Chickpea

Botrytis gray mould (BGM) is a disease that mainly attacks the reproductive structures of a chickpea plant. Flower abortion is a common symptom of the disease (Fig. 1) which remains undiscovered until the damage is visible on the canopy. As a result, timely application of fungicides is hampered in the integrated disease management. The predictive models (Shtienberg and Elad 1997) to estimate disease severity and timing are based on complex mathematical calculations, and they do not account for inoculum pressure. To identify an alternative indicator for a reliable diagnosis, forecasting and management of BGM, several ornamental plants commonly grown during the chickpea season as a collateral host of *Botrytis cinerea* were evaluated.

The controlled environment investigations on host pathogen interaction were carried out with marigold *(Tagetus erecta* L.). Flowering plants of marigold when spray-inoculated with *B. cinerea* (3×10^5 conidia mL^{-1}) from chickpea and incubated in an environment (15°C and 100% RH) needed for BGM development, produced symptoms on the leaves, flowers, flower buds and stems. Six days after inoculation (DAI), dark lesions were observed on a fully bloomed flower (Fig. 2A). Concurrently, all the young buds appeared completely rotted, but did not support sporulation (Fig. 2B). By 12 DAI, masses of wind blown grey sporulation on flowers and flower buds were clearly visible (Fig. 2C and 2D). Between 15 and 20 DAI, profuse grey sporulation was observed on all the aerial plant parts (Fig. 2E).

The early infection of *B. cinerea* causing moldy infection on marigold clearly identified its usefulness to farmers as a diagnostic tool to predict BGM epidemics and its management in chickpea. Marigold as an indicator plant to apply prophylactic fungicidal protection to chickpea crop in Nepal has been successfully validated. Infection of *B. cinerea* on the flowers of marigold and

Figure 1. BGM infection on chickpea flowers.

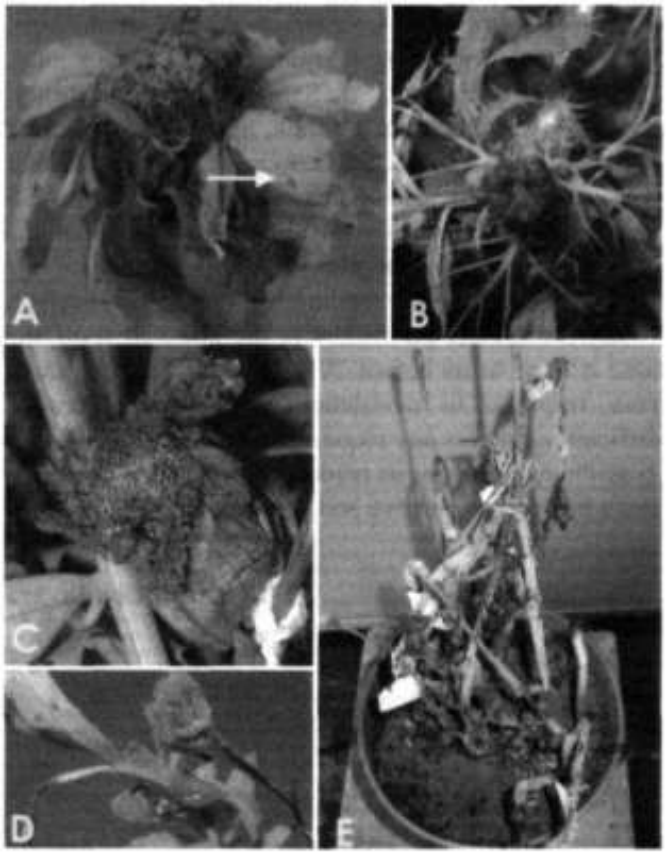


Figure 2. Progressive symptoms of *Botrytis cinerea* infection on marigold: (A) Initial lesion development and sporulation on bloomed flowers and (B) rotted young buds; (C) sporulation on flowers; (D) sporulation on flower buds and lesion development on leaves; (E) sporulation on all the aerial plant parts.

Dahlia, grown at Ishurdi and Jessore in Bangladesh, indicates the possible integration of this farmer friendly, low-cost B G M forecasting system.

Reference

Shtienberg D and **Elad Y. 1997.** Incorporation of weather forecasting in integrated, biological-chemical management of *Botrytis cinerea. Phytopathology* 87:332-340.

Contributed by Suresh Pande, G Krishna Kishore and J Narayana Rao
Crop Improvement Theme
ICRISAT, Patancheru, India

Visiting Scientists

SL Dwivedi has joined ICRISAT Genetic Resources Unit as a Visiting Scientist to work on Generation Challenge Program supported chickpea project on "assessing the genetic diversity and allelic variation associated with beneficial traits in global composite chickpea core collection" in partnership with ICARDA, which is another CGIAR Center participating in this project. This composite core consists of 3000 accessions, drawn from vast collection of chickpea germplasm maintained at the ICRISAT and ICARDA gene banks - chickpea core collection, elite germplam, advanced lines/ cultivars, unique germplasm with specific traits, and wild *Cicer* species. Using ABI3700 and SSR markers, the accessions will be molecularly profiled at MS Swaminathan Applied Genomics Laboratory, ICRISAT, to define the genetic structure of the global composite collection, and to form a subset of 300 accessions representing the maximum diversity for the isolation of allelic variants of candidate gene associated with beneficial traits. It is expected that molecular biologists and plant breeders will have ample opportunities to use diverse lines in functional and comparative genetics, in the mapping and cloning of gene(s) of particular interest, and in applied breeding to diversify the genetic base of the populations which leads to the development of cultivars with superior performance.

Ranjana Bhattacharjee joined the Genetic Resources Unit (GRU), ICRISAT, as a Visiting Scientist for the project "molecular characterization of pigeonpea composite collection." The project is supported by the Generation Challenge Program of the Consultative Group on International Agricultural Research (CGIAR). Dr Bhattacharjee has a PhD on establishing pearl millet core collection, which she pursued at the GRU, ICRISAT, and at the Haryana Agriculture University. Following this, she worked at the International Institute of Tropical Agriculture (IITA), Nigeria, as Postdoctoral Fellow on cocoa molecular genetics. In her new stint at ICRISAT, she will be involved in characterizing pigeonpea accessions using micro-satellite markers to determine the genetic structure of the global pigeonpea composite collection. The results of this study will further diversify the genetic base of populations, and assist in mapping and cloning gene(s). Data generated will also contribute to comparative and functional genetics. Breeders will have opportunity to use genetically diverse parents in their program to develop broad based cultivars.

Research Reports

Chickpea

Genetics/Breeding/Biotechnology

Detection of Polymorphism Using CAPS and dCAPS Markers in Two Chickpea Genotypes

PN Rajesh, Kevin McPhee and **Fred J Muehlbauer***
(USDA-ARS, Dept of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6434, USA)
*Corresponding author: muehlbau@wsu.edu

Cleaved amplified polymorphic sequence (CAPS) and derived cleaved amplified polymorphic sequence (dCAPS) are sequence-based and co-dominant markers. CAPS markers result from differential restriction digestion of gene / allele specific polymerase chain reaction (PCR) products based on the loss or gain of restriction enzyme recognition sites due to the presence of single nucleotide polymorphisms (SNPs) or insertion / deletion mutations. In dCAPS analysis, a restriction enzyme recognition site that includes the SNP is introduced into the PCR product by a primer containing one or more mismatches to template DNA (Neff et al. 1998). These markers were developed previously and have shown utility in other plant species but have not been used in chickpea genome analysis prior to this report. Using available DNA sequences from BAC ends and gene specific markers, we studied the usefulness of CAPS and dCAPS markers to identify polymorphism in a region of the chickpea genome lacking visible polymorphism.

Primers were designed from the ends of 4m10, 15o9 BAC clones and the partial sequences of Aldolase (visit http:// frodo. wi. mit. edu/cgi- bin/primer3/primer3 www.cgi). These primers were used to amplify genomic DNA of FLIP 84-92C and PI 599072 which are parental lines that resulted in monomorphic bands of expected size. To develop CAPS and dCAPS markers, the amplified products were run on 1% agarose gels, and the fragments eluted from the agarose gels using DNA gel extraction kit (Millipore, USA) were cloned into the pGEM-T easy plasmid vector (Promega, USA). The cloned DNA fragments were sequenced on an ABI Prism 377 DNA sequencer (Applied Biosystems, USA) using the dideoxy sequencing method with T7 universal primer. In CAPS analysis, the sequences of both parental DNAs were compared using Vector NTI Advance 9.0 software (www.informaxinc.com) for SNP detection and restriction mapping. The SNPs that conferred differential restriction enzyme sites between the parents were used for further analysis. Amplified product size of aldolase primers is 168bp and the polymorphism was detected by *Afl* lll restriction enzyme digestion (Fig. 1).

CAPS analysis did not detect polymorphism in the product amplified with the primer (MF) designed from forward end of 4m10 BAC clone. In this case we used dCAPS technique by designing primers with a single nucleotide mismatch adjacent to SNP position creating restriction site in the amplified PCR product of one parent but not the other. The primers for dCAPS analysis were designed using a web-based software package and the program is available on http://helix.wustl.edu/dcaps/dcaps.html. The size of the product amplified by MF is 553bp and *Taq* 1 restriction site was created by replacing an adenosine with a thymidine at the third position 5' to the SNP. The amplified products were digested using *Taq* 1 enzyme and separated on 2% agarose gel to detect polymorphism between the parental lines and the segregating population (Fig. 2). Metaphor agarose gel or 6% acrylamide gel is recommended for improved resolution of the digested bands.

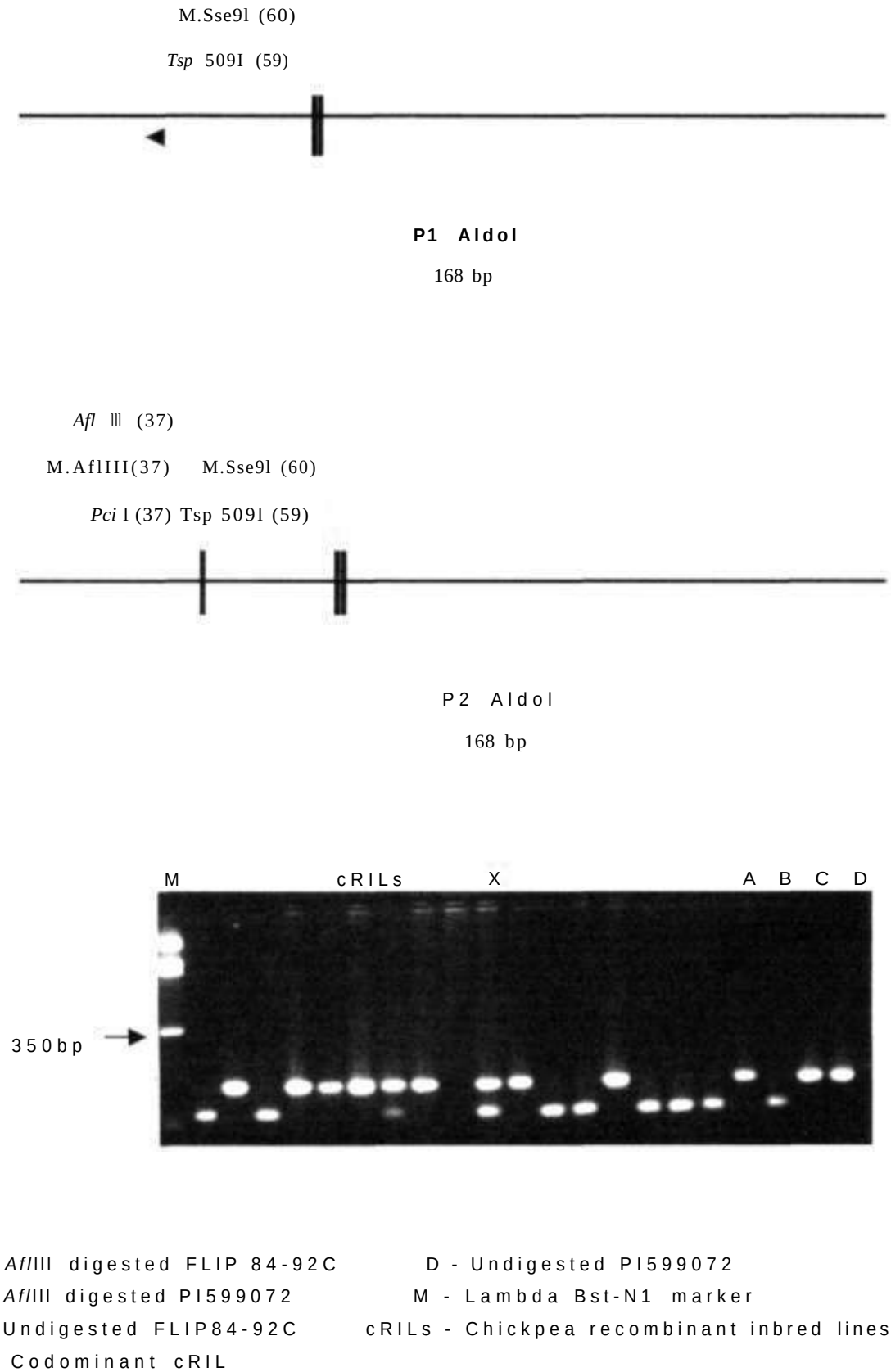


Figure 1. CAPS analysis using Aldolase specific primers.

AACTTGAAGATATTTAATATGGCAC ***T***C -dCAPSMF primer

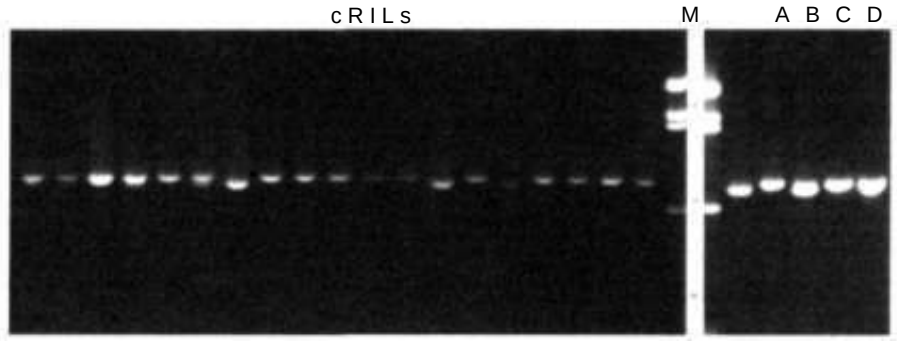
AACTTGAAGATATTTAATATGGCACAC**A**AACA -FLIP84-92C
AACTTGAAGATATTTAATATGGCACAC**G**AACA -PI599072

Taq 1 TCGA

*Taq*1 digestion

AACTTGAAGATATTTAATATGGCAC***T***C**A**AACA

AACTTGAAGATATTTAATATGGCAC***T***/C**G**AACA



A - *Taq*1 digested FLIP 84-92C
B - *Taq*1 digested PI599072
C - Undigested FLIP84-92C
D - Undigested PI599072
M - Lambda Bst-N1 marker
cRILs - chickpea recombinant inbred lines

Figure 2. dCAPS analysis using BAC end primers.

SNP detection between parental allelic sequences was verified by comparing replicate sequences. Although the frequency of SNPs present in the chickpea genome is not known, SNPs arc reported to be abundant in plant genome (Griffin and Smith 2000). Development of CAPS and dCAPS markers is simple and does not require expensive instruments. It involves common laboratory methods such as polymerase chain reaction, restriction digestion and agarose electrophoresis. Application of these markers in chickpea mapping where absence of polymorphism is a constraint is expected to improve generation of high density maps necessary for map-based cloning and integration of physical and genetic maps.

References

Neff M, Neff J, Chory J and **Pepper A. 1998.** dCAPS, a simple technique for the genetic analysis of single nucleotide polymorphisms: experimental applications in *Arabidopsis thaliana* genetics. The Plant Journal 14(3):387 392.

Griffin TJ and **Smith LM. 2000.** Single-nucleotide polymorphism analysis by MALDI-TOF mass spectrometry. Trends in Biotechnology 18:77-84.

Nutritional Constituents in Chickpea Varieties

R Bhataagar*, JP Yadavendra and **KV Patel** (Department of Biochemistry, BA College of Agriculture, Anand Agricultural University, Anand 388 110, Gujarat, India)
Corresponding author: bhatnagarramesh@yahoo.com

Chickpea *(Cicer arietinum)* is an important source of dietary protein of the predominant vegetarian population of the Indian sub-continent. It is also adopted as protein supplement food by the people of European countries (Viveros et al. 2001). The green chickpea is used for vegetable purpose whereas, dry seed is consumed in the form of whole seed, *dhal,* and in the form of fried items from the chickpea flour. However, many people use the chickpea in flour form. Limited information on proximate composition of chickpea is available (Gopalan et al. 1971 ; Sotelo et al. 1987). Therefore, here an attempt was made to evaluate different varieties of chickpea for nutritional constituents and tannin contents in the flour of dry seeds of ten varieties including the dominant varieties of the region *viz* Dohad Yellow and GG 1.

Seeds of ten varieties were collected from a replicated breeding trial conducted at the Plant Breeding Farm, Gujarat Agricultural University, Anand, during winter season of 1999-2000. The dry seeds were ground in mechanical grinder from each replicate and 60-mesh powder was used for chemical analysis. The analysis was done for oil, ash and protein, as per AOAC standard whereas crude fiber and methionine were estimated according to the procedures described by Maynard (1978) and Mc Carthy and Paille (1959), respectively. Total carbohydrate percentage was determined by subtracting the sum of the percentage of crude protein, crude fiber, fat, ash and moisture from 100%. The energy value of seeds was calculated (Osborne and Voogt 1970). Total phosphorus and iron was determined colorimetrically. The procedure of AOAC (1970, 1980) was used to determine the calcium.

Tannin and anti-nutritional factor was determined as per the procedure described by Sadasivam and Manikam (1992). All these above mentioned analytical observations of three replicated samples for individual components were used for the analysis of variance by Randomized Block Design (RBD) (Steel and Torrie 1980). The results obtained for various parameters are presented in Table 1. The flour moisture content was found highly variable indicating variable moisture holding capacity of flour. This was also reported in cereals and pulses (Patel and Parameswaran 1992).

Table 1. Biochemical composition (%) of chickpea flour samples.

Variety	Moisture (%)	Oil (%)	Protein (%)	Ash (%)	Crude fiber (%)	Total Carbohydrate (%)	Energy content kcal/100 g	Methionine (% pro.)	Mineral content			Tannin (%)
									Ca(%)	P(%)	Fe(%)	
Pusa 267	7.63	6.58	18.53	3.50	1.81	61.72	380.40	0.83	0.18	1.20	0.50	0.81
Pusa 1003	8.41	5.42	19.03	3.45	2.26	61.72	370.55	0.63	0.23	1.13	0.51	0.82
Pusa GS	5.96	6.02	17.29	3.48	5.79	61.88	371.30	0.61	0.13	1.15	0.54	1.02
GCP 105	6.74	6.12	18.53	3.25	8.18	57.15	358.02	0.65	0.23	1.00	0.25	1.19
GCP 106	6.84	5.07	19.33	2.87	7.07	58.79	357.46	0.49	0.18	1.09	0.59	1.08
GCP 9516	6.00	6.39	18.53	2.93	6.81	59.41	369.21	0.47	0.13	0.96	0.35	0.99
GCP 9707	4.42	5.58	17.29	3.14	5.84	63.79	374.07	0.60	0.20	1.03	0.38	1.02
GCP 9605	5.68	5.94	17.36	3.50	5.97	61.21	368.61	0.68	0.20	0.94	0.41	1.38
GG 1	6.34	5.97	17.58	3.62	4.79	61.66	372.18	0.65	0.23	1.02	0.46	1.12
D. Yellow	6.24	5.31	19.92	3.32	6.28	59.01	363.21	0.48	0.18	1.17	0.52	1.12
SEm (±)	0.26	0.07	0.15	0.04	0.43	8.63	1.76	0.05	0.02	0.07	0.01	0.12
CD (0.05)	0.77	0.20	0.44	0.14	1.37	NS	5.56	0.15	NS	NS	0.02	NS
CV (%)	7.02	2.04	1.42	1.90	11.2	21.1	0.68	14.1	17.1	8.7	4.2	16.0

The analysis of variance for chemical constituents of the chickpea varieties revealed significant differences for oil, protein, ash, crude fiber, iron and energy content among the varieties. Maximum protein content was observed in variety Dohad Yellow (19.9%). However, its methionine content (0.48%) was the lowest. Across the varieties, there was no significant difference in total carbohydrates, calcium, phosphorus and anti-nutritional factor such as tannin. High fat and carbohydrate makes variety Pusa 267 a good source of energy (Table 1) besides its high protein content. There was a wide range of crude fiber content, a non-nutritional constituent required for maintenance of good health, (1.81 to 8.18%) that was lower than that of the Mexican chickpea (9.1%) reported earlier (Sotelo et al. 1987). It was also reported that cooking diminished only the ash content and the Mexican variety Poranero was only one that had a high amount of crude fiber, as far as the varieties evaluated globally.

A significant variation in the ash content of different chickpea varieties was also prevalent. Iron content differed significantly among the varieties studied. Maximum iron content was observed in the variety GCP 106 (0.59%). Pusa 267 had the maximum methionine percent (0.83%). Wide range of tannin content, the anti-nutritional factors, had been found in most of the legumes. Tannins, which reduce the digestibility of proteins, were found to be the highest in GCP 9605 (1.38%).

References

AOAC. 1970. Official methods of analysis, 11th edition. Washington DC, USA: Association of Official Analytical Chemists.

AOAC. 1980. Official methods of analysis. 13th edition. Washington DC, USA: Association of Official Analytical Chemists.

Gopalan C, Sastri BVR and **Balasubramanium SC. 1971.** Nutritive value of Indian foods. Hyderabad, India: National Institute of Nutrition.

Maynard AJ. 1978. Methods in food analysis. New York, USA: Academic Press. 176 pp.

Mc Carthy TE and **Paille M M . 1959.** A rapid determination of methionine in crude protein. BBA Research Communication 1:29.

Osborne DR and **Voogt P. 1970.** The analysis of nutrients in food. New York, USA: Academic Press.

Patel KV and **Parameswaran M. 1992.** Effects of heat treatment on lipid degradation in bajra flour during storage. Journal of Food Science and Technology 29(l):51-52.

Sadasivam S and **Manikam A. 1992.** Biochemical methods. New Delhi, India: Wiley Eastern Ltd. 190 pp.

Sotelo A, Flores F and **Hernandez M. 1987.** Chemical composition and nutritional value of Maxican varieties of chickpea (Cicer *arietinum* L.). Plant Foods Human Nutrition 37(4):299-306.

Steel Robert GD and **Torrie JH. 1980.** Principles and procedures of statistics. A biometrical approach, 2nd edn. New Delhi, India: McGraw Hill Kogakusha Ltd. 155 pp.

Viveros A, Brenes A, Elices R, Arija I and **Canales R. 2001.** Nutritional value of raw and autoclaved kabuli and desi chickpea *(Cicer arietinum* L.). British Plant Science 42(2):242-51.

A New Kabuli Chickpea "Vihar" for South India

BM Jamadagni, LB Mhase and **DV Deshmukh** (Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri 413 722, Ahmednagar, Maharashtra, India)

Kabuli chickpea is mostly suitable for the region where the span of winter season is long. Its cultivation has attracted several progressive farmers in the south zone as it fetches premium price when compared to d*esi.* Hence developing a cultivar of *kabuli* chickpea suitable for the region with mild and short winter, large seed size and resistance to fusarium wilt are the basic requirements. On this background, the variety Phule G-95311 released by 'All India Co-ordinated Research Project on Chickpea' has fulfilled a long awaited demand. Twenty advanced breeding lines of *kabuli* chickpea were obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, in 1996-97 at Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. ICCV 95311 derived from a multiple cross of [ICCC-32 x ICCL-80004) x [(ICCC-49 x FLIP-82-8C) x ICCV-3] was found promising for yield and seed size. It was, therefore, tested in Station Trial and Regional Varietal Trial during 1996-98. On the basis of its performance, it was promoted to State Multilocation Trial in 1998-99. Further, it was included in All India Co-ordinated trials where it performed extremely well in Initial Varietal Trial, Advance Varietal Trial-1 and Advance Varietal Trial-2, especially for southern zone. Considering its high yield performance in comparison with the standard check ICCV *2,* K A K 2 and BG 1003, it was released for general cultivation in the south zone in

Table 1. Yield and ancillary characters of 'Vihar'.

Character	
Yield (t ha^{-1})	1.81
Height (cm)	35-43
Number of branches/plant	6-9
Flower color	Whitish
Duration of flowering (days)	38-43
Maturity period (days)	105-115
Test weight in g (100 seeds)	34-36
Color of seed	Creamy white

Table 2. Percent increase in yield of 'Vihar' over standard control cultivars.

Variety	Yield (kg ha^{-1})	Increase over (%)
Vihar (17)[1]	1811	-
ICCV 2 (10)	1490	21.54
KAK 2 (5)	1357	33.46
BG 1003 (11)	943	92.05

1. Figures in parentheses indicate number of trials.

Table 3. Reaction of 'Vihar' to fusarium wilt and *Helicoverpa armigera* (1997-2003).

Genotypes	Wilt (%)	Pod borer (%)
Vihar	7.04	12.19
ICCV 2	35.72	18.97
L 550	77.90	17.10
KAK 2	13.98	-
BG 1003	37.98	-
JG 62	100.00	-

2002 under the name 'Vihar'. The important features of this variety are given in Table 1.

Typically, in 17 trials conducted at different locations, Vihar has given average grain yield of 1811 kg ha^{-1} as against 1490 kg ha^{-1} of ICCV 2, 1357 kg ha^{-1} of KAK 2, and 943 kg ha^{-1} of BG 1003 (Table 2). Thus, the increase in yields over the three controls were 21.54, 33.46 and 92.05 percent, respectively.

The grain yield in Agronomy trial revealed that 'Vihar' was significantly superior under irrigated (3241 kg ha^{-1}) and rainfed (1070 kg ha^{-1}) conditions as compared to other genotypes.

The variety has shown high resistance to fusarium wilt (7.04%) as against 35.72% in check ICCV 2, 77.90% in L 550 and 13.98% in KAK 2 over 5-year period in fusarium wilt sick plot at Rahuri (Table3). In addition, this variety showed least pod borer damage (12.19%) than ICCV 2 (18.97%) and L 550 (17.10%), showing high degree of tolerance to *Helicoverpa.*

The Central Variety Release Committee, New Delhi, identified this variety for cultivation in south zone in December 2002. This variety is expected to fulfill the demand of Indian market for extra bold seed size.

Performance of Kabuli Chickpea Cultivar KAK 2 in Rainfed Black Soils of Prakasam District, Andhra Pradesh, India

T Srinivas', MC Obaiah and **SP Moula** (District Agricultural Advisory and Transfer of Technology Centre, Acharya NG Ranga Agricultural University, AMC Compound, Throvagunta PO, Ongole 523 262, Andhra Pradesh, India)

*Corresponding author: vasuthumati28@yahoo.co.in

Prakasam district, the southern part of Andhra Pradesh state has about 100,000 ha under rainfed black soils. In the last few decades, the major crops in this farming situation were tobacco and cotton. During 2000-2001, due to declaration of crop holiday for tobacco, there has been a shift from tobacco crop to chickpea *(Cicer arietinum* L.), and now chickpea occupies 67 percent of the rainfed black soils. Most farmers in the district grow a *desi* chickpea variety Annigeri. To increase the net income of the farmer, the District Agricultural Advisory and Transfer of Technology Centre, Ongole, AP, India, initiated testing of two kabuli chickpea varieties KAK 2 and ICCV 2 along with the popular cultivar Annigeri in the farmers' fields (during 2001-2002 and 2002-2003). Each variety was sown in an area of about 500 m^2 replicated five times in Randomized Block Design (RBD).

The sowings were done during the first fortnight of November and the crop was harvested during the first fortnight of February. The seed was sown with seed drill and in each plot the plant population was approximately 33 plants m^{-2} A fertilizer dose of 20 kg N and 50 kg P_2O_5 per hectare was applied as basal dose in the form of urea and single super phosphate. All the operations during the crop growth period such as seed treatment with fungicides, weeding at 30 days after sowing, and plant protection measures were followed for the management of pod borers, viz, *Helicoverpa armigera, Spodoptera exegua.*

Table 1. Performance of chickpea varieties under rainfed condition in black soils of Prakasam district of Andhra Pradesh, 2001-2002 and 2002-2003.

Year	Variety	Plant height (cm)	Number of pods plant^{-1}	Yield (t ha^{-1})	100-seed weight (g)
2001-2002	KAK 2	57.0	95.0	2.75	39.2
	ICCV 2	41.5	32.5	1.65	25.0
	Annigeri	41.0	68.0	2.40	24.3
SEd±				0.058	0.602
CD at 5%				0.16	1.67
CV(%)				14.3	12.4
2002-2003	KAK 2	55.8	82.0	2.82	38.2
	ICCV 2	40.0	28.0	1.58	24.5
	Annigeri	39.2	63.4	2.34	23.3
SEd±				0.061	0.555
CD at 5%				0.17	1.54
CV(%)				16.8	14.5

Table 2. Cost benefit particulars of chickpea varieties grown under rainfed conditions in black soils of Prakasam district of Andhra Pradesh, 2001-2002 and 2002-2003 seasons.

	2001-2002			2002-2003		
Parameters	KAK 2	ICCV 2	Annigeri	KAK 2	ICCV 2	Annigeri
Yield (t ha^{1})	2.75	1.65	2.40	2.82	1.58	2.34
Market rate in Rs per kg	20.00	18.00	14.50	22.00	20.00	15.00
Gross returns (Rs)	55000	29700	34800	62040	31600	35100
Total cost of cultivation (Rs)	15737	13827	13337	15425	13515	13025
Net returns (Rs)	39263	15873	21463	46615	18085	22075
Cost benefit ratio	1:2.49	1:1.15	1:1.61	1:3.02	1:1.34	1:1.69

The data on plant height and number of pods per plant were recorded on ten plants selected at random in each plot. Seed yield and 100-seed weight were recorded for each plot. The cost benefit ratios for all the cultivars were calculated for both the years by using the following formula:

$$\text{Cost benefit ratio (C:B)} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

The cultivar KAK 2 gave the highest yield in both the years (2.75 t ha^{-1} during 2001-2002 and 2.82 t ha^{-1} during 2002-2003) while ICCV 2 gave the lowest yields. The 100-seed weight was also significantly higher in KAK 2 as compared to that of Annigeri and ICCV 2 which had similar seed size. The number of pod plant^{-1} and yields of ICCV 2 were significantly less compared to Annigeri and KAK 2 during both the years (Table1).

The cost benefit ratios were calculated based on the market price during the test years (Table2). Due to higher cost of seed, the cost of cultivation was high for KAK 2 and ICCV 2 compared to *desi* chickpea varieties. The highest net returns were obtained with KAK 2 (Rs 39,263 during 2001-02 and Rs 46,615 during 2002-03) followed by Annigeri. The cost benefit ratio for KAK 2 was 1:2.49 during 2001-02 and 1:3.02 during 2002-03. The ICCV 2 gave least net returns due to poor yields. Though the yield differences were not much between Annigeri and KAK 2, the high relative net returns were

obtained with KAK 2 (Rs 17,800 during 2001-2002 and Rs 24,540 during 2002-2003) due to high market price for KAK 2 produce. From the results it is clear that, kabuli variety KAK 2 can be cultivated by the farmers in rainfed black soils of Prakasam district so as to obtain highest net returns.

Acknowledgments: The authors are highly grateful for the support given by Dr A Satyanarayana, Director of Extension, ANGRAU, Hyderabad, AP, India.

Identification of Chickpea Genotypes with Combined Resistance to Ascochyta Blight and Fusarium Wilt

RS Waldia*, BPS Malik, Hari Chand, VS Lather, IS Solanki and Ram Kumar Yadav (Department of Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar 125 004, India)
*Corresponding author: chhabrak@hau.ernet.in

Chickpea is mainly cultivated as rainfed crop and is grown on residual moisture. In such environments, fusarium wilt is the common root disease, which cause heavy losses. Among foliar diseases, ascochyta blight is the most important disease and its occurrence can completely destroy the crop. Ascochyta blight is more prevalent in humid and sub-tropical climates. These diseases are the major limiting factors for higher production and stable performance. There is a need to develop high yielding genotypes with combined resistance to these diseases. Genetic variability exists among chickpea genotypes for resistance to one or more different diseases (Gaur et al. 1992; Haware et al. 1994). However, a few genotypes exhibit multiple resistance to two or all the major diseases (Singh and Hari Chand 1996). Such genotypes can ensure higher productivity and stable performance across the various growing conditions and environments.

Fifteen high yielding chickpea genotypes and two control cultivars, viz, JG 62 for wilt and a mixture of L 550 and Pb 7 for ascochyta blight (Table 1), were screened for wilt plant mortality (%) in wilt sick plots and for ascochyta blight in separate fields. Each genotype was sown in a 2.5 m row with inter-row spacing of 30 cm and plant-to-plant spacing of 10 cm, mixture of L 550 and Pb 7 was used as the susceptible control after every two test genotypes throughout the field for ascochyta blight

Table 1. Reaction of chickpea genotypes to Fusarium wilt (FW) and Ascochyta blight (AB).

S. No.	Genotype	Pedigree	Average yield (kg ha^{-1})	Disease reaction	
				FW (%)	AB (1-9 Scale)
1	H92-67 (1996-97 to 1999-2000)*	(GG 588 x H81-73) x (BG 257 x H81-73)	2264	0-4.6	8-9
2	H00-256(2000-01 to 2003-04)*	HC -1 x *C. reticulatum*	2116	0 -4.4	3-5
3	H97-93(2000-01 to 2003-04)*	HC -1 x E 100 Ym	2033	0-9.0	3-5
4	H00-216 (2001-02 to 2003-04)*	DCP92-3 x PDG 84 -16	2142	0-6.7	7-9
5	HO 1-07(2001-02 to 2003-04)*	DCP92-3 x PDG 84 -16	2139	0-6.7	7-9
6	H01-08 (2001-02 to 2003-04)*	DCP92-3 x PDG 84 -16	2168	1.66-3.7	8-9
7	H01-09 (2001-02 to 2003-04)*	(HC-1 x NARC 9006) x NARC 9006	2070	1.69-4.2	8-9
8	H01-10 (2001-02 to 2003-04)*	(HC-1 x NARC 9006) x NARC 9006	2129	3.92-9.5	8-9
9	HO 1-67(2001-02 to 2003-04)*	(H 91 - 40 x H 91-38) x H 91 - 38	2180	0 - 9.1	3-5
10	H01-74 (2001-02 to 2003-04)*	HC -3 x GIGAS	2146	0 9.6	6-8
11	H01-79 (2001-02 to 2003-04)*	HC-3 x NARC 9006	2164	0-8.1	3-5
12	H01-80 (2001-02 to 2003-04)*	H 92-68 x NARC 9006	2014	0-27.6	3-5
13	H00-02 (2000-01 to 2002-03)*	HC -1 x H 91 - 37	2112	3.3-26.1	3-5
14	H00-126 (2000-01 to 2002-03)*	(H 94-67 x H 92-67)x NARC 9006	2234	6.8-17.9	3-4
15	H00-249 (2000-01 to 2002-03)*	HC -1 x *C. reticulatum*	1995	4.3- 11.36	3-5
16	JG 62(1996-97 to 2003-04)*	Check (not available)	Nil	100	-
17	Mixture of L 550 & Pb 7 (1996-97 to 2003-04)*	Check (not available)	Nil	–	8-9

* Year of testing.

screening and JG 62 after every two test genotypes throughout the fields for wilt screening. *Ascochyta rabiei* was multiplied on chickpea flour agar medium at 20± 1°C for 20 days for inoculation. At the flowering stage, when the average environmental temperature was 18-20°C, the crop was inoculated with a spore suspension containing approximately 30000 spore mL^{-1} water. High humidity was maintained with perfo-irrigation up to three weeks after the inoculation. Disease score was recorded 30 days after inoculation on 1-9 scale (1 = no infection and 9 = completely killed). Whereas for wilt, the material was planted in wilt sick plot maintained at the Pulses Research Area, Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar. The disease reactions for genotypes at Sr. No. 1 to 3 were tested for 4 years and for the rest for 3 years (Table1). The genotype, H92-67, H97-93, H00-216, H00-256, H01-07, H01-08, H01-09, H01-10, H01-67, H01-74 and H01-79, were resistant to wilt (< 10% mortality), whereas, H00-02, H00-126, H00-249 and H01-80 were resistant to ascochyta blight (3 to 5 score). H97-93, H00-256, H01-67 and H01-79 were resistant to wilt and ascochyta blight. It is suggested that the genotypes which provide resistance to more than one disease should be used as donor parents to transfer resistance to adapted promising genotypes for higher productivity and stable performance.

Reference

Gaur RB, Maheshwari RV and **Verma RS. 1992.** Evaluation of chickpea cultivars for resistance to ascochyta blight under artificial conditions II. Screening of breeding material. International Chickpea Newsletter 26:23-24.

Haware MP, Narayana Rao J, Hari Chand. Ghanekar AM and **Jalali BL. 1994.** Multilocational testing of chickpea for field resistance to ascochyta blight. International Chickpea and Pigeonpea Newsletter 1:18-21.

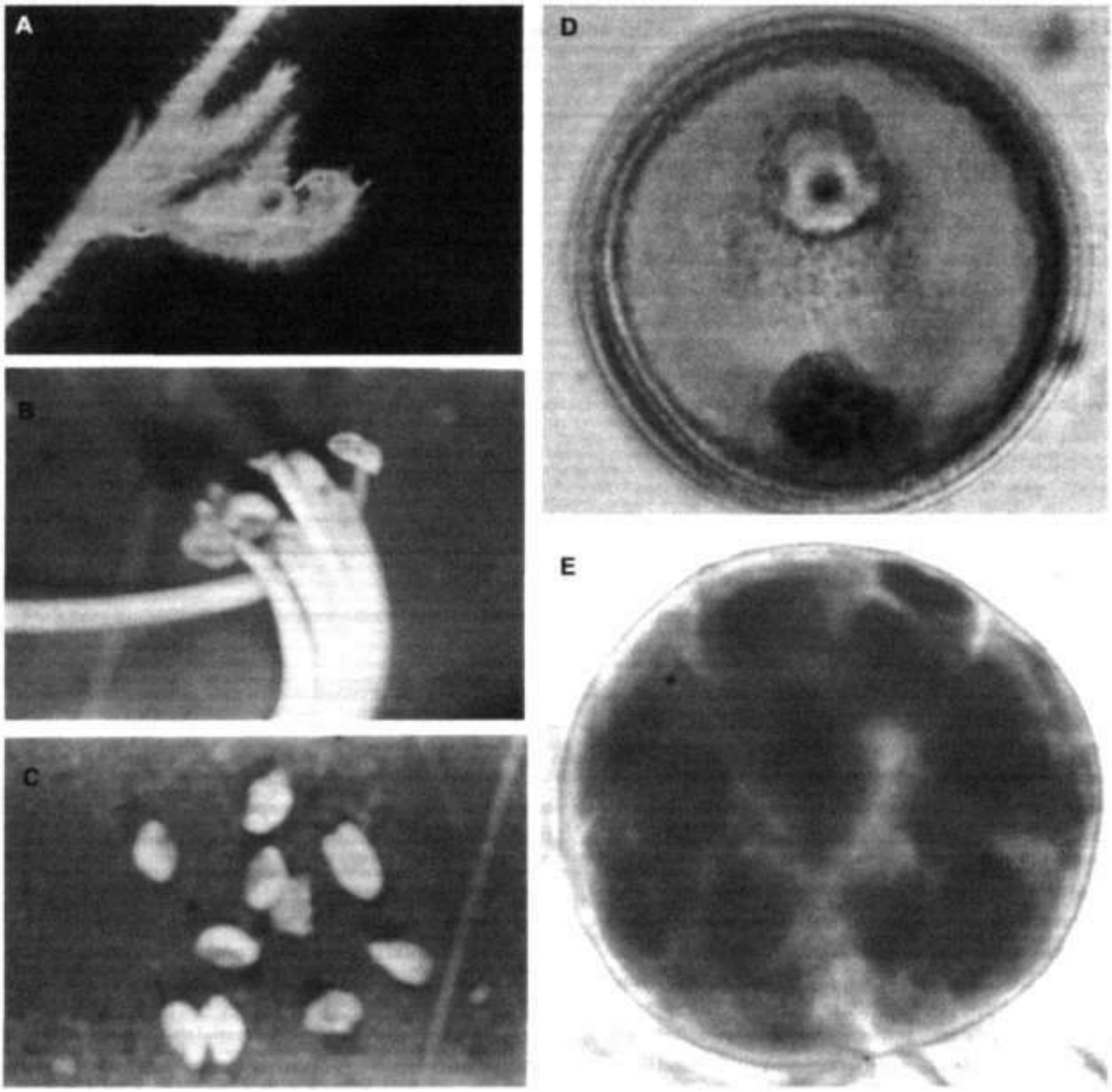
Singh Rang Pal and **Hari Chand. 1996.** Identification of multiple disease resistance in chickpea at Hisar, Haryana, India. International Chickpea and Pigeonpea Newsletter 3:32-33.

Induction of Androgenesis as a Consequence of Wide Crossing in Chickpea

Nalini Mallikarjuna[1], Deepak Jadhav[1], Heather Clarke[2], Clarice *Coyne*[3] and **Fred Muehlbauer[3]** (1. ICRISAT, Patancheru, India; 2. Centre for Legumes in Mediterranean Agriculture, University of Western Australia; 3. USDA-ARS, Washington State University, Pullman, Washington 99164-6434, USA)

The value of haploids in genetics and plant breeding has been known for a long time. Natural haploid embryos and plants have been described in about 100 species of angiosperms, and documented in detail by Kimber and Riley (1963). However, haploids occur rarely in nature. Doubled haploids are equivalent to inbred lines, with normal fertility, retaining the advantage of homozygosity, which by conventional program of producing pure lines would require 6-7 generations of selfing to achieve a satisfactory level of homozygosity.

Three principal methods of haploid production include 1. parthenogenesis, 2. wide crosses - chromosome elimination, and 3. haploid plants from anther/ovule culture. In the first method of haploid production, haploids arise from both an unfertilized egg and from a male gamete. Gynogenetic haploids arise as a result of stimulation of the unfertilized egg, and in a few cases the offsprings resembled the male parent and hence were thought to have originated from the pollen (Clausen and Laments 1929; Kostoff 1929; Rhoades 1948). The doubled haploid method used in barley, is an example of preferential chromosome elimination in the cross between barley and *Hordeum bulbosum*, where the chromosomes of H. *bulbosum* were gradually eliminated. In that method, a cross is made between cultivated barley (*Hordeum vulgare)* and *H. bulbosum.* During embryo development, the chromosomes of *H. bulbosum* are gradually eliminated resulting in haploid plants (Subrahmanyam and Kasha 1973). The chromosome elimination phenomenon is quite prevalent among wide crosses between wheat and *H. bulbosum* as well (Barclay 1975). A more recent procedure to produce haploid plants is by anther culture/microspore culture (Maheshwari 1996; Guha and Maheshwari 1966; Melchers 1972). The culture of anthers or microspores gives rise to haploid plants whose chromosomes can be doubled by suitable treatment to produce homozygous diploid plants. Later Rangan (1994) and Keller and Korzun (1996) reported parthenogenesis of the egg in culture.



A Fragile buds from the cross *C. arietinum* x *C. pinnatifidum.*
B & C anther bundle and anthers from the cross *C. areitinum* x *C. pinnatifidum.*
D A normal pollen grain undergoing the microsporogenesis.
E A multicellular pollen grain from the hybrid.

Table 1. Androgenic response in interspecifc incompatible cross *Cicer arietinum* x *C. pinnatifidum.*

Plant No.	Total microspores	No. Normal microspores	No. Androgenic microspores (%)	Maximum no. of cells in **a** microspore
1	57	43	14 (25)	3-4
2	122	109	13(11)	3-4
3	73	73	0	
4	46	18	28(61)	2-4
5	28	23	5(18)	4-6
6	27	12	15(56)	2-4
7	83	51	32 (39)	2-4
8	86	86	0	
9	151	143	8(5)	4-6
10	31	12	19(61)	2-4
11	35	35	0	
12	74	74	0	
13	43	36	7(16)	2-4
14	16	0	16(100)	8-10
15	65	62	3 (5)	
16	11	0	11 (100)	8-10

Chickpea procedures for developing haploid plants have not been reported, and induction of androgenesis by anther culture is of a very low frequency (Mallikarjuna, personal observation). Androgenesis was observed in a wide cross of *Cicer arietinum* x *C. pinnatifidum.* Hybrids between *C. arietinum* x *C. pinnatifidum* were obtained after rescuing the hybrid embryos in vitro. The hybrids were initially devoid of any chlorophyll pigment and were albinos. Upon continuous culture in a zeatin-rich medium and in the presence of light, the hybrids turned semi-green (Mallikarjuna 1999). Hybrid shoots were grafted to chickpea root stocks to obtain hybrid plants. None of the hybrid plants flowered. When the nutrient solution with zeatin (1 mg/L) was added, flower buds were observed on the hybrid plants. Flower buds were fragile, albino to semi-green, but with normal morphology (Fig. 1A). Anthers (Figs. 1B and 1C) were squashed in acetocarmine and divisions were observed in some of the microspores (Fig. 1E). The number of divisions varied from 4-6. Adding nutrient solution with zeatin (1 mg/L) to in vivo grown chickpea plants did not induce divisions in the microspores.

A total of 16 hybrid plants were obtained. The number of microspores/pollen grains in an anther varied from 11-151 compared to more than 500 pollen grains in cultivated chickpea. The number of pollen grains, which had undergone microsporogenesis and induction of androgenesis, varied from plant to plant. Percent androgenic pollen grains varied from 0-100%. Plant no. 8, 11 and 12 (Table 1) did not have any androgenic pollen grains, whereas in plant no. 14 and 16, all the pollen grains were androgenic, or in other words had multicellular microspores. The number of cells in multicellular microspores in plant no. 14 and 16 varied from 8-10 (Fig. 1E) unlike 4-6 cells in multicellular microspores in other hybrid plants which had androgenic microspores.

This is the first report in literature wherein multicellular microspores have been consistently produced as a result of wide crossing. Wide crosses are not only important in gene transfer from wild species but also in the production of haploid plants by *in vitro* culture of anthers with multicellular microspores.

Next logical step would be to explore the feasibility of androgenesis from wide crosses, for rapid development of homozygous lines.

References

Barcaly IR. 1975. High frequencies of haploid production in wheat *(Triticum aestivum* L.) by chromosome elimination. Nature (London) 256 : 410-411.

Clausen RE and **Lammerts WE. 1929.** Interspecific hybridization in Nicotiana X Haploid and diploid merogony. Amer Nat 43:279-282.

Guha S and **Maheshwari SC. 1966.** Cell division and differentiation of embryos in the pollen grains of Datura in vitro. Nature 212:97-98.

Keller ERJ and **Korzun L. 1996.** Ovary and ovule culture for haploid production. In vitro haploid production in higher plants (Jain SM, Sopory SK and Veilleux RS, eds.). Vol. 1. Dordrecht, The Netherlands: Kluwer Acad. Publi.

Kimber G and **Riley R. 1963.** Haploid angiosperms. Bot Rev 29:480-531.

Kustoff D. 1929. An androgenic Nicotiana haploid. Zeit. Zellforschg 9 :391 - 396.

Maheshwari SC. 1996. The discovery of anther culture techniques for the production of haploid plants - A personal reflection. In vitro haploid production in higher plants, Vol. 1. (Jain SM, Sopory SK and Veilleux RS, eds.). Dordrecht, The Netherlands: Kluwer Acad Publ.

Mallikarjuna N. 1999. Ovule and embryo culture to obtain hybrids from interspecific incompatible pollinations in chickpea. Euphytica 110:1-6.

Melchers G. 1972. Haploid higher plants for plant breeding. Z. Pflanzenzuchtg 67:19-32.

Rangan TS. 1984. Culture of ovules. *In* Cell culture and somatic cell genetics of plants (Vasil IK, ed.). New York, USA: Acad Press.

Rhoades MM. 1948. Androgenesis. Maize Genet Coop Newsl. 22:10.

Subrahmanyam NC and **Kasha KJ. 1973.** Selective chromosome elimination during haploid formation in barley following interspecific hybridization. Chromosoma (Berl.) 42:111-125.

Chefe (ICCV 92318) - A New Kabuli Chickpea Variety for Ethiopia

Ketema Daba[1], Geletu Bejiga[1], Yadeta Anbessa[1], PM Gaur[2,*], Jagdish Kumar[2] and **BV Rao[2]** (1. Debre Zeit Agricultural Research Centre, Debre Zeit, Ethiopia; 2. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, AP, India)
*Corresponding author: p.gaur@cgiar.org

Ethiopia is the largest chickpea growing country in Africa, with a share of about 37% in area and 48% in production. During 2003/2004, Ethiopia produced 195,800 t of chickpea from an area of 176,554 ha (FAOSTAT 2004). There has been an increase of about 10% in the area and 42% in the production of chickpea during the past decade (1994/95 to 2003/04). Most of the chickpea production is used for domestic consumption. However, there has been a substantial export of chickpea by Ethiopia during the past five years, with the highest of 48,549 t (valued at US$14.7 million) during 2002 (FAOSTAT 2004).

The Debre Zeit Agricultural Research Center (DZARC) is the premier institute for chickpea research in Ethiopia. It has collaborated with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, and the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, in chickpea improvement and released eight chickpea varieties in Ethiopia. Of these, three *(DZ 10-4, DZ 10-11,* and *Dubie)* were developed from its own breeding materials, four (*Mariye, Worku, Akaki* and *Shasho)* from the breeding materials supplied by ICRISAT, and one (Arerti) from the breeding materials supplied by ICARDA. Three of these varieties (DZ 10-4, Shasho and Arerti) are *kabuli* type and the remaining are *desi* type.

The Ethiopian chickpea production is predominated by *desi* chickpea (about 95%). However, in recent years, there has been an increase in the interest of farmers in growing large-seeded *kabuli* varieties due to their higher price in the market. The market price for one ton *kabuli* chickpea currently varies from 3000 to 4000 Birr (US$344 to 459) depending on the seed size, while the *desi* chickpea is sold at about 2000 Birr (US$230). The first *kabuli* chickpea variety released in Ethiopia (year 1974) was *DZ 10-4* with a very small seed size (10-11 g 100 seed^{-1}) and is now almost out of cultivation. The

Figure 1. Seed of kabuli chickpea variety Chefe.

Table 1. Mean seed yield (kg ha^{-1}) of chickpea variety (ICCV 92318) as compared to standard check (Arerti) and local check (DZ-10-4) across locations and over years.

	Location									
Variety	Minjar	Debre Zeit	Akaki	Chefe Donsa	Enewari	Adet	Sirinka	Ambo	Arsi Negale	Mean
1999/2000										
ICCV 92318	1231	3274	4778	3129	1879	2515	3117	-	-	2784
Arerti	1728	3844	4608	3091	1669	3867	1989	-	-	2971
DZ 10-4	501	2057	3892	2614	1790	3338	1519	-	-	2244
2000/2001										
ICCV 92318	2739	3513	3861	3542	2794	1543	-	2010	-	2858
Arerti	3804	3730	4054	4321	3320	1426	-	2915	-	3367
DZ 10-4	3173	3997	2913	3524	2580	1455	-	1469	-	2730
2001/2002										
ICCV 92318	1247	1493	2749	-	-	-	-	-	2499	1997
Arerti	1397	1791	2953	-	-	-	-	-	2875	2254
DZ 10-4	1066	1069	1329	-	-	-	-	-	1754	1305
Over all mean										
ICCV 92318	1594	2760	3798	3336	2337	2029	3117	2010	2499	2546
Arerti	2310	3122	3872	3706	2495	2647	1989	2915	2875	2864
DZ 10-4	1580	2374		3069	2185	2397	1519	1469	1754	2093

other two kabuli varieties, Arerti and Shasho, with medium (26 g 100-seed^{-1}) and large seeds (30 g 100-seed^{1}), respectively were released in 1999.

ICCV 92318, a breeding line developed from a 3-way cross (ICCV 2 x Surutato) x ICC 7344 at ICRISAT, Patancheru, was received by DZARC from ICRISAT along with many other advanced breeding lines. After preliminary yield evaluation at the station, it was selected for multilocation evaluation along with the controls *DZ 10-4* (local check) *and Arerti* (standard check). The trials were conducted at seven locations each during 1999/ 2000 and 2000/2001 and at four locations during 2001/ 2002. The overall average yield of ICCV 92318 was 2546 kg ha^{-1} against 2864 kg ha^{-1} for the standard check *Arerti* and 2093 kg ha^{-1} for the local check DZ 10-4 (Table 1). Though ICCV 92318 was not superior to *Arerti* in yield, it was selected for release primarily because of its attractive and larger (35 g 100-seed^{-1}) seeds (Fig. 1) as compared to *Arerti* (26 g 100-seed^{-1}) and high resistance to fusarium wilt. It was released as "Chefe" in 2004 by the National Variety Release Committee. Chefe is one of the research stations of DZARC where chickpea productivity is always very high.

A high preference by farmers was observed for the new variety *Chefe* during on-farm trials because of its large pods. We presume that the increased price in the international market for the large-seeded *kabuli* varieties will help in faster adoption of the variety. Also there is a large market for chickpea immature fresh seeds, for human consumption in Ethiopia and large-seeded varieties are preferred for this purpose. Thus, the new variety also has potential for this local market. Ethiopian Seed Enterprise and private commercial farmers are multiplying this variety for further distribution as seed and also for export.

Acknowledgment. We are thankful to Canadian International Development Agency (CIDA) for funding the project "Improving income of farmers in eastern Africa through increased chickpea yield" during 2000 to 2003 under the CGIAR-Canada Linkage Fund (CCLF).

Reference

FAOSTAT. 2004. http://faostat.fao. .org/faostat/ (lastupdated 20December2004).

Leaf and Pod Characters as Selection Criteria for Large-Seeded *Kabuli* Chickpea

JS Sandhu, SK Gupta, Pritpal Singh, TS Bains and **Ajinder Kaur** (Department of Plant Breeding, Genetics and Biotechnology, Punjab Agricultural University, Ludhiana 141 004, Punjab, India)

Large seed size is a premium trait of *kabuli* chickpea because of consumer's preference. Hence, large-seeded *kabulis* are sold at higher price in the market. Large variation (8 g to 75 g 100 - seed^{-1}) has been recorded for this character in global germplasm (Singh and Saxena 1999). Most of the released cultivars of *kabuli* chickpea have a seed weight of 20-25 g 100-seed^{-1}, except five recently released cultivars namely K A K 2, BG 1053, BG 1003, JKG 1 and Phule G 95311. Efforts are being made to develop the cultivars with more than 30 g 100 seed^{-1}. Selection for most of the characters in the segregating generations is made visually based on the morphological traits. The advantage of this practice is that the selection of individual plant is based on a number of desirable traits. On the other hand, selection for seed size is carried out after the crop harvest. Thus, some morphological traits need to be identified which may be used as markers for large seed size while selection is practised for other traits in segregating generations. This will help identify the plants superior in number of traits simultaneously in the field itself. Keeping this in view, an attempt has been made in this study to correlate the leaf and pod characters with seed size in *kabuli* genotypes.

The material consisted of 12 *kabuli* genotypes, grown in 6 row plots with row length of 4 m and rows spaced at 30 cm, in a randomized block design with three replications during the crop season 2003-04. Observations were recorded on five plants on each genotype in all replications, for plant height (cm), primary branches plant^{-1}, leaf length (cm), leaf breadth (cm), leaflets leaf^{-1}, leaflet length (cm), pods plant^{-1}, pod length (cm), pod circumference (cm), days to flower, days to maturity, seed yield plant^{-1} (g) and 100-seed weight (g). Leaf length and breadth were measured at the center of a branch. The central leaflets of these leaves were used for measuring the length of the leaflets. Pod characteristics such as pod length and pod circumference were recorded using vernier caliper. Correlations were estimated on replicated data following the methodology of Dewey and Lu (1959).

The range and mean values showed that wide variation (Table1) was available for characters under study. The leaflet

Table 1. Range and mean for leaf, pod and seed characteristics in *kabuli* chickpea.

Character	Plant height (cm)	Primary branches Plant^{-1}	Leaf length (cm)	Leaf breadth (cm)	Leaflets leaf^{-1} (no.)	Leaflet length (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Pod circumference (cm)	Days to flower (no.)	Days to maturity (no.)	Seed yield plant^{-1} (g)	100-seed weight (g)
Range	50.4-67.33	2.30-3.33	4.37-6.00	2.07-3.43	12.00-13.67	1.00-1.63	47.63-106.87	2.43-3.47	3.57-4.43	90.00-102.00	152.00-158.00	7.70-22.57	16.50-36.10
Mean	58.6	2.8	5.2	2.8	12.6	1.3	68.6	3.1	4.1	97.2	154.7	13.8	26.2

Table 2. Phenotypic correlations among leaf, pod and seed characteristics in *kabuli* chickpea.

Character	Primary branches plant^{-1}	Leaf length	Leaf breadth	Leaflets leaf^{-1}	Leaflet length	Pods plant^{-1}	Pod length	Pod circumference	Days to flower	Days to maturity	Seed yield plant^{-1}	100-seed weight
Plant height	−0.07	0.18	0.38	−0.25	0.28	0.18	0.39	0.43	0.08	0.03	0.21	0.26
Primary branches plant^{-1}	1.00	−0.30	−0.30	0.17	−0.42	0.27	−0.22	−0.30	0.07	−0.27	−0.04	−0.37
Leaf length		1.00	0.68*	0.02	0.72**	−0.16	0.54	0.63*	−0.44	0.13	0.20	0.69*
Leaf breadth			1.00	−0.02	0.88**	−0.34	0.38	0.57*	−0.39	0.13	0.16	0.48
Leaflet leaf^{-1}				1.00	−0.01	−0.24	0.00	−0.08	−0.02	−0.02	−0.21	0.05
Leaflet length					1.00	−0.41	0.54	0.68*	−0.35	0.18	0.06	0.60*
Pods plant^{-1}						1.00	0.09	−0.21	0.20	−0.06	0.52	−0.25
Pod length							1.00	0.79**	−0.07	0.20	0.18	0.54
Pod circumference								1.00	−0.20	0.21	0.04	0.61*
Days to flower									1.00	0.09	−0.22	−0.26
Days to maturity										1.00	−0.03	0.33
Seed yield plant^{-1}											1.00	−0.01

*, ** significant at .05 and .01 level, respectively.

number was least variable while leaflet length showed the maximum variability. Pod characters, pod length and pod circumference also had high variability. The phenotypic correlations among leaf, pod and seed components revealed that leaf length, leaflet length and pod circumference had a positive and significant correlation with 100-seed weight (Table 2). All these three visually observable morphological characters were also positively correlated with each other, indicating that these were the most important components of 100-seed weight. Among these three traits, leaf length had strong positive significant correlation (r = 0.69) with 100-seed weight. In a similar study of 106 desi and *kabuli* genotypes, Dahiya et al. (1988) found leaf length, leaflet length and leaflet width to be significantly and positively correlated to 100-seed weight and concluded that the leaflet width was a predictor for seed characteristics.

It was concluded that easily observable morphological traits such as leaf length, leaflet length, pod length and pod circumference, could be used as a selection criterion for the large-seeded *kabuli* chickpea.

References

Dahiya BS, Waldia RS and **Ram Kumar. 1988.** Relationship between leaf and seed characteristics in chickpea. International Chickpea Newsletter 18:6-7.

Dewey DR and **Lu KH. 1959.** A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal 51:515-18.

Singh KB and **Saxena MC. 1999.** The chickpeas. London, UK: MacMillan Education Ltd.

Low Temperature Effects on Early Maturing Chickpea Genotype ICCV 96029

S Kumar, H Nayyar*, TS Bains', G Kaur and **RK Bhanwra** (Department of Botany, Panjab University, Chandigarh 160 014, India; [1]Department of Plant Breeding, Punjab Agricultural University, Ludhiana 141 004, Punjab, India).

*Corresponding author: nayarbot@pu.ac.in

Low temperatures (< 10°C) are detrimental for reproductive growth of chickpea *(Cicer arietinum* L.) and induce abortion of flowers, pods, impaired seed growth and reduced yield (Srinivasan et al. 1999; Nayyar et al. 2005). Since the reproductive phase of early maturing genotypes coincides with the cold spells of northern region of India, they are expected to face varying degree of chilling stress depending upon the intensity and duration of low temperature. Low temperatures may induce anthocyanins that may allow the plant to develop resistance against stress possibly by improving sugar translocation in stressed tissues and acting as anti-oxidants (Chalker-Scott 1999). In the present study, we assessed the performance of an early maturing chickpea genotype ICCV 96029 under two contrasting temperature environments - low temperature conditions of the field and warm conditions of the glasshouse - in order to assess the chilling damage, if any. It was hypothesized that cold might limit the yield potential of plants as compared to those growing under warm conditions.

A super early maturing chickpea genotype ICCV 96029 (seeds procured from PAU, Ludhiana) was grown in pots (30 cm height, 25 cm diameter, 14.72 L volume) during the first week of November (2003) under low temperature conditions in the field (FD) as well as under warm conditions of the glasshouse (GH). Temperature profile during growth season under both the environmental conditions is shown in Table1. Light intensity (as photosynthetic photon flux density; PPFD) at mid-day ranged between 800 - 1100 μmol m^{-2} s^{-1} and 1300-2200 μmol m^{-2} s^{-1} in glasshouse and field conditions, respectively. Observations on the fate of flowers (retention or abortion) at different temperatures of field as well as glasshouse were recorded by tagging the flowers everyday in 25 plants and following them precisely for abortion or pod set during this period. These observations were correlated with daily temperature profiles of December and January. Observations on growth and yield were recorded on plants (50 in each case) growing in the contrasting environments. Data were subjected to t-test using SIGMASTAT software (USA).

The FD plants as compared to the GH plants showed marked reduction in plant height as well as delayed vegetative and reproductive growth in terms of days to flowering, days to podding, days to pod maturity and days to crop maturity (Table2), whereas the number of primary branches (basal) increased markedly in the former. The duration of flowering did not differ significantly between the two conditions whereas duration of podding was reduced significantly in the FD plants. The total number of flowers produced $plant^{-1}$ in FD plants during the season was almost threefold of GH plants, but the floral retention was significantly more in the latter. Though pod set was significantly lower in the FD plants than in the GH plants, the former showed appreciably more pod retention. All the traits contributing to yield, ie, pods $plant^{-1}$, average pod weight, seeds $plant^{1}$, seed weight $plant^{-1}$, average seed weight, 1-seeded pods, 2-seeded pods, were markedly high in FD plants than in GH ones. There was no difference between the numbers of infertile pods in the two environments.

One of the peculiarities observed in the FD plants was the appearance of anthocyanins in the pedicels of flowers, which was in contrast to the GH plants. The FD grown plants had an average of 30 single flowers $plant^{-1}$ with purple pedicel (43% of total flowers) while GH plants had no such flowers but had 14.4 single flowers $plant^{-1}$ with green pedicel (60% of total flowers) (Table

Table 1. Average maximum and minimum temperature (°C) in warm (glasshouse) and cold (field) conditions.

	Nov.		Dec.		Jan.		Feb.		March	
Environment	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Warm	30	15	25	15	25	15	30	15	38	25
Cold	25	10	20	8	17	7	23	10	32	17

Table 2. Growth and yield traits per plant (Mean ± SEM) in ICCV 96029 under warm and cold conditions.

Parameters	Warm	Cold
Plant height (cm; at 60 *DAS)	51.9 ± 1.8	33.4 ± 1.5
No. of basal primary branches (at 100 DAS)	1.4±0.17	6.0 ± 0.69
Days to flowering (DAS)	37.8 ± 1.5	59.7 ± 1.6
Flowering duration (days)	63.6 ± 1.5	65.3 ± 1.8 NS
Days to podding (DAS)	48.2 ± 1.8	93.6 ± 3.2
Podding duration	62.4 ± 1.9	49.2 ± 2.3
Days to pod maturity (DAS)	92.0 ± 3.2	120.0 ±2.7
Days to crop maturity (DAS)	113 ± 2.6	138 ± 2.8
Total flowers produced during the season	23.8 ± 4.9	69.2 ± 4.4
Total flowers abscised during the season	9.4 ± 1.3	46.0 ± 2.0
Floral retention (%)	60.5 ± 2.5	33.6 ±2.2
Pod set (%)	44.4 ± 0.8	35.4± 1.3
Pod retention (%)	44.0 ± 2.4	58.9 ± 2.2
No. of Pods	4.4 ± 0.7	14.4 ± 1.3
Average Pod wt. (g)	1.0±0.1	3.2 ± 0.3
No. of seeds	4.0 ± 0.7	15.6 ± 1.2
One-seeded pods	2.8 ± 0.6	10.0 ± 1.4
Two-seeded pods	1.5 ±0.17	2.8 ± 0.34
Infertile pods	2.0 ± 0.3	1.4 ± 0.3 NS
Seed yield plant"' (g)	0.6 ± 0.11	2.7 ± 0.4
Average seed wt. (g)	0.18 ±0.02	0.18 ± 0.03

*DAS-days after sowing

Differences between warm and cold treatments are significant at P<0.05 (t-test); NS-non-significant.

Table 3. Observations per plant (Mean ± SEM) on single and double flowers as well as pod set under warm and cold conditions.

Parameters	Warm	Cold
Total flowers during the season	23.8 ± 1.0	69.2 ± 1.0
Single flower with green pedicel	14.4 ± 0.75	0
Single flower with purple pedicel	0	30.0 ± 0.80
Double flowers*	4.7 ± 0.63	19.6 ± 0.75
Double flowers with both green pedicels	4.7 ± 0.63	0
Double flowers with purple and green pedicel	0	19.6 ±0.75
Pod set in Single flower with green pedicel	8.6 ±0.75 (60 %)	0
Pod set in single flower with purple pedicel	0	24.5 ± 0.98 (82%)
Pod set in double flowers with both green pedicels	4.0 ±0.57 (85 %)	0
Pod set in double flowers with purple and green pedicel	0	7.8 ± 0.75 (40%)

*Refers to a pair of flowers on a peduncle

Differences between warm and cold treatments are significant at P<0.05 (t-test).

3). The double flowers in FD plants (19.6 plant^{-1}) had one green and another purple pedicel (57% of total flowers) unlike in GH plants (4.7 plant^{-1}), which had both green pedicels (40% of total flowers) (Plate 1 A; Table 2). The flower with purple pedicel emerges earlier than the other with green pedicel. These flowers set pods according to the temperature of the environment. At temperature of 2-11°C, both types of flowers abort while at temperature between 12-20°C, the flower with purple pedicel sets pods and the other with green pedicel aborts and gets abscised (Plate 1B ; Table 2). The green type also shows abnormal growth and cannot complete its development in FD plants. Distortion of flower and its organs may also occur in green type as twisted anthers leading to impaired fertilization and pod abortion. Depending upon the stage of cold exposure, the flowers with green pedicel may

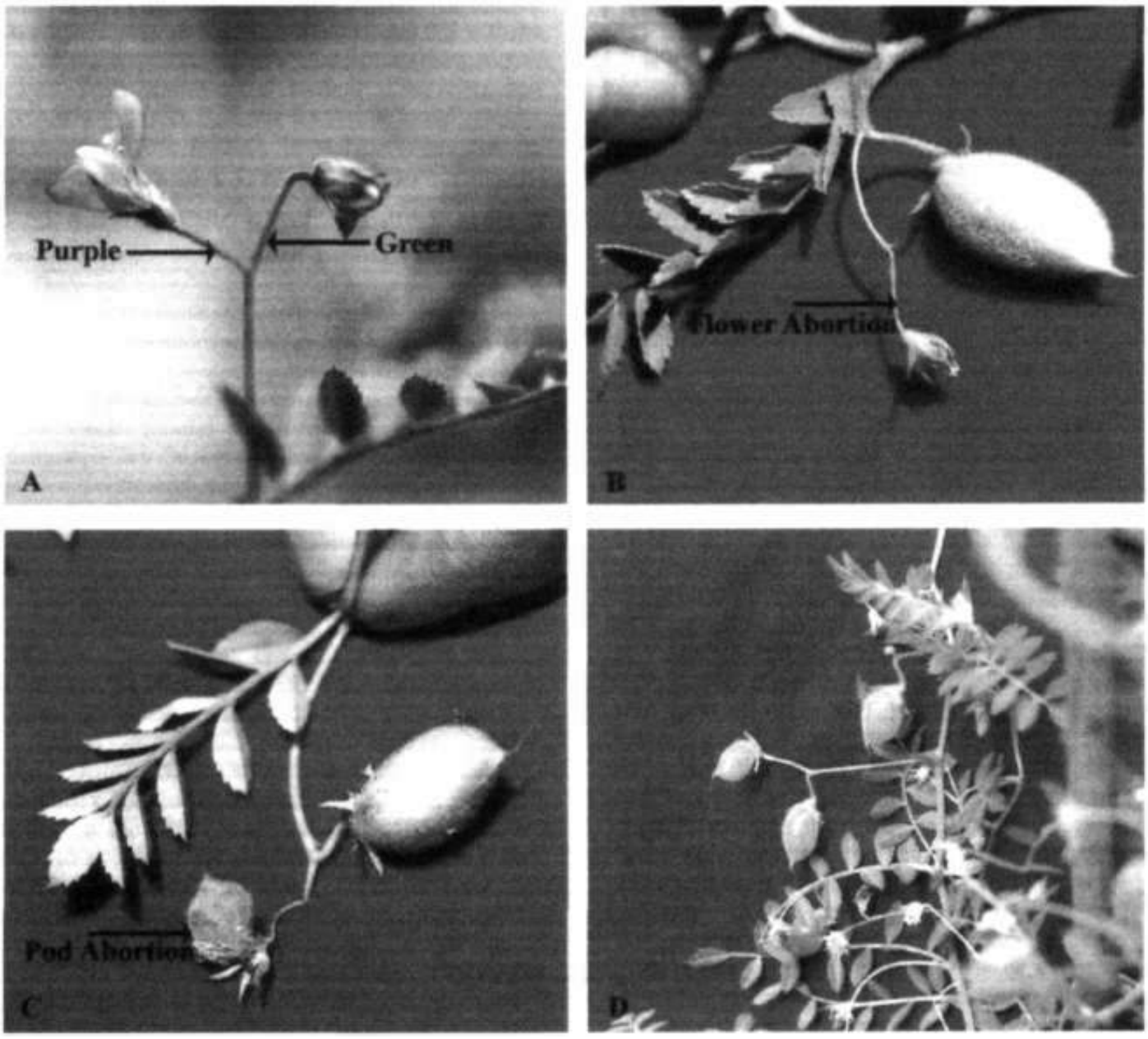


Plate 1. Cold-induced abnormalities; A - Flowers with purple and green pedicel under cold conditions; B - Flower with green pedicel aborts while the other one sets pod; C - Pod abortion in green pedicel and normal pod in purple pedicel; D - normal pod set by both the flowers under warm conditions.

either get abscised at bud or at anthesis stage. At 15-30°C conditions of the glasshouse, both the flowers set pods with higher intensity (Plate 1D; Table 2), whereas under cold conditions of the field, only flowers with purple pedicel are able to set pods and those with green pedicels abort leading to reduction in pod set (Table 2). Purple coloration in pedicels is because of accumulation of anthocyanins, which have been suggested to impart cold tolerance in several plant species (Chalker-Scott 1999) that also appears to be substantiated by the present findings. Since, this pattern was prevalent only in the FD plants, cold-induced restrictions in photosynthesis and in preferential mobilization of photosynthates towards the flowers having purple pedicel may be some of the key causative factors related to this variation (Nayyar et al. 2005). Anthocyanins are indicated to assist in sugar translocation in stressed tissues and may thus protect the purple flowers from abortion due to stress-induced starvation (Chalker-Scott 1999). Additionally, being antioxidants, they may protect the oxidative damage to stressed tissues. The exact mechanisms by which anthocyanins protect the cold-stressed tissues remain to be probed and are being investigated by us. Nevertheless, these findings indicate that anthocyanins accumulation can be employed as reliable marker in screening for cold-tolerance in chickpea.

The present findings indicated that in spite of reduction in vegetative growth and delay in onset of subsequent growth phases, cold conditions did not appear to inhibit the yield potential of this genotype. The FD plants as compared to the GH plants compensated their reduced plant height by increasing the number of branches. Though cold conditions caused damage to the flowering phase, the plants produced more flowers and consequently higher number of pods as the field temperature increased in February. On the other hand, warm conditions throughout the growth season proved to be relatively much inhibitory for yield, which was in contrast to our hypothesis. Additional testing of plant response to intermediate temperature treatment may be needed to confirm the cold compensation of ICCV 96029.

It is concluded that ICCV 96029 possesses highly effective yield compensation mechanisms to face the chilling conditions. Accumulation of anthocyanins in the pedicels of flowers may be exploited as a screening trait in studies on cold tolerance. In-depth studies are underway to probe the mechanisms related to the differential effects of the temperature.

References

Chalker-Scott L. 1999. Environmental significance of anthocyanins in plant stress responses. Photochemistry and Photobiology 70:1-9.

Nayyar H, Bains T and **Kumar S. 2005.** Low temperature induced floral abortion in chickpea: relationship to abscisic acid and cryoprotectants in reproductive organs. Environmental and Experimental Botany 53:39-47.

Srinivasan A, Saxena NP and **Johansen C. 1999.** Cold tolerance during early reproductive growth of Chickpea *(Cicer arietinum* L.) : genetic variation in gamete development and function. Field Crops Research 60:209-222.

Response of Chickpea *(Cicer arietinum)* to Irrigation, F Y M and Sulphur on a Sandy Clay Loam Soil

RA Patel* and RH Patel (Dept of Agronomy, BA College of Agriculture, Anand Agricultural University, Anand 381 110, Gujarat, India.)

*Corresponding author: kmgediya@yahoo.co.in

Chickpea in India is usually grown on well-conserved soil moisture. Though soil moisture depletes much after the harvest of preceding crop, which necessitates the pre-sowing irrigation. Besides, improving physical-chemical and biological properties of soil, F Y M also enhances water-holding capacity of the soil. Sulphur is essential for the synthesis of protein, vitamin and S-containing amino acids. It promotes roots and nodule development in legumes. Therefore, proper management of irrigation, F Y M and sulphur, is essential for increasing the quality and productivity of chickpea.

A field experiment was conducted at the Regional Sugarcane Research Station, Anand Agricultural University, Thasra, on sandy clay loam soil during rabi season of the year 2002-2003. The soil was low in organic matter (0.37%) and nitrogen (0.032%), medium in available P (32.5 kg ha^{-1}) and high in available K (296 kg ha^{-1}) with pH 7.9. The experiment was conducted in split-plot design with four replications, comprised of two levels of irrigation and F Y M each in main plots and three levels of sulphur in sub plots. The crop (variety ICCC 4) was sown in rows 30 cm apart with 60 kg seed ha^{-1}. One

pre-sowing irrigation of 100 mm depth was given before the layout was done and later on one irrigation was given at flowering as per treatment (60 mm depth). The crop was sown on 31 October 2002, and harvested on 1 March 2003 and 7 March 2003 for the treatments of only pre-sowing irrigation and irrigation at pre-sowing plus flowering stage, respectively. N was applied in the form of urea, whereas P and S were applied in the form of diammonium phosphate and gypsum, respectively. N content in seeds was estimated by micro-kjeldhal's method (Jackson 1973). Protein content in seeds was calculated by multiplying N-content of seed (%) with the conversion factor of 6.25. Sulphur content in seed was estimated by Turbidmetric method (Chaudhary and Cornfield 1966). N, P, K and S contents in soil samples were determined through procedures described by Jackson (1973). Soil moisture at 30 cm depth on flowering (50 DAS) and pod development (90 DAS) stages were recorded in each treatment with TDR soil moisture meter.

There was a significant effect of irrigation on growth, yield attributes, yield and quality of chickpea (Table1). Application of two irrigations each at pre-sowing and at flowering stage recorded significantly higher number of branches per plant, number of pods per plant, grain and straw yields. Similar results were also observed by Sharma (1994). Quality parameters such as protein and sulphur contents in grain were also higher under two irrigations. The postharvest available soil nutrients such as N, K_2O and S, were unaffected due to irrigation schedule, while postharvest available P_2O_5 was significantly higher under I, (Table 1). Moisture content in soil at flowering stage (50 DAS) and at pod development stage (90 DAS) differed significantly due to irrigation treatments and these were recorded considerably higher under I_1 than under I_0 treatment.

Number of branches per plant increased due to application of FYM. This resulted in more number of pods per plant, test weight and thereby more grain and straw yields. The protein content also improved significantly, whereas sulphur content in grain was unaffected. Further, the FYM application increased the moisture retention of soil and the postharvest available soil nitrogen and phosphorus. Available soil potassium and sulphur content did not differ much. FYM significantly improved the soil moisture content recorded at flowering and pod development stages.

Sulphur application in chickpea had important effect on almost all attributes. Number of branches and number of pods per plant as well as total grain and straw yields improved up to S_1 (20 kg S ha^{-1}), but was at par with S_2

Table 1. Effect of different treatments on yield, growth and quality parameters of chickpea as well as postharvest nutrient status and soil moisture content.

Treatment	No. of branches plant^{-1}	No. of pods plant^{-1}	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}	Protein (%)	S (%)	Nutrient status in soil after harvest of the crop (kg ha^{-1})				Moisture content in soil at 30 cm depth (mm)	
							N	P_2O_5	K_2O	S	At flowering stage	At pod development stage
Irrigation (I)												
I_0-At pre-sowing	5.3	68.9	1951	2612	17.6	0.25	218.7	28.6	277.8	23.2	68.2	39.0
I_1-At pre-sowing + at flowering	5.9	85.7	2311	3228	19.8	0.26	217.7	36.4	269.3	22.9	73.8	53.2
CD (P = 0.05)	0.6	9.5	186	173	0.4	0.01	NS	1.6	NS	NS	1.3	0.9
FYM (F)												
F_0 - 0 tone FYM ha^{-1}	5.2	70.9	2002	2754	18.4	0.25	203.1	30.4	274.3	22.9	66.5	43.8
F_1 - 10 tone FYM ha^{-1}	6.0	83.7	2360	3086	19.0	0.26	233.3	34.6	272.8	23.2	75.9	48.5
CD (P= 0.05)	0.6	9.5	186	173	0.4	NS	27.9	1.6	NS	NS	1.3	0.9
Sulphur (S)												
S_0 - 0 kg sulphur ha^{-1}	5.0	71.1	2027	2747	16.6	0.21	223.9	32.7	266.3	18.3	72.9	45.9
S_1 -20 kg sulphur ha^{-1}	5.8	78.3	2151	2947	19.4	0.26	212.4	32.9	273.1	24.3	72.9	45.9
S_2 -40 kg sulphur ha^{-1}	6.1	82.6	2215	3066	20.1	0.30	218.4	31.9	281.1	26.5	74.6	46.3
CD (P = 0.05)	0.7	9.2	131	148	0.4	0.01	NS	NS	NS	4.8	1.3	NS

Table 2. Moisture content (v/v) in soil as influenced by I x F interaction

Treatment	Moisture content (v/v)			
	At flowering stage (50 DAS)		At pod development stage (90 DAS)	
Irrigation (1)	F_0	F_1	F_o	F_1
l_0	62.2	74.2	35.6	42.0
l_1 70.3		77.2	51.5	54.9
CD (P = 0.05) 3.4			1.3	

(40 kg S ha^{-1}). Application of sulphur @ 40 kg ha^{-1} recorded higher protein and sulphur contents than in grain with 20 and 0 kg S ha^{-1} (Table1). The differences in postharvest available nutrients such as nitrogen, phosphorus and potassium, were not observed due to sulphur application, while, the postharvest S content was higher under 40 kg S ha^{-1} than in 20 and 0 kg S ha^{-1}. Further, moisture content in soil at flowering stage (50 DAS) was higher in plots at 40 kg S ha^{-1}, while, at pod development stage (90 DAS), it was unaffected due to sulphur application (Ram Hari and Dwivedi 1992).

As regards to effect of irrigation x FYM interaction (Table 2) with respect to moisture content in soil at pod development stage (90 DAS), the combination I_1F_1 showed higher moisture content than in the other treatment combinations, while, at flowering stage (50 DAS), moisture content remained at par due to with or without application of irrigation in presence of FYM. The application of FYM improved the moisture content at flowering (50 DAS) and pod development stages (90 DAS) even in the absence or presence of irrigation. This might be due to organic manure's (FYM) role to improve the physical condition of the soil and increase the water-holding capacity of the soil.

Conclusion

It could be inferred from the present study that application of two irrigations (one at pre-sowing and second at flowering stage) with the application of FYM @ 10 tonnes and sulphur 20 kg ha^{-1} can increase the yield of chickpea.

References

Chaudhary JA and **Cornfield AH. 1966.** The determination of total sulphur in soil and plant material. Analyst 11:521-530.

Jackson ML. 1973. Soil Chemical Analysis. New Delhi, India: Prentice Hall of India Pvt Ltd.

Ram Hari and **Dwivedi KN. 1992.** Effect of source and level of sulphur on yield and grain quality of chickpea. Indian Journal of Agronomy 37(1):112-114.

Sharma RS. 1994. Response of chickpea to irrigation and fertility levels under double cropping system. Indian Journal of Agronomy 39(2):310-311.

Effect of Soaking Seeds on Polyphenols of Chickpea

S Paramjyothi and **B Anjali** (Department of Biochemistry, Gulbarga University, Gulbarga 585 106, Karnataka, India)

Chickpea *(Cicer arietinum* L.) occupies a unique position in pulse crops due to its seed protein content and wide adaptability as a food grain. India contributes to about 80% of the total world production of chickpea. Although, a valuable source of protein, chickpea is known to synthesize certain anti-nutritional factors such as polyphenols, which cause damage to intestinal tract and lowers feed efficiency in animals. However, these polyphenols can be wholly or partly removed by processing (Singh 1988). Soaking seeds is one such method of processing and this note is intended towards it. Seeds of varieties of chickpea, viz., BGD 237, SAKI 93130 and ICC 11320, were procured from the Pulse Research Station, Aland, Gulbarga, Karnataka, India. The seeds were soaked in distilled water for 6, 12 and 18 h, and in 2% solution of citric acid, sodium bicarbonate and mixed salt solution (MSS) of 1.5% sodium bicarbonate, 0.5% sodium carbonate and 0.75% citric acid for 18 h at room temperature. Polyphenols were determined in triplicate of all treated seed samples by method of Folin and Denis (1915).

Soaking of chickpea seeds resulted in significant loss of polyphenols in all the three varieties. Greater losses were observed when the seeds were soaked in MSS (Table 1). Deshpande and Cheryan (1985) have reported similar losses in polyphenols for dry bean (*Phaseolus vulgaris)* seeds when soaked in distilled water, sodium bicarbonate and MSS. Nearly 50% reduction in polyphenols of chickpea due to overnight soaking in water is reported by Rao and Deosthale (1982). The losses resulting from soaking may be due to leaching out of polyphenols into the soaking media. The phenolic compounds have been detected in leacheates of chickpea seeds by Rajkumar et

Table 1. Effect of soaking seeds on loss of polyphenols of chickpea.

Treatment	Polyphenols (mg/100 g)		
	BGD 237	SAKI 93130	ICC 11320
Raw untreated seeds	29.33 ± 0.57	51.68 ± 0.54	46.00 ± 0.86
Soaked Seeds			
DH_2O	26.70 ±0.61	44.53 ± 0.84	41.58 ±0.55
6 h	(9.01)	(13.8)	(9.6)
12 h	18.32 ±0.63	34.88 ± 0.98	34.38 ± 1.73
	(37.5)	(32.6)	(25.3)
18 h	16.00 ±0.10	25.50 ± 0.57	27.35 ± 1.30
	(45.4)	(50.7)	(40.6)
2% Citric acid	14.00 ± 1.02	24.33 ± 1.75	25.25 ± 0.26
18 h	(52.3)	(52.9)	(45.2)
2% Sodium bicarbonate	13.70 ±0.61	22.16 ±0.57	19.00 ± 1.02
18 h	(53.3)	(57.2)	(58.7)
2% MSS	11.27 ± 1.09	20.25 ± 0.43	15.92 ± 1.13
18 h	(61.6)	(60.9)	(65.4)

Values are mean ± standard deviation of triplicate determination. Values in the parentheses denote percent reduction over control.

al. (1979). The greater losses observed as a result of soaking in MSS or sodium bicarbonate may be due to the effect of these chemicals in creating an ionic environment. Under such conditions, changes in seed coat permeability may be much greater and rapid thus allowing higher losses.

It may be concluded from this attempt that soaking chickpea seeds is the most simple and inexpensive method for bringing significant reduction in polyphenols.

References

Deshpande SS and **Cheryan M. 1983.** Changes in phytic acid, tannin and trypsin inhibitor activity on soaking of dry beans. Nutritional Report International 27:371-375.

Folin O and **Denis W. 1915.** A colorimetric estimation of phenols (Phenol derivatives) in urine. Journal of Biological Chemistry 22:305-308.

Rajkumar N, Reddy AN and **Rao KN. 1979.** Levels of phenolic substances in the leacheates of *Cicer* seed. Indian Journal of Experimental Biology 17:114 - 116.

Rao VP and **Deosthale YG. 1982.** Tannin content of pulses: varietal differences and effect of cooking and germination. Journal of Science of Food and Agriculture 33:1013-1016.

Singh U. 1988. Antinutritional factors of chickpea and pigeonpea and their removal by processing. Plant Foods for Human Nutrition 38:251-256.

Increased Chickpea Yield and Economic Benefits by Improved Crop Production Technology in Rainfed Areas of Kurnool District of Andhra Pradesh, India

A Ramakrishna[1,*], SP Wani[1], Ch Srinivasa Rao[1] and **U Srinivas Reddy[2]** (1. Global Theme-Agroecosystems, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; 2. Assistant Project Director-Engineering (APD-Eng.), Nandyal, Kurnool, Andhra Pradesh, India)

*****Corresponding author: a.ramakrishna@global.net.pg

Chickpea, *Cicer arietinum* L., is a drought tolerant leguminous crop used in various foods in several developing countries, particularly in India as a source of dietary protein. There is a big gap between the yield realized in experimental station (2200 kg ha^{-1}) and the farm yield (1274 kg ha^{-1}) in Andhra Pradesh. The major constraints responsible for this untapped yield potential are inappropriate production practices, viz, usage of low yielding and non-responsive genotypes, pest and disease problems, lack of stress-resistant high-yielding genotypes, lack of improved soil and crop management practices and lack of appropriate institutional support.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Government of Andhra Pradesh have initiated the Andhra Pradesh Rural Livelihood Project (APRLP) to help reduce rural poverty by increasing agricultural productivity and improving livelihood opportunities through technical backstopping and convergence through a consortium of institutions. Watersheds were used as an entry point for research and development activities.

Nandavaram and Jillella villages of Banaganapalle mandal in Kurnool district of Andhra Pradesh were selected for undertaking on-farm research. Systematically collected soil samples from thirty farmers' fields in Nandavaram and Jillella watersheds on a toposequence were analyzed for physical and biological parameters and various nutrients. The soil analysis indicated that the fields in the two watersheds were low in N (496 and 333 mg kg^{-1} soil), low to medium in available P (5.71 and 2.72 mg kg^{-1} soil) (Olsen's P), high in exchangeable K (223 and 178 mg kg^{-1} soil), and low in available Zn (0.39 and 0.24 mg kg^{-1} soil), S (7.52 and 4.09 mg kg^{-1} soil) and B (0.5 and 0.45 mg kg^{-1} soil). This critical information aided in identifying better options to improve the chickpea yield levels and for sustaining natural resources.

Sixteen on-farm trials in 2002 and nine trials in 2003 were conducted during the postrainy season with the objective to demonstrate the beneficial effects of improved production technologies over farmers practice. Improved production technology was compared with the farmers' method in an area of 1000 m^2 in each of the farmers' fields. The improved technology package included improved cultivar (ICCC 37), a seed rate of 60 kg ha^{-1}, seed treatment with thiram (3 g kg^{-1} seed), inoculation with *rhizobium*, a fertilizer dose of 20 kg N and 50 kg P_2O_5 ha^{-1}, basal application of micro-nutrient mixture of 5 kg borax (0.5 kg B ha^{-1}), 50 kg zinc sulphate (10 kg Zn ha^{-1}) and 200 kg gypsum (30 kg S ha^{-1}) per hectare together with need-based pest and disease control measures. Two inter-cultivations at 25 and 50 days after sowing to control weeds was taken up. One insecticide spray was given at pod formation stage to control pod borers. The fanners' method included a local variety, a seed rate of 50 kg ha^{-1} and a fertilizer dose of 14 kg N and 35 kg P_2O_5 ha^{-1}. Entire dose of N and P was applied as basal. The amount of rainfall from June to December was 708 mm during 2002 and 504 mm during 2003. The data was analyzed separately for both years considering farmers as replications using one-way ANOVA with randomized blocks on GenStat. Subsequently, pooled analysis of two year's data was carried out using two-way ANOVA. The analysis of variance indicated that

Table 1. Yield and economics of chickpea in on-farm trials, Nandavaram and Jillella watersheds, Kurnool district, Andhra Pradesh, postrainy season 2002 and 2003.

Cultivation method	Grain yield (t ha^{-1})			Cost of cultivation (Rs ha^{-1})			Net return (Rs ha^{-1})			Benefit Cost Ratio		
	2002	2003	Pooled	2002	2003	Pooled	2002	2003	Pooled	2002	2003	Mean
Improved Production technology	2.13	2.03	2.09	8311 (US$185)	8200 (US$182)	8271 (US$184)	23598 (US$524)	24330 (US$541)	23862 (US$530)	2.8	3.0	2.9
Farmers' practice	1.42	1.29	1.37	5792 (US$129)	5706 (US$127)	5761 (US$128)	15450 (US$343)	14996 (US$333)	15287 (US$340)	2.7	2.6	2.7
SE ±	0.06	0.05	0.04	14	19	12	924	836	666			
CV %	14.0	9.6	12.8	0.9	0.7	0.8	18.9	12.8	17			
LSD(5%)	0.19	0.17	0.13	43	62	34	2786	2726	1949			

Table 2. Yield components of chickpea in on-farm trials, Nandavaram and Jillella watersheds, Kurnool district, Andhra Pradesh, postrainy season 2002 and 2003.

	Total dry matter (t ha^{-1})			100 grain weight (g)			Harvest Index		
Cultivation method	2002	2003	Pooled	2002	2003	Pooled	2002	2003	Pooled
Improved Production technology	3.76	3.85	3.80	18.93	19.41	19.10	0.57	0.53	0.55
Farmers' practice	2.83	2.74	2.80	17.22	17.74	17.41	0.50	0.47	0.49
SE+	0.12	0.08	0.08	0.34	0.34	0.25	0.01	0.01	0.01
C V %	14.6	7.5	12.6	7.5	5.4	6.8	8.9	8.0	8.6
LSD(5%)	0.36	0.27	0.24	1.02	1.10	0.73	0.04	0.04	0.03

management practices (improved crop production technology and farmers practice) differed significantly in both years (P=<0.001-0.008), as well as in the combined analysis (P=<0.001). The year and year x management were non-significant (data not given).

The improved production technology gave higher grain yields and recorded a mean yield of 2.09 t ha^{-1} which was 53% higher than that obtained with farmers' practice yields of 1.37 t ha^{-1} (Table 1). The increased grain yield with improved production technology was mainly because of increased total dry matter, higher 100-grain weight and harvest index (Table 2). Yield increase in response to fertilizer recommendations was also reported by Tamboli et al. (1996).

The economic viability of improved technology over the traditional farmers' practice was calculated depending on prevailing prices of input and output costs. The additional cost of US$56 ha^{-1} (Table 1) incurred in the improved technology as compared to farmers practice was mainly due to balanced fertilization (micro-nutrients and additional N and P), additional seed cost, seed treatment, IPM and one additional inter-cultivation. However, the improved technology resulted in increased mean income of US$190 with a cost-benefit ratio of 2.9 (Table 1). This additional income could substantially benefit the resource poor farmers and improve their livelihoods in the dry regions of Kurnool district of Andhra Pradesh. Thiyagarajan et al. (2003) reported that the use of sulphur and micronutrients (Zn, B, Mo and Fe) improved productivity of pulse crops considerably. Balanced nutrition is indispensable for achieving higher productivity. Sachdev et al. (1992) obtained increased grain yield and harvest index of chickpea due to balanced fertilization. Shinde and Mane (1996) reported that the balanced application of fertilizers based on soil testing improved the yield of chickpea by 47 percent and monetary returns by Rs 7676 (US$171) per hectare over control. The results from the current study clearly brought out the potential of improved production technology in enhancing chickpea production and economic gains in the dry ecoregions of Andhra Pradesh.

Acknowledgments. We gratefully acknowledge the Andhra Pradesh Rural Livelihoods Project (APRLP)/ DFID for financial assistance and all the farmers for their overwhelming support in conducting the trials.

References

Sachdev P, Chatterjee SR and **Deb DL. 1992.** Seed yield, harvest index, protein content and amino acid composition of chickpea as affected by sulphur and micronutriets. Annals of Agricultural Research 13:7-11.

Shinde PB and **Mane DA. 1996.** Influence of balanced fertilizer application in improving yield of Bengal gram. Page 24 *in* Strategies for increasing pulses production in Maharashtra (Wanjari KB, Raut BT and Potdukhe SR, eds.). Directorate of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Tamboli BD, Kadu PP, Patil TIN, **Patil Y M, Somawanshi RB** and **Sonar KR. 1996.** Fertilizer recommendations for desired yields of chickpea on Vertisols. Page 24 *in* Strategies for increasing pulses production in Maharashtra (Wanjari KB, Raut BT and Potdukhe SR, eds.). Directorate of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Thiyagarajan T M, Backiyavathy MR and **Savithri P. 2003.** Nutrient management for pulses-a review. Agricultural Reviews 24:40-48.

A method for germinating perennial *Cicer* species

CJ Coyne[1]*, T Sharp-Vincent[1], MJ Cash man[1], CA Watt[1], W Chen[2], FJ Muehlbauer[2] and **Nalini Mallikarjuna[3]** (1. USDA-ARS Western Regional Plant Introduction Unit, Washington State University, Pullman, WA 99164-6402, USA; 2. USDA-ARS, Grain Legume Genetics and Physiology Unit, Washington State University, Pullman, WA 99164-6434, USA; 3. ICRISAT, Patancheru 502 324, Andhra Pradesh, India)
*Corresponding author: coynec@wsu.edu

The germplasm collection at the USDA ARS National Plant Germplasm System includes chickpea that consists of cultivated *Cicer arietinum* accessions containing genetic diversity immediately accessible for breeding, and wild *Cicer* species that may be of importance in the future as sources of genes for resistance to biotic and abiotic stresses. The wild *Cicer* species in the collection include 113 accessions of seven annual wild *Cicer* species and 59 accessions of 13 perennial *Cicer* species (available online at www.ars-grin.gov/npgs). At USDA-ARS, located in Pullman, WA USA, in earlier years, seed aeration technique was used to promote germination in perennial *Cicer* species. N Kameswara Rao has used *in vitro* germination on water agar to uniformly germinate annual wild *Cicer* species (personal communication 2000).

In the present study, an *in vitro* germination method was examined as an alternative method to provide uniform germination of the perennial species with the goal of establishing a nursery for regeneration and evaluation of inter- and intra-accession genetic variability. Twenty-eight accessions of nine perennial species were surface disinfested, scarified, and cultured under sterile conditions on water agar. The average germination of 25 accessions of eight species was 82% in 2001 with a range of 43 to 100%. Two accessions of C. *montbretii* failed to germinate *in vitro*. In 2002, an additional 13 accessions were successfully germinated with the same method (data not shown) and three accessions of *C. montbretii* failed to germinate on water agar.

Seeds to be germinated were surface disinfested with a 30 sec dip in 95% ethanol followed by 10 min in 0.6% NaCIO (100% commercial bleach) with drops of the detergent Tween 80 (Sigma, St. Louis, MO USA). After surface disinfestations, the seeds were soaked in sterile water for 1-5 days, or until they soften enough to scarify using a sterile scalpel. Scarified seed were then placed either on agar plus Murashige & Skoog (1962) Salt Mixture (M5524, Sigma, St Louis, MO USA) or on agar (Difco Bacto agar, Fisher Scientific, USA) medium alone. The culture vessels (Magenta GA-7-3, Sigma, St Louis, MO USA) were then placed under cool-white fluorescent lights until radicle emergence. Plantlets were left on agar until the shoots were between 2-5 cm long.

An experiment was conducted to test the effects of Murashige and Skoog (1962) mineral nutrients plus agar vs. unamended agar on germination. The percentage germination was similar; however, MS nutrient amended agar reduced root growth (data not shown).

The vessels containing the plantlets were then partially opened to begin a 2 or 3 day acclimation at lower relative humidity. Plantlets were then pulled from the agar and their roots dipped in a fungicidal slurry (Captan, Gustafson, Plano, TX USA) before transplanting to 18 cm flats (Rootrainers, Hummert, Earth City, MO USA) filled with soil-less planting mix (Sunshine Mix Aggregate Plus Blend #4, SunGro, Bellevue, WA USA) with added coarse perlite (#2 sieve, Therm-o-rock, Chandler, AZ USA). The planted flats were moved to a humidity-controlled chamber constructed on a greenhouse bench. Plastic sheeting, 67% light-reducing shade fabric (PAK Woven Shade Fabric, Hummert, Earth City, MO USA) and a humidifier (Model 500, Hummert, St. Louis, MO USA) were used to maintain a cooler atmosphere with constant relative humidity. Initial humidity settings were between 75-80% with a steady decline to approximately 50% over the course of 4 to 5 days. The seedlings were able to tolerate the ambient humidity after five days and were moved to an open greenhouse bench covered with shade fabric. The greenhouse conditions were 21°C day/15.5°C night temperature, no humidity control, and 16 h day length.

The *Cicer* plants were retained there for a few weeks and the plants grew robust enough to withstand the outdoor conditions. Later, the plants were moved to an outdoor lathe house to harden the seedlings for at least two weeks before planting in the field. The seedlings were hand-planted on either side of a central irrigation drip line with emitters next to each plant.

This procedure provided uniform germination of most of the perennial *Cicer* accessions, except *C. montbretii* (Table 1). Aseptic germination of perennial chickpea on water agar is a fast and efficient method to provide a uniform set of transplants for field regenerations, and also to offer sufficient uniform seedlings for replicated screenings to detect resistance to biotic and/or abiotic stresses. Once established, grafting may also be useful in supplying plants for resistance testing experiments (Chen

Table 1. Results of aseptic germination of perennial *Cicer* species on water agar after seed surface disinfestation and scarification at USDA-ARS, Pullman, in 2001.

Accession Number	Genus	Species	Seed quantity	Germinated	% Germinated	Number Rotted[1]	% Rotted
PI 383626	*Cicer*	*anatolicum*	30	24	80.0%	4	13.3%
PI 561078	*Cicer*	*anatolicum*	30	14	46.7%	8	26.7%
PI 599087	*Cicer*	*anatolicum*	30	17	56.7%	3	10.0%
PI 557453	*Cicer*	*canariense*	30	13	43.3%	0	0.0%
PI 599079	*Cicer*	*macracanthum*	30	23	76.7%	2	6.7%
PI 599080	*Cicer*	*macracanthum*	30	28	93.3%	1	3.3%
PI 599081	*Cicer*	*macracanthum*	30	25	83.3%	2	6.7%
PI 532928	*Cicer*	*microphyllum*	30	27	90.0%	3	10.0%
PI 593718	*Cicer*	*microphyllum*	30	28	93.3%	0	0.0%
PI 593719	*Cicer*	*microphyllum*	30	27	90.0%	1	3.3%
PI 599061	*Cicer*	*microphyllum*	30	27	90.0%	1	3.3%
PI 599082	*Cicer*	*microphyllum*	30	29	96.7%	0	0.0%
PI 599083	*Cicer*	*microphyllum*	30	30	100.0%	0	0.0%
PI 599084	*Cicer*	*microphyllum*	30	27	90.0%	0	0.0%
PI 599088	*Cicer*	*microphyllum*	30	24	80.0%	2	6.7%
PI 599089	*Cicer*	*microphyllum*	30	29	96.7%	0	0.0%
PI 599093	*Cicer*	*microphyllum*	30	28	93.3%	0	0.0%
PI 599085	*Cicer*	*multijugum*	30	27	90.0%	0	0.0%
W6 11516	*Cicer*	*multijugum*	30	30	100.0%	0	0.0%
PI 561084	*Cicer*	*oxyodon*	30	27	90.0%	0	0.0%
PI 561103	*Cicer*	*oxyodon*	30	25	83.3%	1	3.3%
PI 599053	*Cicer*	*songaricum*	30	13	43.3%	0	0.0%
PI 504550	*Cicer*	*yamashitae*	30	28	93.3%	1	3.3%
PI 510657	*Cicer*	*yamashitae*	30	30	100.0%	0	0.0%
PI 510664	*Cicer*	*yamashitae*	30	21	70.0%	1	3.3%
PI 599090	*Cicer*	*montbretii*	30	0	0.0%		
PI 599091	*Cicer*	*monthretii*	30	0	0.0%		

1. Seed was scored as rotted if contaminated *in vitro* with a micro-organism, usually fungal or bacterial in appearance.

et al. 2004). As reported by Kaiser et al. (1997), cold treatment followed by aeration of *C. montbretti* seed in fresh water failed to promote germination. At ICRISAT, Patancheru, India, seedlings of C. *montbretii* were routinely established following normal germination procedures. (Anonymous communication), and plants of C. *montbretti* were established at Pullman, WA USA, in the early 1990s using an unpublished germination procedure (Hellier, personal communication). Further research is needed to improve surface disinfestation of the seed to reduce losses from fungal and bacterial contamination (rotted seed), and compare this method with (1) aeration in fresh water and (2) ICRISAT procedures in germination efficiency and efficacy. A technique to achieve seed germination in C. *montbretii* has to be developed.

Acknowledgments. The Land Institute is gratefully acknowledged for Natural Systems Agriculture Graduate Research Fellowships to T Vincent-Sharp and C Watt. This project was supported by ARIS Project 5348-21000-020-00 and AID-ICRISAT-USDA Linkage ARIS Project 5348-21000-014-02.

References

Chen W, McPhee KE and **Muehlbauer FJ. 2004.** Use of grafting to study chickpea resistance to ascochyta blight. International Chickpea and Pigeonpea Newsletter 11:39-41.

Kaiser WJ, Hellier BC , Hannan RM and **Muehlbauer FJ. 1997.** Growing techniques in conservation of wild perennial *Cicer* species in US Pacific Northwest. International Chickpea and Pigeonpea Newsletter 4:7-9.

Murashige T and **Skoog F. 1962.** A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol Plant 15:473-497.

Antifungal Metabolites from *Arachniotus* sp for the Control of Wilt Disease of Chickpea

Iftikhar A Khan[1], S Sarwar Alam[1,*], M Sarwar[1], M Jahangir Iqbal[3] and **Abdul Jabbar[2]** (1. Nuclear Institute for Agriculture and Biology, PO Box 128 Jhang road Faisalabad, Pakistan; 2. Department of Chemistry, Islamia University, Bahawalpur, Pakistan; 3. University of the Punjab, Lahore, Pakistan)
*Corresponding author: drssalam@yahoo.com

More than 50 pathogens of chickpeas have been reported in different part of the world (Nene 1980), but the most important of them are ascochyta blight and fusarium wilt. Chickpea wilt caused by *Fusarium oxysporum* Schlecht. emnd Synd. & Hans. f. sp. *ciceris* (Padwick) Matuo and K Sato, (FOC), is reported from all areas of chickpea cultivation in the world. Both the diseases are reported to cause substantial yield losses to the crop (Halila et al. 1984) and are highly influenced by environmental conditions, being prevalent in warm and dry environments. In Pakistan, wilt is a major problem in Thal area where most of the chickpea crop is cultivated. Due to the absence of true resistance in chickpea against wilt disease and a continuous problem of the occurrence/ development of new pathogenic races (Jimenez-Diaz et al. 1989), it has become very difficult to overcome the yield losses. *Arachniotus* sp has successfully been used as bio-control agent for the control of wilt (Ansar et al. 1996a,b) and other diseases of chickpea in field conditions (Saleem et al. 2000). The bioactive metabolites from antagonistic micro-organisms can be successfully used to control the microbial diseases (Momose et al. 1998).

Fungal metabolites were produced by the procedure reported by Khan et al (2001). *Arachniotus* sp (white isolate) was grown on liquid minimal medium (100 mL) taken in roux bottles for 14 days in dark at 25°C. The culture filtrates (85 mL) was harvested by filtering and squeezing the contents of the bottles through muslin cloth (Alam and Khan 1996), pH of the culture filtrates was adjusted to 3.0 using dilute hydrochloric acid and then extracted in half the volume of ethyl acetate three times. Ethyl acetate phase was dried over anhydrous sodium sulphate and then concentrated on rotary evaporator to dryness and the contents were dissolved in 1.0 ml of ethanol (Alam and Strange 1992). Anti-fungal assay against a virulent wilt causing isolate of *Fusarium oxysporum* f. sp. *ciceris*, 2012 (Khan et al. 2002) was done by disc diffusion method as described by Jacoby and Archer (1991). Ethyl acetate extracts (50 ml) was poured in the metallic well (1.0 cm outer diameter) placed in the center of pre-inoculated PDA plates (inoculated with 50 ml of spore suspension of 1×10^4

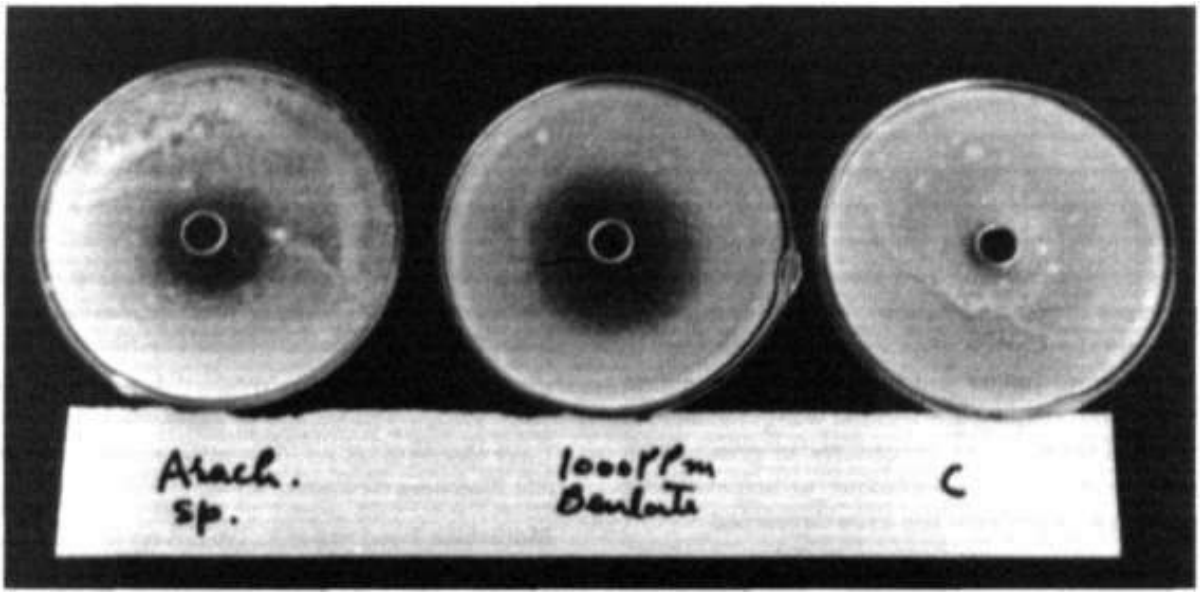


Figure 1. Inhibition zone produced by the ethyl acetate extract of *Arachniotus* sp and benlate against *F. oxysporum* f. sp. *ciceris.*

Table 1. Effect of ethyl acetate phase of *Arachniotus* sp. and benlate on the colony growth of *F. oxysporum* f. sp. *ciceris*.

S.No.	Treatment *	Inhibition zone (cm)	Percent inhibition
1.	EtoAc Phase (50 µl) of *Arachniotus* sp	2.1±0.115	30%
2.	Benlate (1000 ppm)	3.2±0.00	46%
3.	Control	0.0±0.00	0.0 %

Inner diameter of the petri dish was 7.0 cm.
*mean of the three replications

spores/ml of FOC isolate) in three replicates. Ethanol (50 ml) was used as control, while benlate (1000 ppm) was also tested as reference fungicide. The plates were incubated at 25°C for 7 days and the activity was determined by measuring the diameter of inhibition zones produced.

The bioassay revealed that the ethyl acetate phase of *Arachniotus* sp produced inhibition zones against *F. oxysporum* f. sp. *ciceris* isolate (Fig.1). Benlate solution produced 3.2 cm average inhibitory zone (46% inhibition as compared to control) at 1000 ppm concentration, while 2.1 cm average zones (30% inhibition) were produced by the ethyl acetate extract of *Arachniotus* sp at 50 ml concentration, which was equivalent to 4.25 ml of culture filtrates, against the FOC isolate (Table1). On the other hand, the activity produced by 4.25 ml of culture filtrates of *Arachniotus* sp is equivalent to 625 ppm of benlate. No inhibition zones were produced by the control treatments. Results concluded that the metabolites produced by *Arachniotus* sp. were active against *F. oxysporum* f. sp. *ciceris* and may be used to manage wilt disease either by seed treatment or through soil treatments.

References

Alam SS and **Khan IA. 1996.** Phytotoxins from *Fusarium oxysporum* f. sp. *ciceri* involved in wilt of chickpea. Pak J Phytopath 8:132-135.

Alam SS and **Strange RN. 1992.** Phytotoxins in chickpea blight. Pages 200-208 *in* Proceedings of the National Symposium Status of Plant Pathology in Pakistan, University of Karachi, 3-5 December 1991. Pakistan: Shamim Printing Press.

Ansar M, Akhtar C M, Ahmad R and **Alam SS. 1996a.** Effect *of Arachniotus* sp. along with soil amendments in the control of chickpea wilt caused by *Fusarium oxysporum* f. sp. *ciceri.* Pak J Phytopath 8:37-39.

Ansar M, Akhtar C M, Ahmed R and **Alam SS. 1996b.** Effect of *Arachniotus* sp and organic substrate on chickpea wilt disease caused by *Fusarium oxysporum* f. sp. *ciceri.* Pak J Phytopath 8:40-42.

Halila H M, Girdley HE and **Houdiald P. 1984.** Sources of resistance to fusarium wilt in kabuli chickpea. International Chickpea Newsletter 10:13-14.

Jacoby GA and **Archer GL. 1991.** New mechanisms of bacterial resistance to antimicrobial agents. *J Medicine* 324:601-602.

Jimenez Diaz R M, Trapero Casas A and **Cabreva de La colina J. 1989.** Races *of Fusarium oxysporum* f. sp. *ciceri* infecting chickpea in southern Spain. Pages 515-520 *in* Vascular wilt diseases of plants (Tjamos EC and Beckman CH, eds.). NATO AS1 Ser H, vol 28. Berlin, Germany: Springer-Verlag.

Khan IA, Alam SS and **Jabbar A. 2001.** Standardization of medium for the production of maximum phytotoxic activity by *Fusarium oxysporum* f. sp. *ciceris.* Pak J Biol Sci 4:1374-76.

Khan IA, Jabbar A and **Alam SS. 2002.** Genetic variation among *Fusarium oxysporum* f. sp. *ciceris* isolates in Pakistan as determined by biological pathotyping and vegetative compatibility. Pak J Botany 34:433-440.

Momose I, Chen W, Kinoshita N, Iinuma H, Hamad M and **Takeuchi T. 1998.** Polyketomycin a new antibiotic from streptomycets sp MIK 277-AF1. J Antibiotics 51:21-25.

Nene YL. 1980. Diseases of chickpea. Pages 171-178 *in* Proceedings of International Workshop on Chickpea Improvement, 28 February-2 March 1979, ICRlSAT, India. Patancheru, AP 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Saleem A, Hamid K and **Jamil FF. 2000.** Biological control of root and collar rot of chilies. Pak J Phytopathology 12:87-94.

Management of root knot nematode and fusarium wilt disease complex by fungal bioagents, neem oilseed cake and/or VA-Mycorrhiza on chickpea

Rajesh Kumar Pandey, BK Goswami and **Satyendra Singh** (Division of Nematology, Indian Agricultural Research Institute, New Delhi 110 012, India)
*****Corresponding author: goswami_bk@yahoo.co.in

Heavy infestation of both root-knot nematode and wilt fungus on common host chickpea has a synergistic effect in the farmers' fields around Allahabad. The present investigation was carried out under pot trial in a glasshouse with the objective to manage the disease complex through ecofriendly methods. The management components for this were fungal bioagents *(Paecilomyces lilacinus* and *Trichoderma viride),* VA-Mycorrhizal and neem oilseed cake under glasshouse condition. On uprooting the affected chickpea plants from the affected farmers' fields with heavy infection of root galls, the presence of wilt fungus, *Fusarium oxysporum* f. sp. *ciceri,* and galls of root-knot nematode, *Meloidogyne incognita* (Race-1) was confirmed. A preliminary pot trial with both *M. incognita* and *F. oxysporum* f. sp. *ciceri* on chickpea (cv H-108) confirmed synergistic effect on the host. This preliminary trial for establishment of disease complex with the above pathogens was done in 15-cm earthen pots filled with sandy loam soil in September 2003.

On establishment of the disease complex, the management experiment was carried out. The simultaneously inoculated treatment showing synergistic effect was taken as control with each of the treatments where management components were tried (Table1). The work was carried out with neem oilseed cake, fungal bioagents and vesicular-arbuscular mycorrhizas *(Glomus fasciculatum).* While the last component of the management trial, ie, V A M was isolated from the affected chickpea field; the two fungal bioagents and the neem oilseed cake were procured from fungal bioagents laboratory in the Division of Nematology. All the three management components were tested individually as well as collectively in 15-cm earthen pots filled with autoclaved sandy loam soil, to each of which both the pathogens (M *incognita + Fusarium oxysporum* f. sp. *ciceri)* were given prior treatment simultaneously as control *(M. incognita + Fusarium oxysporum* f. sp. *ciceri,* Tables1 and *2). A* week before sowing of seeds, inoculations of *M. incognita 2* larvae/g soil was done while about 100 chlamydospores of *G fasciculatum* were added to each of the Mycorrhizal treatments. Two weeks prior to sowing, the dosage of neem oilseed cake was 0.5% w/w. Both the fungal bioagents were applied to respective treatment in each pot along with sowing of chickpea seeds in talc based formulations with spore load of 12x108/g. Adequate control constituting all the components (Tables1 and 2) were also maintained.

The observations with respect to plant growth parameters, yield, number of nodules and also chlorophyll contents of each treatment were recorded after 90 days of final inoculation along with the population of root knot nematode, wilt percentage, mycorrhizal colonization percentage in root and also the population of V A M chlamydospores. Thus, in general, as is clear from Tables 1 and 2, there is a significant improvement of plant growth parameters and also the reduction in the disease incidence including suppression of *M. incognita* population in the treatments where more than one management component was used. The best performance, however, among the combined treatments was observed in the treatment constituting V A M , oilseed cake and both bioagents together followed by the treatment with V A M coupled with both bioagents. For years, attempts have been made to reduce the disease incidence through combination of either oil-seed cake and nematicide. References are available where either oilseed cake and nematicides (Singh 1965) or oilseed cake and fungal bioagents were applied, and the dual application of botanical antagonist with oil seed cake were noted. The present investigation focuses on more than two management components for two plant pathogens, i.e., root knot nematode and wilt fungus, both infecting common host chickpea. The cumulative effect of neem oilseed cake, *G. fasciculatum* and both fungal bioagents in reduced dose exhibited most promising results in reducing root knot nematode population and also the intensity of the wilt fungus (Table 1). The same treatment also revealed an outstanding improvement in plant vigor, which is significantly superior to oilseed cake treatment.

The discovery of an excellent recovery of chickpea plants from both *M. incognita* and *F. oxysporum* f. sp. *ciceri* is attributed to the joint reaction of neem oilseed cake, which possesses both fungicidal (Singh and Singh 1970) and nematicidal properties (Goswami and Swarup 1972). This is supplemented with the biopesticidal properties of both the fungal bioagents used with the growth hormonal character of *T. viride* (Chang et al. 1986). V A M , which in general occur abundantly around the rhizosphere of pulse crops (Allen 1991), is also

Table 1. Effect of *G. fasciculatum, T. viride, P. lilacinus,* neem oil-seed cake individually and together on disease complex caused by root-knot nematode and wilt fungus, with respect to plant growth characters, chlorophyll content, yield and test weight of chickpea.

Treatment	Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)	Chlorophyll contents (mg/g)	No of bacterial nodules	No of pods/ plant	100 seed weight (test weight)
Glomus fasciculatum + C (N+F)	25.8	21.8	18.4	10.8	26.7	42	31	17.5
T. viride + C	23.3	19.3	17.3	10.1	26.3	37	29	17.1
P. lilacinus + C	22.2	17.6	15.6	8.7	25.9	36	27	16.8
Neem oilseed cake + C	20.7	14.7	14.5	8.2	25.8	36	28	16.2
G. fasciculatum + *T. viride* + C	38.6	35.7	22.5	13.6	27.2	56	35	18.5
G. fasciculatum + *P. lilacinus* + C	37.5	32.1	21.7	13.2	27.1	52	34	18.3
G. fasciculatum + Neem oilseed cake + C	39.7	36.2	23.2	13.5	27.2	54	36	18.2
G. fasciculatum + *T. viride* + *P. lilacinus* + C	41.6	37.5	23.7	15.2	27.9	64	47	26.8
G fasciculatum + *T. viride* + *P. lilacinus* + Neem oilseed cake + C	44.9	39.2	25.2	16.8	28.2	69	56	31.8
Control (N + F)	16.5	11.5	12.5	6.5	20.7	16	18	11.8
CD at 5%	2.20	3.63	2.50	1.13	0.01	3.92	3.16	2.11

C = Control (*M. incognita* + *Fusarium oxysporum* f. sp. *ciceri*)

Table 2. Effect of *G. fasciculatum, T. viride, P. lilacinus,* neem oil-seed cake individually and together on disease complex caused by root-knot nematode and wilt fungus, with respect to nematode population, wilt percentage, and colonization and chlamydospores formation of VAM.

Treatment	No. of galls/ plants	Egg mass/ plant	Soil population/ 500g.	Wilt percentage	Colonization % of VAM	Chlamydospores population of *G. fasciculatum*/ 100 g soil
Glomus fasciculatum + C (N+F)	8	1.8	125.8(11.1)	23.8	46.7	417.8(20.4)
T. viride + C	11	1.9	147(12.1)	27.3	-	-
P. lilacinus + C	13	2.1	153(12.3)	29.6	-	-
Neem oilseed cake + C	16	2.6	167(12.9)	36.7	-	_
G. fasciculatum + *T. viride* + C	4	0.2	117(10.8)	21.1	53.6	369.5 (19.2)
G. fasciculatum + *P. lilacinus* + C	5	0.3	121(11)	22.6	57.2	348.6(18.6)
G. fasciculatum + Neem oilseed cake + C	4	0.2	120(10.9)	23.4	69.1	485.6 (22.0)
G. fasciculatum + *T. viride* + *P. lilacinus* + C	3	0.1	107(10.3)	8.6	72.1	450.5(21.2)
G. fasciculatum + *T. viride* + *P. lilacinus* + Neem oilseed cake + C	-	-	73 (8.5)	-	79.6	528.7 (22.9)
Control (N + F)	38	4.8	1575(39.6)	73.5	-	-
CD at 5%	2.35	0.12	3.72	4.82	6.73	1.23

Figures in parenthesis is the transformed value, C = Control (*M, incognita* + *Fusarium oxysporum* f. sp. *ciceri)*

considered as one of the management components (protecting the host from other root enemies by occupying cortical regions of the root). Bhagawati et al. (2000) have demonstrated that the combination of mustard oil-seed cake and V A M yielded better result. The results of this preliminary investigation will be confirmed under glasshouse and field conditions.

References

Allen M F. 1991. The ecology of Mycorrhiza. Cambridge, UK: Cambridge University Press.

Bhagawati B, Goswami BK and **Singh CS. 2000.** Management of disease complex of tomato caused by *Meloidogyne incognita* and *Fusarium oxysporum* f sp *lycopersici* through bioagents. Indian J Nematol 30 (1): 16-22.

Chang Y C, Baker R, Kleifeld P and **Chet I. 1986.** Increased growth of plants in the presence of the biological control agent, *Trichoderma harzianum.* Plant Disease 70:145-148.

Goswami BK and **Swarup G. 1972.** Effect of oil-seed cake amended soil on the growth of tomato and root knot nematode population. Indian Phytopath 24(3):491-494.

Singh RS. 1965. Control of root knot of tomato with organic soil amendments. FAO Plant Prot Bull 13:35-37.

Singh RS and **Singh N. 1970.** Effect of oil-cake amendment of soil on population of some wilt causing species of fusarium. Phytopath Z 69 :160-167.

Screening of Chickpea Lines for Resistance to Ascochyta Blight

SM Iqbal*, A Bakhash, SR Malik and **AM Haqqani** (Pulses Programme, National Agricultural Research Centre (NARC), PO NIH, Park Road, Islamabad 45500, Pakistan)

*****Corresponding author: iqbalsh65@hotmail.com

Chickpea (*Cicer arietinum* L.) is an important winter grain legume sown under rainfed conditions in Pakistan. Average yield of chickpea in Pakistan is slightly above 500 kg ha^{-1} (GOP 2003) that is lower than its actual yield potential (Haqqani et al. 2000). Ascochyta blight caused by *Ascochyta rabiei* (Pass) Lab is the most devastating disease of chickpea. The disease is widely prevalent in the chickpea growing areas of the world (Nene et al. 1996).

Resistant varieties offer an economical solution to combat this disease and reduce production losses. In this context, 495 promising chickpea lines received from the International Center for Agricultural Research in the Dry Areas (ICARDA), Syria; National Agricultural Research Centre (NARC), Islamabad; Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad; Arid Zone Agricultural Research Institute (AZRI), Bhakkar; and Regional Agricultural Research Institute (RARI), Bahawalpur, Pakistan, were screened for resistance to ascochyta blight at NARC during the crop season of 2004-05.

Each entry was planted in a single row of 4 m long with 30 cm row-to-row and 10 cm plant-to-plant spacing. A highly susceptible cultivar AUG 424 was sown as a disease spreader and indicator after every five test entries. The genotypes were artificially inoculated with diseased crop debris collected form the previous year. Additionally crop was inoculated with spore suspension (5×10^4 spores mL^{-1}). Inoculations were done in the evening hours on cloudy days, at the preflowering stage. High humidity which is a prerequisite for disease epidemic was naturally created by the continuous rains during the crop season. Final disease observations were recorded on a 1-9 disease rating scale (Singh et al. 1981) in mid-March.

Test genotypes varied for disease reaction and three genotypes (FLIP 97-132C, FLIP 98-226C and FLIP 98-231C) were resistant (score 2-3) while eleven genotypes - FLIP 97-120C, FLIP 97-221C, FLIP97-229C, FLIP 98-33C, FLIP 98-54C, FLIP 98-206C, FLIP 00-20C, FLIP 02-28C, FLIP 02-45C, ILC 1929 and ICC 12004 - were moderately resistant (score 4-5). The potential resistant material identified in the study was originated at ICARDA (Table 1). Several sources of resistance to ascochyta blight have been reported at ICARDA (Reddy and Singh 1984; Singh et al. 1984). Some of the lines, eg, ILC 72 and ILC 3279 that showed high level of resistance in several other countries were not found highly resistant in Pakistan (Iqbal et al. 1994). Therefore, resistant genotypes originated from ICARDA need to be re-tested with aggressive pathotypes of Pakistan before their use in the breeding program. Our data indicates *that A. rabiei* is highly variable and the pathotypes present in Pakistan and India are more aggressive than those prevalent in the Mediterranean region (Singh et al. 1984).

The information on the resistance to *A. rabiei* generated in the present study indicated that there is sufficient genetic variation in chickpea for this trait that can be exploited for disease control through breeding blight resistant varieties of chickpea.

Table 1. Distribution of chickpea lines obtained from various sources in the disease reaction groups.

Source	Total	Resistant	Moderately resistant	Susceptible
ICARDA, Aleppo, Syria	164	3*	11**	150
NARC, Islamabad, Pakistan	132	-	-	132
NIAB, Faisalabad, Pakistan	99	-	-	99
AZRI, Bhakkar, Pakistan	90	-	-	90
RARI, Bahawalpur, Pakistan	10	-	-	10
Total	495	3	11	481

* 2 - 3 score on 1-9 rating scale.
** 4 - 5 score on 1-9 rating scale.

References

GOP. 2003. Agricultural Statistics of Pakistan. Islamabad, Pakistan: Ministry of Food, Agriculture and Livestock, Economic Wing, Government of Pakistan. 45 pp.

Haqqani AM, Zahid MA and **Malik MR. 2000.** Legumes in Pakistan. Pages 98-128 *in* Legumes in rice and wheat cropping systems of the Indo-Gangetic Plains - constraints and opportunities. (Johansen C, Duxbury JM, Virmani SM, Gowda CLL, Pande S and Josh PK, eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Ithaca, New York, USA: Cornel University. 230 pp.

Iqbal SM, Husaain S and **Malik BA. 1994.** Screening of chickpea lines against ascochyta blight. International Chickpea and Pigeonpea Newsletter 1:21.

Nene YL, Sheila VK and **Sharma SB. 1996.** A world list of chickpea and pigeonpea pathogens. ICRISAT Pulse Pathology Progress Report No. 32, 5th edition.

Reddy MV and **Singh KB. 1984.** Evaluation of world collection of chickpea germplasm accessions for resistance to ascochyta blight. Plant Disease 68:900-901.

Singh KB, Hawtin GC, Nene YL and **Reddy MV. 1981.** Resistance in chickpea to ascochyta blight. Plant Disease 65:586-587.

Singh KB, Reddy MV and **Nene YL. 1984.** International testing of chickpeas for resistance to ascochyta blight. Plant Disease 68(9):782-784.

Entomology

First-instar *Helicoverpa punctigera* larvae: feeding responses and survival on desi chickpea and the wild relative *Cicer bijugum*

SL Clement[1*], J Ridsdill-Smith[2] and **S Cotter[2]**
(1. USDA-ARS, Plant Germplasm Introduction and Testing Research Unit, Washington State University, Pullman, WA 99164-6402, USA; 2. CSIRO Entomology, Private Bag 5, Wembley WA 6913, Australia)
*Corresponding author: slclement@wsu.edu

Lepidopterous pod borers in the genus *Helicoverpa* are major constraints to chickpea (*Cicer arietinum)* production in the Indian subcontinent [especially *H. armigera* (Hubner)], Australia [especially *H. punctigera* (Wallengren)], and in many other parts of the world (Lateef 1985; Clement et al. 2000). Conventional insecticides are often used to control pod borers on chickpea and many other crops. However, intensive insecticide use on a wide variety of crops has led to widespread development of insecticide-resistant populations off *H. armigera* in India (Amies et al. 1996). Development of insect resistance to insecticides and the possible adverse effects of insecticides on humans and environment have stimulated interest in other methods such as resistant genotypes to manage pod borers (Lateef 1985). Screenings *of Cicer arietinum* germplasm stocks showed that *H. armigera* larvae reared on 'less susceptible' genotypes were lighter in weight and took longer to develop than those reared on 'more susceptible' genotypes (Srivastava and Srivastava 1989 ; Yoshida et al.

1995). Likewise, Sharma et al. (2002) recorded low weights for larvae of *H. armigera* and *H. punctigera* reared on some wild annual *Cicer* species, indicating that wild relatives of chickpea could be sources of resistance to *Helicoverpa*.

Although detailed observations of neonate lepidopteran larvae commencing their feeding on test plants have been used for evaluating resistance in crop plants (Zalucki et al. 2002). This approach has not been used to identify *Cicer* genotypes with varying levels of resistance and susceptibility to *H. punctigera*. Previously, > 5 day trials, albeit without detailed observations of the host acceptance and feeding behavior of first-instar larvae, have been used to identify *Cicer* genotypes with varying levels of susceptibility to both *H. armigera* and *H. punctigera*. We employed 48 h trials to observe and quantify the onset of feeding and survival of neonate *H. punctigera* on *Cicer* genotypes to assess the usefulness of short-term trials so as to identify resistant germplasm and possible mechanisms of resistance (antibiosis and anti-feedant effects) in this pest.

The trials were carried out at the Entomology Laboratory, Commonwealth Scientific and Industrial Research Organization (CSIRO), Centre for Mediterranean Agricultural Research, Western Australia. A *H. punctigera* culture at the Entomology Laboratory provided larvae for experiments, and the experimental plant material was obtained from potted plants grown in a glasshouse (natural light, 15 to 26°C). Neonate larvae were exposed to test material from pre-flowering plants of two *C. arietinum* genotypes (Annigeri-susceptible; and ICC 506-resistant) and two accessions of annual wild species of *C. bijugum* (ILWC 260, ILWC 7, both resistant), which exhibited a range of susceptibility to *H. armigera* and *H. punctigera* in > 5 day trials (Sharma et al. 2002, Ridsdill-Smith TJ unpublished data). Test material consisted of a main stem (with two branching stems and leaves) embedded into water-agar (10 g Bacto agar/l water) in a 35 ml plastic cup using forceps. There were three trials, each involving two *Cicer* genotype or species combinations (Table1). The experimental design was a completely randomized design with three replicates per

Table 1. Comparison of feeding and mortality rates of first-instar larvae of *Helicoverpa punctigera* on selected *Cicer arietinum* (Annigeri and ICC 506) and *C. bijugum* (ILWC 7and ILWC 260) genotypes (Perth, Australia).

		% larvae feeding at[1]				
Trial	Genotypes	1 h	4 h	24 h	48 h	% mortality at 48 h[2]
1.	Annigeri	61.1	94.3	94.3	94.3	5.6a
	ICC 506	39.0	78.0	83.3	83.3	16.7a
	ANOVA		F	*P*		
	Genotype (G)		2.78	0.17		
	Time (T)		19.48	<0.01		
	G x T		0.40	0.76		
2.	ILWC 7	27.7	66.7	100.0	94.3	5.6a
	ICC 506	44.3	66.7	78.0	66.7	33.3b
	ANOVA		F	*P*		
	Genotype (G)		1.15	0.34		
	Time (T)		42.11	<0.01		
	G x T		8.11	<0.01		
3.	ILWC 260	66.7	94.3	88.7	77.7	22.2a
	ICC 506	44.3	72.3	78.0	78.0	22.2a
	ANOVA		F	*P*		
	Genotype (G)		2.86	0.17		
	Time (T)		15.96	<0.01		
	G x T		2.72	0.09		

1. Means are based on three replications of 6 larvae per replication.
2. Means followed by the same letters do not differ significantly ($P = 0.05$). Data transformed ($\log_{10}(x + 1)$) to meet assumptions of ANOVA. Untransformed means reported here.

Cicer genotype. One potted plant provided all of the test material for a replication, which consisted of six larvae (one per plastic cup). After a 2 h starvation period, a neonate larva was transferred with a camel-hair brush to the basal part of test plant material and its movements were observed with the aid of a stereoscopic microscope for 2 minutes at 1,4, 24 and 48 h intervals. At each reading, we recorded if a larva had established a feeding site and was feeding or if it had not commenced feeding. The number of dead larvae was also recorded. Cups were randomly distributed on a laboratory (≈ 22°C) bench near a window for natural light and redistributed after each reading. From these observations, the percentage of larvae feeding on the plant per replication was calculated.

The analysis of variance [completely randomized design with one-way treatment structure (genotypes) with repeated measures] showed that larval feeding rates were not affected by genotype, but time significantly affected feeding with the lowest rates at 1 h and higher rates (irrespective of plant genotype) recorded from 4 h onwards in all trials. There was a significant genotype x time interaction in trial 2, indicating that the effect of time on feeding rates on lLWC 7 and ICC 506 was different. In all trials, the onset of feeding by neonate *H. punctigera* larvae was consistently delayed on ICC 506 and larval mortality was relatively high (16.7-33.3%) on this d*esi* chickpea (Table1). The leaf chemistry of this genotype may influence the feeding and survival of neonate and first-instar *H. punctigera,* as was suggested for *H. armigera* (Lateef 1985; Yoshida et al. 1995). Also, the results of trial 1 confirmed the susceptibility of Annigeri to *H. punctigera.* Contrary to Sharma et al. (2002), who detected //. *punctigera* resistance in ILWC 7 and ILWC 260 after 5 day feeding assays, our 48 h trials did not reveal the existence of strong resistance (compared to ICC 506) in the *C. bijugum* genotypes (Table1).

This study detected *H. punctigera* resistance and susceptibility in ICC 506 and Annigeri, respectively, but failed to confirm resistance in C. *bijugum* as previously found after 5-day feeding trials (Sharma et al. 2002). More investigations are required, because this study shows that interactions between first-instar larvae of *H. punctigera* and species and genotypes of *Cicer* are variable, with the possibility that different plant resistance factors are involved.

Acknowledgments. The authors are grateful to the Grains Research and Development Corporation (Project no. VF 58), Australia, for research funding and Louisa Bell and Kate Detchon (CSIRO, Floreat, WA) for technical assistance.

References

Armes NJ, Jadhav DR and **DeSouza KR. 1996.** A survey of insecticide resistance in *Helicoverpa armigera* in the Indian subcontinent. Bulletin of Entomological Research 86:499-514.

Clement SL, Wightman JA, Hardie DC, Bailey P, Baker G and **McDonald G. 2000.** Opportunities for integrated management of insect pests of grain legumes. Pages 467-480 *in* Linking research and marketing opportunities for pulses in the 21st century (Knight R, ed.). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Lateef SS. 1985. Gram pod borer (*Heliothis armigera*) (Hub.) resistance in chickpeas. Agriculture, Ecosystems and Environment 14:95-102.

Sharma HC, Mann K, Kashyap S, Pampapathy G and **Ridsdill-Smith J. 2002.** Identification of resistance to *Helicoverpa* in wild species of chickpeas. Pages 277-280 *in* Proceedings of the 12th Australasian plant breeding conference, Perth, W. Australia, 15-20 September 2002 (McComb JA, ed). Australia: Australasian Plant Breeding Association, Inc.

Srivastava CP and **Srivastava RP. 1989.** Screening for resistance to the gram pod borer, *H. armigera,* in chickpea genotypes and observations on its mechanism of resistance in India. Insect Science Applications 10:255-258.

Yoshida M, Cowgill SE and **Wightman JA. 1995.** Mechanism of resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea: role of oxalic acid in leaf exudates as an antibiotic factor. Journal of Economic Entomology 88:1783-1786.

Zalucki M, Clarke AR and **Malcolm SB. 2002.** Ecology and behavior of first instar larval Lepidoptera. Annual Review of Entomology 47:361-393.

Screening of Chickpea for Resistance to Pod Borer *Helicoverpa armigera* (Hubner) at Rahuri, Maharashtra, India

MM Sanap* and **BM Jamadagni** (Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri 413 722, Maharashtra, India)

***Corresponding author: rvnakat@yahoo.com**

Gram pod borer, *Helicoverpa armigern* (Hubner) is a key pest and with its regular occurrence in the state of Maharashtra early vegetative to podding stage causing losses (Puri et al. 1998) in chickpea. It ls economically significant. In North India, Sehgal and

Ujagir (1990) reported 90% pod damage by *Helicoverpa.* Management strategies for gram pod borer relied heavily on chemical insecticides. However, concerning chemical insecticides, the farmers' reluctance to use it, the non-availability, high cost, development of resistance and environmental pollution (Armes et al. 1996), have opened up avenues for the identification and adoption of chickpea genotypes resistant/tolerant to *Helicoverpa.* The genotype is the best/preferred component of integrated pest management.

Twenty-five promising chickpea genotypes from the International Chickpea *Helicoverpa* Resistant Nursery (ICHRN) were screened under pesticide-free field conditions during *Rabi* 2002-03 and 2003-04 seasons in a randomized block design in three replications at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India (532 m altitude with longitude of 19°44' to 19°57' N and latitude of 74°82' to 74°91' E).

The genotypes were sown in two row plots of 2 m length with the spacing of 30 x 10 cm on 28 October 2002 and 2003. All the recommended agronomic practices were adopted for raising the chickpea crop.

The observations on pod damage were recorded on five randomly sampled plants at maturity by counting the total number of healthy and damaged pods from which percent pod damage of each entry was calculated and compared with that of resistant check, ICC 506EB. The percentage data was converted to pest susceptibility rating on a scale of 1-9 as suggested by Lateef and Reed (1983).

The mean pod damage among the test entries (Table1) ranged from 20.37% in ICCL 87311 to 34.27% in ICC 12492

Table 1. Performance of chickpea genotypes against *Helicoverpa armigera* at Rahuri, Maharashtra, India, *Rabi* 2002-03 and 2003-04.

	Pod damage (%)				Grain yield (kg ha^{-1})		
Entries	2002-03	2003-04	Mean	PSR*	2002-03	2003-04	Mean
ICCL 79033	32.63	14.27	23.45	6	733	1650	1191
ICC 13	37.19	15.10	26.14	7	1250	616	933
ICC 14	32.10	19.54	25.82	6	583	1100	841
ICCX 730041	35.03	20.40	27.71	7	750	1392	1071
ICCL 80129	36.30	16.78	21.56	6	1275	1083	1179
ICC 11509	32.85	17.87	25.22	6	1133	1058	1095
ICC 9854	33.64	20.00	26.86	7	900	1883	1391
ICC 926	38.64	21.18	29.91	8	700	1500	789
ICC 5800	34.42	19.50	26.96	7	900	775	837
ICC 12476	28.33	17.81	23.07	6	800	1450	1125
ICC 12479	24.03	19.45	21.74	6	966	1266	1116
ICC 12480	26.32	19.23	22.77	6	791	1558	1174
ICC 12493	38.08	19.60	28.84	7	800	750	775
ICC 12492	40.82	27.73	34.27	8	858	1341	1100
ICC 12490	31.82	20.64	26.23	7	916	2050	1483
ICC 87220	45.59	21.95	33.77	8	841	1375	1108
ICC 87311	19.55	21.20	20.37	5	1041	1558	1033
ICC 87314	22.01	23.07	22.54	6	1191	592	891
Vijay	30.27	18.72	24.49	6	666	1608	1137
JG 362	26.63	19.23	22.94	6	916	1300	1108
ICCV 2	21.05	19.73	20.39	5	833	392	612
ICC 37	40.49	19.01	29.75	8	675	1350	1012
Annigeri	26.35	20.80	23.57	6	1066	1508	1287
ICCV 10	32.39	19.46	25.92	6	425	2124	1247
ICC 50 EB (ch.)	28.82	18.57	23.69	–	1125	1650	1387
Mean	31.94	19.47	25.51		885	1329	1088
SD	6.23	2.07	3.61		205	416	209

*-PSR= Pest susceptibility rating. Ch. = Resistant check.

with the mean damage of 25.51 ± 3.61%. Of the 25 genotypes screened, ICCL 87311 recorded the lowest damage (20.37%), which was significantly less than 14 genotypes. From the pest susceptibility ratings (on a scale of 1-9), it was noticed that ICCL 87311 and ICCV 2 were scored at 5 and were most promising, whereas eight other genotypes ICCL 79033, ICCL 80129, ICCL 12746, ICC 12479, ICC 12480, ICCL 87314, IG 362 and Annigeri, were at 6 and suffered less damage than the resistant check ICC 506EB. Genotypes ICC 13, ICCX 730014, ICC 9854, ICC 5800 and ICC 12493, with a rating of 7, and ICC 926, ICC 12492 and ICCL 87220, with a rating of 8, were susceptible to *Helicoverpa* damage.

Genotypes ICC 9854 and ICC 12490 had grain yield of 1391 and 1483 kg ha^{-1}, respectively, and were superior over resistant check, ICC 506EB. Despite, recording higher pod damage (26.86% and 26.23%), they recorded higher grain yield indicating their tolerance to *Helicoverpa* damage.

Thus, the genotypes ICCL 87311, ICCV 2, ICCL 12490 and ICC 9854, showed fairly good resistance/ tolerance against pod borer, and they derive an attention for *per se* cultivation by the farmers.

Acknowledgments. The authors are thankful to Dr HC Sharma, lCRlSAT, for the supply of the seed material of promising chickpea genotypes.

References

Armes NJ, Jadhav DR, Bond and **De Souza KR. 1996.** A survey of insecticide resistance in *Helicoverpa armigera* in Indian subcontinent. Bulletin of Entomological Research 86:499-514.

Lateef SS and **Reed W. 1983.** A suggested system of rating pigeonpea and chickpea entries for field resistance to *Heliothis armigera.* In Nationa Seminar on Breeding Crop Plants for Resistance to Pests and Diseases, 25-27 May, 1983.Tamil Nadu Agricultural University, Coimbatore, TN. India: 127-131.

Puri SN, Murthy KS and **Sharma OP. 1998.** Integrated management of insect pests in chickpea and pigeonpea. Abstracts. National Symposium on Management of Biotic and Abiotic stresses in pulse crops. 7 pp.

Sehgal VK and **Ujagir R. 1990.** Effect of synthetic pyrethroids, neem extracts and other insecticides for the control of pod damage by *Helicoverpa armigera* (Hubner) on chickpea and pod damage yield relationship at Pantnagar in northern India. Crop Protection 9:29-32.

Preliminary evaluation of chickpea genotypes for resistance to pod borer and wilt complex

Harminder Kaur, SK Gupta, Daljeet Singh and **Kuldip Singh** (Punjab Agricultural University-Regional Station, Faridkot 151 203, Punjab, India)

Chickpea *(Cicer arietinum* L.) production in India (4.33 million tonnes in 1980 and 5.12 million tonnes in 2000) has stagnated in the last two decades. The major limiting factor has been the susceptibility of cultivars to several biotic and abiotic stresses that affects yield adversely (Singh et al. 1994). Most of the existing varieties are susceptible to fusarium wilt, ascochyta blight and podborer *(Helicoverpa armigera),* which are the major bottlenecks in increasing production potential of chickpea (Kalia and Dawa 1988; Singh et al. 1994). The parents which are resistant to pod borer and fusarium wilt are not yet available. In the present studies, one hundred and eighty four genotypes of chickpea were evaluated, during 2002-2003 at PAU, Regional Station, Faridkot, to find a donor for pod borer and wilt resistance, together.

The genotypes were sown in multiple disease sick plot with susceptible variety JG 62 as a check, in two replications. Each genotype has row length of 4 m and 30 cm apart with plant-to-plant spacing of 15 cm and recommended package of practices were followed. One hundred and eleven genotypes having less than 25% (moderately resistant reaction) combined score for wilt complex (wilt/foot rot/root rot complex) were selected for further entomological study. Pod borer infestation was recorded as percent bored pods of total pods at the end of harvesting. The data was subjected to analysis of variance to compare their relative performance (resistance) and the genotypes were categorized as per the method given by the All India Research Project on Soybean (1995) and used by Aditya Pratap et al. (2002) for chickpea.

The results on pod borer infestation are given in the Table 1. There was a large variation (30.87-70.65%) in pod damage among all the entries screened. Pod damage was highest in PBG 126 (70.65%) and lowest in IPC 96-3 (30.87%). Out of the 111 genotypes, 64 showed very high insect infestation and fell under lowly resistant group with infestation range of 52.15-70.65%. Forty-five genotypes were moderately resistant with infestation range of 34.05-51.65%. Only two genotypes IPC 96-3 and FG 1235 with mean infestation of 30.85% and

Table 1. Reaction of different genotypes of chickpea according to percent pod borer infestation.

S.No.	Type of resistance	Name of varieties
1	R = Resistant	FG 1235, IPC - 96 - 3
2	MR = Moderately resistant	BG 1087, BG 1088, BG 1087, BG 1088, BG 1106, BGD 110, BGD 112, C53-104, CSJ 9807,FG 559, FG 711, FG 712, FG 908, FG 1044, FG 1100, FG 1121, FG 1184, FG 1186, FG 1204, FG 1206, FG 1212, FG 1221, FG 1222, FG 1228, FGK 848, FGK 1220, GL 1267, GL 20010, GL 940022, GLK 90079, GNG 469, GPF 2, H 82-2, IPC - 99 - 1 , IPC 99-4, IPC 2000-1, PBG 195, PBG 233, PG 95424, PG 97403, RSG 902, RSG 906, WCG-3, WCG 98-1
3	LR = Lowly resistant	BCP 1002, BG 1053, BG 1067, BG 1080, BG 1103, BG 1108, BGD 32, C 235, CL 99033, CSJ 195, CSJ 253, CSJ 8962, FG 694, FG 702, FG 897, FG 974, FG 1056, FG 1197, FG 1205, FG 1210, FG 1217, FG 1224, FG 1225, FG 1227, FG 1231, FG 1232, FG 1238, FG 1268, FG 1292, FGK 1085, FGK 1133, FGK 1141, FGK 1170, FGK 1199, FGK 1218, GCP 9516, GG 1267, GL 769, GL 20035, GL 20081, GL 98014, GL 99103, H 87-23, H 97-23, H- 97-47, H 98-155, IPC 95-2, IPC 97-1, IPC 97-7, IPC 98-2, IPC 99-38, JG 1100, PBG 126, PBG 161, PBG 168, PBG 204, PBGK 220, PDG 3, PDG 4, PG 96005, PG 97121, PG 97128, WCG 97-16, WCG 9737

30.95% were found to be disease resistant (with 2.6 and 4.2% disease incidence, respectively).

Out of 45 moderately pod borer resistant genotypes 16 were having less than 5% disease incidence and 29 were having more than 5% incidence of disease. The important varieties such as GPF 2 and GNG 469 also fall in moderately resistant group with mean infestation of 43.25 and 41.8%. The genotypes, ie, BG 189, BG 373, BGD 110, FG 559, FG 711, FG 712, FG 908, FG 1184, FG 1206, GLK 90079, GPF 2, PBG 195, PBG 233, RSG 902, RSG 906 and WCG 98-1, reflected promising reaction by having less than 5% disease incidence and moderate resistance to pod borer.

Aditya Pratap et al. (2002) while evaluating the chickpea against pod borer, also reported wide variation (29.33 to 63.44%) in pest infestation among the varieties.

The study revealed that genotypes IPC 96-3 and FG-1235 were resistant to both wilt complex and pod borer infestation and thus they can serve as potential donors for insect pests/disease resistance, in chickpea breeding.

References

Aditya Pratap, Daisy Basandrai, Mehta PK and **Ashwani K Basandrai. 2002**. Evaluation of chickpea *(Cicer arietinum* L.) against pod borer *(Helicoverpa armigera).* Indian J. Genet 62(2):131-134.

Kalia NR and **Dawa T. 1988.** Dwindling chickpea areas in Himachal Pradesh, International Chickpea Newsletter 19 : 8.

Singh KB, Malhotra RS, Halila M H , Knights EJ and **Verma M M . 1994**. Current status and future strategy in breeding chickpea for resistance to biotic and abiotic stress. Euphytica 73:137-149.

Pigeonpea

Genetics/Breeding/Biotechnology

Identification of Dwarf and Extra-early Mutant of Pigeonpea [*Cajanus cajan* (L.) Millsp.]

Ram Dhari and **RS Waldia** [Department of Plant Breeding (Pulses) Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 004, India]

Plant height and maturity contribute significantly for pigeonpea cultivation under different cropping systems. Among the various constraints for higher pigeonpea production and productivity, *Helicoverpa armigera* (gram pod borer) is a major constraint (Shanower et al. 1999). Farmers mainly rely on insecticides to manage this borer. Traditional pigeonpea genotypes are tall (3-4 meters) and farmers have serious practical problems to use insecticides to manage pod borer through spray operations. Dwarf (1 meter) and high-yielding pigeonpea types are then an obvious choice to control the menace of the pod borer. Moreover, the adoption of pigeonpea cultivation by farmers on a large scale should accommodate crop rotations. Extra-short-duration pigeonpea genotypes could contribute to higher productivity of pigeonpea-wheat rotation system (Dahiya et al. 2002). Even the existing pigeonpea short duration (140-150 days) types have been observed to delay the normal sowings of wheat crop.

Table 1. Distinguishing characters of the dwarf mutant (HDM 04-1) and the parental line (ICPL 88039).

Characters	HDM 04-1	ICPL 88039
Days to 50% flowering	49±4.50	90 + 5.90
Days to maturity	90+5.50	135 + 6.20
Plant height (cm)	103.20 + 10.20	271 + 11.32
Fruiting branches/plant	9.10 + 3.21	12 + 2.96
Internode length (cm)	3.40 + 0.70	5.00 + 0.35
Pods/plant	102.80 + 37.11	132 + 25.48
Pod length (cm)	3.97 + 0.26	5.00 + 0.35
Seeds/pod	3.70 + 0.45	4.1 + 0.70
100 Seed weight (g)	8.84 + 0.80	8.17 + 0.75

To solve such problems, efforts were made to identify dwarf and extra-early genotypes through induced mutations. Besides dwarfness and earlyness, such genotypes should possess comparable yield levels to commercial types. Pigeonpea genotypes ICPL 88039 and 'Manak' were used for gamma rays irradiations. Five hundred, 1000 and 1500 dry, healthy and uniform seeds of each of the two genotypes were treated with 10,20 and 30 kR of gamma rays, respectively. The treated seeds were sown immediately in the field during rainy season 2001 to raise M_1 generation. In M_1 generation of ICPL 88039 population, one dwarf and extra-early mutant was obtained from 10 kR dose in ICPL 88039. The generation of this mutant was advanced to M_4 generations (2004) to obtain uniform progenies. The dwarf and extra-early M_4 progeny of this mutant is named as HDM 04-1 and evaluated along with ICPL 88039 in field conditions during rainy season 2004. Five rows of the parent and the mutant genotypes were sown in 4 meter rows 45 cm apart. The plant-to-plant distance was kept at 10 cm. All the recommended cultural practices for pigeonpea were followed. Data were recorded on 50 random plants of HDM 04-1 and ICPL 88039 for morphological characters, viz, days to 50% flowering, days to maturity, plant height (cm), fruiting branches/plant, internode length (cm), pods per plant, seeds/pod and 100-seed weight (g). The data representing mean of 50 plants is presented in Table 1. The mutant possess 103.20 cm height with shorter internodes compared to ICPL 88039 (271 cm). It matures in 90 days as compared to 135 days of parental genotype. Its seed weight (8.84 g/100 seeds) is also higher than ICPL 88039 (8.17 g/100 seeds). The commercial cultivars normally possesses 6.0-7.0 g/100 seeds. Its yield levels are at par with the ICPL 88039. However, yield level are yet to be confirmed through large-scale trials against checks and with varying spacings and fertility regimes.

References

Shanower TG, Romeis J and **Minja EM. 1999.** Insect pests of pigeonpea and their management. Annual Review of Entomology 44:77-96.

Dahiya SS, Chauhan YS, Johansen C, Waldia RS, Sekhon HS and **Nandal JK. 2002.** Extra-short-duration pigeonpea for diversifying wheat based cropping systems in the sub-tropics. Experimental Agriculure 38:1-11.

ICP 7035 - A Sterility Mosaic Resistant Vegetable and Grain Purpose Pigeonpea Variety

KT Rangaswamy[1], V Muniyappa[1], P Lava Kumar[2]*, KB Saxena[2], M Byregowda[1], N Raghavendra[1], K Pandurangaiah[1], R Vijay Kumar[2], F Waliyar[2] and **AT Jones[3]** (1. University of Agriculture Sciences, Bangalore 560 065, India; 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, India; 3. Scottish Crop Research Institute, Invergowrie DD2 5DA, Scotland, UK)
*Corresponding author: p.lavakumar@cgiar.org

Pigeonpea *(Cajanus cajan)* is an important pulse crop in Karnataka, India. Sterility mosaic disease (SMD), caused by the pigeonpea sterility mosaic virus (PPSMV) and transmitted by an eriophyid mite, *Aceria cajani,* is a major problem of pigeonpea (Jones et al. 2004). Pigeonpea yields have been declining due to heavy and recurring occurrence of the SMD in southern Karnataka. Most of the pigeonpea genotypes available for farmers are highly susceptible to the SMD. This was more so because of the PPSMV isolate prevalent in southern Karnataka-the Bangalore (B) isolate-is highly virulent and host-plant resistance to it are scarce. ICP 7035, a landrace collected in 1973 from Bedaghat (near Jabalpur) Madhya Pradesh state, India (Sharma and Reddy, unpublished), was found to be consistently resistant to PPSMV-B isolate. ICP 7035 was evaluated against ten PPSMV isolates at several locations in India, and the genotype was found resistant to all these isolates (Reddy et al. 1993; Kumar et al., unpublished).

ICP 7035 was evaluated, along with the two local varieties, TTB7 and Hy3C, in SMD and wilt nursery at

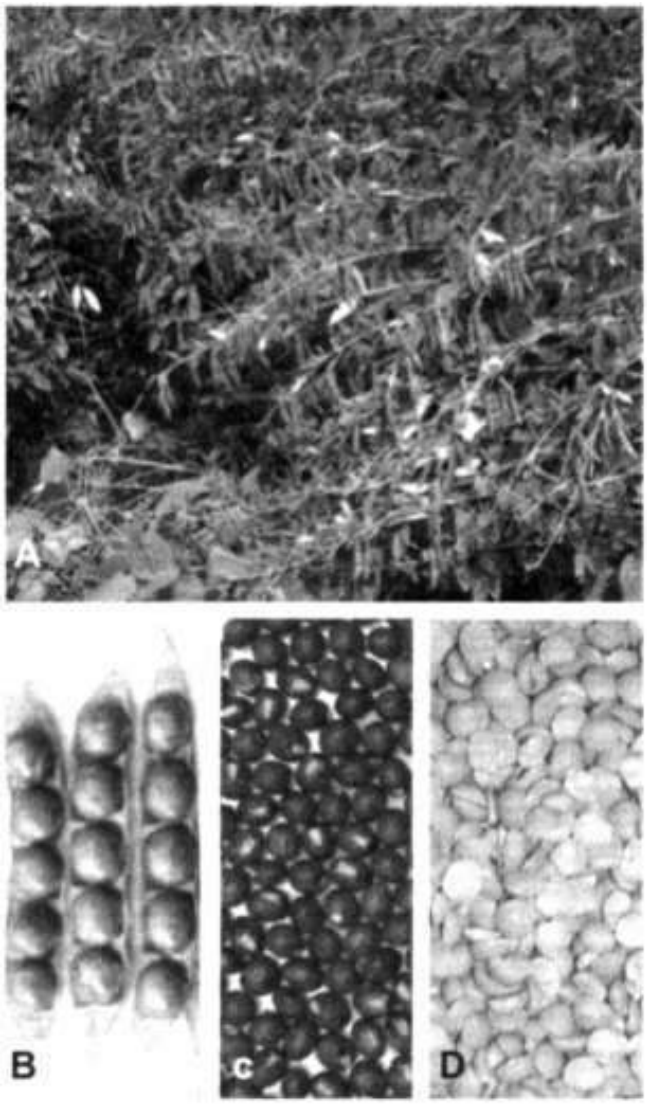


Figure 1. ICP 7035: Pod bearing plant (A), vegetable pods (B), dried whole seed (C) and dried decorticated split seeds - *dhal* (D).

Table 1. Green pod and grain yield of three pigeonpea genotypes at Bangalore.

	% SMD			Green pod yield (kg ha^{-1})[1]			Grain yield (kg ha^{-1})[1]		
Year	ICP7035	Hy3C	TTB7	ICP7035	Hy3C	TTB7	ICP7035	Hy 3C	TTB7
1999	0	15.5	60.5	5085	4521	1785	[illegible]	-	-
2000	0	11.0	82.0	3551	2958	101	-	-	-
2001	0	18.2	75.5	4268	3658	1210	1905	1825	2357
2002	0	23.0	90.3	6107	5189	521	1349	1312	1706
2003	0	<2.0	-	7153	7101	-	1824	1736	
Mean	0	16.93	77.08	5232.8	4685.4	904.25	1692.6	1624.3	2031.5

1. Green pod and grain yields are from separate trials
2. '-' not tested

the Gandhi Krishi Vignana Kendra (GKVK), Bangalore; and also under natural conditions in the State Agriculture Research Stations and farmers' fields in Bangalore Rural, Tumkur and Kolar districts of Karnataka, during 1999-2004 rainy seasons. ICP 7035 produced a mean vegetable pod yield of 5232.8 kg ha^{-1} and dry seed yield of 1692.6 kg ha^{-1} as compared to 4685.4 kg ha^{-1} mean vegetable pod yield and 1624.3 kg ha^{-1} of dry seed yield for Hy3C (Table 1). Average SMD incidence in susceptible cultivars ranged from less than 2.0 to 90.3% during various years, but ICP 7035 remained free from SMD (Table 1). Stability of SMD resistance in ICP 7035 was verified by exposing test plants to high dose of PPSMV-B inoculum using viruliferous *A. cajani* by following the

Table 2. Morphological, cooking and nutritional characters of three pigeonpea genotypes.

Character	ICP7035	Hy3C	TTB7
Plant characters			
Plant height (cm)[1]	160-180	160-170	160-180
Stem colour	Green	Purple	Green
Flower arrangement	Intermediate	Clusters	Clusters
Flower colour	Yellow purple	Red	Yellow
Pod colour	Purple with dark green streaks	Green with black streaks	Green with black streaks
Seed coat colour (fresh)	Light purple and mottled	Light green and plain	Light green and plain
Seed colour (fresh)	Plain green	Plain green	Plain green
Seed coat colour (dry)	Brown and mottled	Dull white	Brown
Seed (dhal) colour (dry)	Yellow	Dull white	Yellow
Days to 50% flowering	75-80[2]	80-90[2]	90-100[2]
Days to maturity	160-170[2]	170-180[2]	180-200[2]
Pods per plant[3]	90-110	70-80	90-110
Seeds per pod	5	4-5	4-5
Pod length (cm)	7.5	-[4]	
100 fresh seed weight (g)	39.6	20.5	17.21
100 dry seed weight (g)	19.2	16.1	10.5
100 fresh pod weight (g)	254.2	-	79.63
Post harvest qualities of dried seed[5]			
Good quality split seed (dhal) (%)	85.8	86.47	85.53
Broken split seeds (%)	1.72	0.78	2.62
Recovery of husk (%)	14.52	14.74	13.54
Nutritional factors in dhal[6]			
Cooking time of vegetable seed (min)	35.62	35.25	35.33
Cooking time of dhal (min)	47.7	42.3	36.8
Water absorption (%)	102.06	104.12	102.54
Solids in the aqueous extract (%)	10.63	12.21	11.46
Moisture (%)	11	10.8	8.1
Protein in dried seeds (%)	19.6	22.14	23.6
Soluble sugars (%)	5.3	3.7	-
Fat (%)	2.4	2.3	-
Methionine (mg g^{-1} of seed)	1.99	2.07	-
Methionine (mg g^{-1} of protein)	8.82	9.35	-
Cystine (mg g^{-1} of seed)	1.80	1.87	-
Cystine (mg g^{-1} of protein)	7.98	8.45	-

1. At the time of pod maturity (around 170 days; plant can grow up to 2 m).
2. In Bangalore region.
3. First pod picking at maturity (around 170 days).
4. '-' Not tested.
5. Determined with mechanical 'dhal' mill.
6. Estimated at Pristine Laboratories, Bangalore.

leaf-stapling technique. Plants were monitored for PPSMV by ELISA method as described in Kumar et al. (2002). All inoculated plants remained symptom free and tested negative to PPSMV, and no vector multiplication observed on these plants. To determine whether the observed resistance was against virus and/or due to vector non-preference, the genotype was tested by petiole graft inoculation as described in Kumar et al. (2002). All graft-inoculated ICP 7035 remained uninfected, indicating that plants were resistant to the virus. ICP 7035 was also evaluated for fusarium wilt and alternaria blight resistance at GKVK, Bangalore. The genotype showed moderate resistance to both these fungal diseases (<10% incidence), whereas TTB-7 is highly susceptible to wilt and blight, and Hy3C is moderately resistant to wilt (<10% incidence), but it was not tested against blight. Up to 35.7% *H. armigera* incidence was observed on ICP 7035, whereas on TTB7 and Hy3C, it was 55.3% and 28.75%, respectively.

ICP 7035 is a medium duration, non-determinate variety. Plants mature in 170-200 days (in south-central regions of India) and at this stage it reaches to an average height of 120-140 cm (Fig 1). Each plant produced around 100 pods and each pod contained 5 seeds, which are nutritionally rich and contain highest percent of digestible carbohydrates, vitamins and micronutrients (Table 2). Fresh seeds are large (9-11 mm diameter) with purple seed coat and green cotyledons, and suitable for consumption as vegetable (Table 2). Fresh seed contains 8.6% protein, 12% fibre and 45.7% carbohydrate and starch. The pinkish-purple colour of pod and seed coats was due to high anthocyanin content, which adds to health benefits as dietary antioxidants. In addition, sweetness of the pigeonpea seed is a preferred trait for vegetable purpose. While normal sugar levels in most pigeonpea varieties is about 5%, sugar content in ICP 7035 seeds is 8.8% (Paris et al. 1987). Decorticated dried split seeds measures 5-6 mm in diameter and 100 dried seeds weigh 19.2 g (Table 2). It contains 19.6% protein, 27.4% dietary fibre, 33% starch, and 67% carbohydrate. It is also rich in copper, calcium, magnesium, phosphorous, and has good dhal making quality.

SMD resistance in ICP 7035 has positive impact on yield as a result of negligible crop loss in endemic areas contributing to the revenue gains to the farmers at no additional cost. Under no disease situation, the crop yields are on par with the local varieties. ICP 7035 does not alter input requirements from existing practice. Cultivation of ICP 7035 prevents buildup of SMD inoculum during the cropping and off-season and controls the disease spread in the fields. Recently, provisional approval was given for the release of this variety in SMD endemic areas of southern Karnataka.

Acknowledgment. This document is an output from a project funded by the Crop Protection Program, Department for International Development (DFID), United Kingdom (Project No. R8205). The views expressed are not necessarily those of DFID.

References

Faris DG, Saxena KB, Mazumdar S and **Singh U. 1987.** Vegetable pigeonpea: a promising crop for India. Patancheru, Andhra Pradesh, 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 13 pp.

Jones AT, Kumar PL, Saxena KB, Kulkarni NK, Muniyappa V and **Waliyar F. 2004.** Sterility mosaic disease - the "green plague" of pigeonpea: advances in understanding the etiology, transmission and control of a major virus disease. Plant Disease 88:436-445.

Kumar PL, Jones AT and **Reddy DVR. 2002.** Pigeonpea sterility mosaic virus: detection and screening for resistance. Methods manual. ICRISAT, Patancheru 502 324, India, 65 pp.

Reddy MV, Raju TN, Nene YL, Ghanekar AM, Amin KS, Arjunan G, Astaputre JV, Sinha BK, Reddy SV, Gupta RP and **Gangadharan K. 1993.** Variability in sterility mosaic pathogen in pigeonpea in India. Indian Phytopathology. 46:206-212.

Effect of Improved Crop Production Technology on Pigeonpea Yield in Resource Poor Rainfed Areas

A Ramakrishna[1,*], SP Wani[1], Ch Srinivasa Rao[1] and **U Srinivas Reddy[2]** (1. Global Theme-Agroecosystems, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; 2. Assistant Project Director-Engineering (APD-Eng.), Nandyal, Kurnool, Andhra Pradesh, India)
*Corresponding author: a.ramakrishna@global.net.pg

Pigeonpea *(Cajanus cajan* (L.) Millspaugh) is a deep-rooted and drought-tolerant (Troedson et al. 1990) leguminous food crop used in several countries particularly in India as a source of dietary protein. India accounts for about 80% of the total world pigeonpea production. It is one of the principal dryland crops in Andhra Pradesh with a very low productivity (450 kg ha^{-1}). The production is constrained by the use of less productive land, water logging or dry spells during critical stages of crop growth, pest and disease problems, and lack of drought-resistant, high-yielding genotypes, and appropriate agronomic management.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Government of Andhra Pradesh have initiated the Andhra Pradesh Rural Livelihoods Project (APRLP) in the drought prone districts of Andhra Pradesh state of India, viz, Kurnool, Mahabubnagar, Nalgonda, Anantpur and Prakasam, to help reduce poverty by increased agricultural productivity and improved livelihood opportunities through technical backstopping and convergence through a consortium of institutions. Watersheds are used as an entry point for these activities.

Nandavaram village of Banaganapalle mandal in Kurnool district was selected as a representative watershed site based on the extent of rainfed area in the district, current crop productivity, and willingness of the community to participate in the on-farm research activities. Systematically collected soil samples from thirty farmers' fields in the Nandavaram watershed on a toposequence were analyzed for physical and biological parameters and various nutrients. The soil analysis indicated that all the fields are low in N (496 mg kg^{-1} soil), low to medium in available P (5.71 mg kg^{-1} soil) (Olsen's P), high in exchangeable K (223 mg kg^{-1} soil), and low in available Zn (0.39 mg kg^{-1} soil), S (7.52 mg kg^{-1} soil) and B (0.5 mg kg^{-1} soil). The information from soil analysis along with historical rainfall, and minimum and maximum temperature data enabled to calculate the length of growing period (LGP). This critical information assisted in identifying better options for pigeonpea cultivation to improve the productivity levels and for sustaining the natural resources.

Twelve on-farm trials were conducted during the 2002/03 rainy season with the objective to demonstrate the effect of improved production technologies over farmers' practice. Improved production technology was compared with the farmers' method in an area of 1000 m^2 in each of the farmers' fields. The improved technology package included medium duration high-yielding variety (ICPL 87119) resistant to fusarium wilt and sterility mosaic diseases; a seed rate of 12 kg ha^{-1}; seed treatment with thiram (3 g kg^{-1} seed); inoculation with *rhizobium;* a fertilizer dose of 20 kg N and 50 kg P_2O_5 ha^{-1}; basal application of micro-nutrient mixture of 5 kg borax (0.5 kg B ha^{-1}), 50 kg zinc sulphate (10 kg Zn ha^{-1}) and 200 kg gypsum (30 kg S ha^{-1}) per hectare together with

Table 1. Yield and economics of pigeonpea in on-farm trials (average of 12 trials), Nandavaram nucleus watershed, Kurnool district, Andhra Pradesh, rainy season 2002.

Cultivation method	Grain yield (t ha^{-1})	Stalk yield (t ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit cost ratio
Improved production technology	1.61	2.93	6838 (US$152)	16476 (US$366)	2.4
Farmers' practice	0.53	1.10	4260 (US$95)	3437 (US$76)	0.8
SE±	0.096	0.202	14.2	1393.8	
CV%	31.2	34.7	0.9	48.5	
LSD (5%)	0.30	0.63	44.3	4338.3	

Table 2. Yield components of pigeonpea in on-farm trials (average of 12 trials), Nandavaram nucleus watershed, Kurnool district, Andhra Pradesh, rainy season 2002.

Cultivation method	Total dry matter (t ha^{-1})	Pod weight (tha^{-1})	Shelling (%)	100 grain weight (g)	Harvest index
Improved production technology	5.26	2.33	69.1	10.3	0.31
Farmers' practice	1.92	0.82	65.6	9.0	0.28
SE±	0.321	0.132	0.93	0.31	0.009
CV%	31.0	29.0	4.8	11.1	10.3
LSD (5%)	1.00	0.41	2.89	0.96	0.027

appropriate need-based pest and disease control measures. Two inter-cultivations at 25 and 50 days after sowing to control weeds were taken up. One insecticide spray was given at pod formation stage to control pod borers. The farmers' method included a seed rate of 10 kg ha^{-1} and a fertilizer dose of 12 kg N and 30 kg P_2O_5 ha^{-1}. Entire dose of N and P was applied as basal. The seasonal rainfall was 695 mm. The data was analyzed considering farmers as replications using analysis of variance (ANOVA) with randomized blocks on GENSTAT. ANOVA indicated that management practices (improved crop production technology and farmers practice) differed significantly for all the parameters presented in Tables 1 and 2.

The improved production technologies gave higher yields and recorded a mean grain yield of 1.61 t ha^{-1} which was 204% higher than that obtained with the farmers' practice yields of 0.53 t ha^{-1} (Table 1). In addition to increased grain yields, improved technology also resulted in higher stalk yield of 2.93 t ha^{-1} compared to 1.10 t ha^{-1} of farmers' practice. The increased grain and stalk yields with improved production practice were mainly because of increased total dry matter, increased pod weight, higher shelling percentage, higher 100-grain weight and harvest index (Table 2). Yield increase in response to recommended fertilizers and rhizobium inoculation were also reported by Jain et al. (1988).

The economic viability of improved technology over the farmers' practice was calculated depending on prevailing prices of inputs and outputs. The additional cost of US$57 ha^{-1} (Table1) incurred due to the improved technology as compared to farmers' practice was mainly due to balanced fertilization (micro-nutrients and additional N and P), additional seed cost, seed treatment, 1PM and one additional inter-cultivation. However, the improved technology resulted in an increased mean income of US$290 with a cost-benefit ratio of 2.4 (Table1). This additional income could substantially benefit the resource poor farmers and improve their livelihoods in the dry regions of the district. Puste and Jana (1995) reported that the yield attributes and seed yield of pigeonpea varieties were significantly influenced by phosphorus and zinc application with a maximum benefit-cost ratio of 4.12. Yadav et al. (1997) reported that with the application of 100% recommended fertilizer, sole pigeonpea gave a grain yield of 2.12 tha^{-1} with net returns of Rs 12,491 per hectare and a benefit-cost ratio of 2.94. The results from the current study indicate the potential benefits of improved production technology in enhancing pigeonpea yields and net returns in the dry regions of Andhra Pradesh.

Acknowledgments. We gratefully acknowledge the Andhra Pradesh Rural Livelihoods Project (APRLP)/DFID for financial assistance and all the farmers for their overwhelming support in conducting the trials.

References

Jain NK, Jain HC and **Khandkar UR. 1988.** Response of kharif legumes to fertilizers and rhizobium inoculation. Indian Journal of Agronomy 33:347-350.

Puste AM and **Jana PK. 1995.** Effect of phosphorus and zinc on the yield attributes and yield of pigeonpea varieties grown during winter season. Madras Agricultural Journal 82:348 - 351.

Troedson RJ, Wallis ES and **Laxman Singh. 1990.** Pigeonpea: Adaptation. Pages 159-177 *in* The pigeonpea (Nene YL, Susan D Hall and Sheila VK, eds.). Wallingford, UK: CAB International.

Yadav RP, Sharma RK and **Shrivastava UK. 1997.** Fertility management in pigeonpea based intercropping system under rainfed conditions. Indian Journal of Agronomy 42:46-49.

Occurrence of *Urentius hystricellus* (Richt.) on Pigeonpea in the Net-House

SC Dhawan*, RD Gautam and **JN Govil** (Indian Agricultural Research Institute (IARI), New Delhi 110 012, India)
Corresponding author: Sdhawan2003@yahoo.co.in

The lace bug *Urentius hystricellus* (Richt.) (*U. echinus* Distant) (Tingidae: Hemiptera) was first reported occurring on the eggplant, *Solanum melongena* Linnaeus, in different parts of India by Fletcher (1914). Since then, it has been reported from time to time as a specific pest of eggplant (Pillai 1921; Jepson 1924; Patel and Kulkarni 1955), with a degree of varietal preference in India. Recently, Chaudhury et al. (2001) recorded its presence on tomato crop in the tarai region of West Bengal. Besides India, it has also been reported from Ghana (Frempong and Buahin 1977) and Thailand (Tigvattn 1990). Nymphs and the adults of the lace bug suck sap from lower surface of leaves causing its yellowing and can be seen congregating. Affected leaves are covered with exuviae and excreta.

A total of 15 genotypes of pigeonpea, *Cajanus cajan* (L.) Millsp., viz., Pusa-33,991,992,2001,2001-1,2002-1, 2002-2, 2003-2, 2004-1, 2004-2, AK 2000-3 N 3, AK 2000-60 N 85, H 89-9x 85024 1 DT SP 2, MS Pusa 33x H 88-45, and RG 02-47 N were potted in the net-house, Division of Nematology, Indian Agricultural Research Institute, New Delhi 12, on 22 June 2004. After one month of sowing, 50-60 percent leaves of all the plants were infested with *U. hystricellus*, irrespective of genotypes. Observations revealed that pigeonpea is a new host record.

The lace bug infestation was also observed on another unrecorded host *(Abutilon theophrastii)*, which is a weed of the wet season. It can be inferred that, although this insect spp is known to inflict injuries mainly to the eggplant, its spread on the other plant species in the vicinity cannot be ignored. Hence, the cultivation of eggplant away from the pigeonpea crop is suggested. With regards to curative measures against the infested plants, further studies indicated that spray application of karate 2.5 EC (lambda cyhalothrinI)@1mL/2L water provided satisfactory protection with in a week's time.

References

Chaudhury N, Deb DC and **Senapati SK. 2001.** Assessment of loss in yield caused by pest complex of tomato under tarai region of West Bengal. Research on Crops 2:71-79.

Fletcher TB. 1914. Some south Indian insects and other animals of importance. Madras, India: Superintendent Government Press. 565 pp.

Frempong E and **Buahin GKA. 1977.** Studies on the insect pests of eggplant *Solanum melongena* L. in Ghana. Bulletin de-1 Institut Fondamental d'Afrique Norie-Serie A. 39:627-641.

Jepson M. 1924. Pests of brinjal. Pages 132-147 *in* Report of Director, Agriculture, Ceylon.

Patel KC and Kulkarni HL. 1955. Bionomics of *Urentius echinus.* Journal of Bombay Natural History Society 53:86-96.

Pillai RN. 1921. Short notes on insect pests of Travancore. Travancore Department of Agriculture, Trivendrum. 53 pp.

Tigvattn Anont S. 1990. Studies on the bionics and local distribution of some lace bugs in Thailand. III. *Urentius echinus* Distant (Hemiptera: Tingidae). Keen Kaset Khon Kaen Agriculture Journal 18:251-260.

Response of Resistant Germplasm to Different Races/Populations of Pigeonpea Cyst Nematode, *Heterodera cajani*

Satish Kumar Mehta and **Harish K Bajaj***
(Department of Nematology, CCS Haryana Agricultural University, Hisarl25 004, Haryana, India)
* Corresponding author: harish_bajaj@hau.ernet.in

The existence of races (race A pigeonpea race and race B clusterbean race) in *Heterodera cajani* Koshy 1967, an important plant parasitic nematode of leguminous crops, has been reported by Walia and Bajaj (1986, 1988). Source of resistance against an unspecified population of *H. cajani* in *Cajanus platycarpus* accessions lCPW 543, ICPW 544 and ICPW 545 (Elyas and Sharma 1997) and against Coimbatore population of *H. cajani* have been reported in *Phaseolus radiatus* L. cv TM 96-1 (Anon. 1998). Reaction of several populations of this species collected from different parts of India and belonging to two races against these resistant sources and also against *Glycine max* is discussed here under.

Table 1. Reaction *of Cajan us platycarpus* accessions to different races of pigeonpea cyst nematode, *Heterodera cajani.*

	Number					
	Race A			Race B		
Accessions	White (Female)	J_2	Male	White (Female)	J_2	Male
ICPW 543	0	0	0	6.0	5.0	1.3
ICPW 544	0	0	0	33.0	14.0	7.0
ICPW 545	0	0	0	8.0	3.7	2.3
Pigeonpea cv Manak (Control)	72.0	14.0	18.0	103.3	26.7	17.3
CD (P=0.05)	-	-	-	0.58	0.68	0.60

(Data are means of three replications)

Populations of *H. cajani* race A and race B collected/ procured from various parts of India (Table1) and their pure cultures were maintained in isolation on their respective hosts under screenhouse conditions at the Department of Nematology, CCS Haryana Agricultural University, Hisar. The egg sacs of different races/ populations were incubated at room temperature (30 ±2°C) separately for collecting second stage juveniles of this species, when needed.

Seeds of C. *platycarpus* accessions ICPW 543, ICPW 544 and ICPW 545, and mung bean cv TM 96-1, and germplasm lines of soybean were procured from the International Crops Research Institute for the Semi-Arid Tropics (lCRISAT), Hyderabad; the Indian Institute of Pulses Research (Kanpur), and CCS Haryana Agricultural University (Hisar), respectively. They were sown singly in 15 cm earthen pots of autoclaved sandy loam soil. Seeds of *C. platycarpus* accessions were, however, mechanically scarified before sowing. After 3 days of germination of seedlings, pots containing different plant species were inoculated @ 200 freshly hatched second stage juveniles/pot in the following manner:

1. *Cajanus platycarpus* accessions: Second stage juveniles of race A and race B
2. Mung bean cv TM 96-1 and soybean cv PK. 564: Second stage juveniles of various populations (Table 2).
3. *Glycine max* germplasm lines: Second stage juveniles of race A and race B.

The plants were depotted after 50 days of inoculation and the soil was processed for white females, juveniles and males. Each treatment was replicated thrice.

Heterodera cajani race A failed to multiply on all the three accessions as reported by Elyas and Sharma (1997). However, race B reproduced on all the three accession lines though with different rate of multiplication (Table 2). Among these accessions multiplication of this race was significantly higher in ICPW 544 than ICPW 545 and ICPW 543. From the above studies it becomes clear that same cultivars show different reaction to different populations/races of *H. cajani* and therefore, one should be cautious while incorporating the resistance in the cultivars. Walia and Bajaj (1986, 1988) differentiated races of *H. cajani* on the basis of their reproduction on clusterbean and sun hemp. ICPW 544 can also be included as a differential host for discriminating races of *H. cajani.* Since race A failed to multiply on C. *platycarpus* accessions and race B multiplication was higher in ICPW 544.

All the populations belonging to race A as well as race B reproduced on *Phaseolus radiatus* L. cv TM 96-1 but with different rates of multiplication. Dharwar, Coimbatore, Ludhiana and Yamunanagar populations belonging to race A reproduced very less (1-10 cysts/ pot) and were statistically at par among each other and hence this cultivar can be designated as resistant to these populations. These results are in agreement with earlier findings (Anon. 1998). Multiplication of rest of the populations was moderate to high. Multiplication of Anand (Gujarat), Jaipur (Rajasthan) and Pusa (Bihar) was moderate in reproduction on TM 96-1 (11.60 cysts/ pot) and statistically at par. Multiplication of clusterbean, Hisar (Haryana), belonging to race B was moderate (60 cysts/pot) but differed significantly from the rest of the populations. Reproduction of New Delhi (Delhi), Pigeonpea, Hisar (Haryana) and Kanpur (U.P.) populations was maximum (>100 cysts/pot) and hence

Table 2. Reaction of *Glycine max* cv PK 564 and *Phaseolus radiatus* cv TM 96-1 to different populations *of H. cajani*

	Number					
	White (Female)	J_2	Male	White (Female)	J_2	Male
Populations	cv PK 564			cv TM 96-1		
Race A						
Anand (Gujarat)	0	0	0	30.0	9.3	2.0
Coimbatore (Tamil Nadu)	0	0	0	8.3	2.0	1.0
Dharwar (Karnatka)	0	0	0	10.0	3.0	3.0
Hisar, Pigeonpea (Haryana)	0	0	0	102.0	27.7	14.0
Jaipur (Rajasthan)	0	0	0	30.0	11.7	4.0
Kanpur (U.P.)	0	0	0	117.7	27.3	8.0
Ludhiana (Punjab)	0	0	0	9.0	4.7	2.0
New Delhi (Delhi)	0	0	0	118.7	24.0	10.0
Pusa (Bihar)	0	0	0	32.3	8.3	3.0
Yamunanagar (Haryana)	0	0	0	7.0	5.0	2.0
Race B						
Hisar, Clusterbean (Haryana)	0	0	0	60.0	17.3	7.0
C.D. (P = 0.05)	-	-		12.6	6.3	0.3

(Data are means of three replications)

mung bean cv TM 96-1 can be categorized as susceptible to these populations. Mung bean (TM 96-1) responds differently to different populations of *H. cajani* and therefore, it is essential to test the virulence of a particular population before using it as a source of resistance for incorporation.

No multiplication of any population of *H, cajani* was found in soybean cv PK 564 (Table 2). Also representative populations of both races of *H. cajani* failed to multiply on all the tested germplasm (AVT 1 PK 416, AVT 1 Pusa 16, MLT PK 416, MLT PK 471, MLT PK 472, SST 1 PB 1, SST 1 PK 472, SST 1 PS 1024). Koshy and Swarup (1973) found a very less reproduction of *H. cajani* on soybean cv Glycine 24, but no multiplication on cvs. Lee, Roanoke and IC 9620. From the above studies it can be speculated that soybean is either a no host or a very poor host for *H. cajani* unlike *H. glycines* Ichinohe, 1952.

References

Anonymous. 1998. Consolidated report mung bean and urdbean (1997), All India Co-ordinated Research Project Improvement of MULLaRP, Annual Group Meet held at Orissa University of Agriculture and Technology, Bhubaneshwar (Orissa) on 15-17 May, 1998.

Elyas Z and **Sharma SB. 1997.** Mechanism of resistance to *Heterodera cajani* in *Cajanus platycarpus* accessions. International Journal of Nematology 7(2): 119-121.

Koshy PK and **Swarup G. 1973.** Susceptibility of plants to pigeonpea cyst nematode, *Heterodera cajani.* Indian Journal of Nematology 2:1-6.

Walia RK and **Bajaj HK. 1986.** Existence of host races of pigeonpea cyst nematode, *Heterodera cajani,* Koshy. Nematologica 32:117-119.

Walia RK and **Bajaj HK. 1988.** Further studies on the races in pigeonpea cyst nematode, *H. cajani.* Indian Journal of Nematology 18:269-272.

Biological Activity of Lectins from Grain Legumes and Garlic against the Legume Pod Borer, *Helicoverpa armigera*

Richa Arora, HC Sharma*, E Van Dreissche[1] and **KK Sharma** (ICRISAT, Patancheru 502 324, Andhra Pradesh, India; 1. Vrije Universiteit, Paardanstraat 65, B-1640 Sint-Genesius-Rode, Belgium)
*****Corresponding author: h.sharma@cgiar.org

Cotton bollworm/legurae pod borer, *Helicoverpa armigera* (Hubner), is one of the most devastating crop pests worldwide (Sharma 2001). It has a wide host range, and feeds on more than 300 plant species. Due to indiscriminate use of insecticides, it has developed high levels of resistance to conventional insecticides (Kranthi et al. 2002). Therefore, it is important to develop alternative methods of controlling this pest, including host plant resistance. However, the levels of resistance to *H. armigera* in the cultivated germplasm of several crops are low to moderate. Therefore, improving plant resistance to pests through genetic transformation, has raised hopes of using plant resistance as an effective weapon for pest management (Sharma et al. 2004). This includes incorporation of novel genes such as crystal protein from *Bacillus thuringiensis* (Bt-Cry genes), enzyme inhibitors (such as protease and alpha amylase inhibitors), vegetative insecticidal proteins (VIPs), small RNA viruses (SRVs), and secondary plant metabolites (SPMs). While the activity of Bt-Cry proteins has been investigated extensively, there is very little information on the biological activity of other insecticidal genes that can be used to confer resistance to insects in transgenic plants (Hilder and Boulter 1999). Therefore, we evaluated the biological activity of plant lectins as candidate genes for conferring resistance to *H. armigera.*

Lectins are carbohydrate-binding proteins (or glycoproteins) of non-immune nature, and bind reversibly to specific mono- or oligo-saccharides (Goldstein et al. 1980, Van Damme et al. 1998). They play an important role in the plant's defense against insect pests, and have been found to be toxic to viruses, bacteria, fungi, insects and higher animals. This paper reports the biological effects of plant lectins from field bean *(Phaseolus vulgaris),* pigeonpea *(Cajanus cajan),* chickpea *(Cicer arietinum),* and garlic (*Allium sativum)* along with snowdrop *(Galanthus nivalis)* lectin on the growth and development of *H, armigera* so as to identify the candidate genes for deployment through transgenic plants to control this pest.

Lectins extracted from chickpea, pigeonpea, garlic (garlic lectin I = from garlic leaves; garlic lectin II = from transgenic tobacco) and field bean were bio-assayed along with snowdrop lectin against the neonate larvae of *H. armigera.* The lectins were bio-assayed against the neonate larvae of H, *armigera* by treating the surface of the artificial diet (Armes et al. 1992) in a glass vial (2 cm diameter and 3.5 cm height) with 100 ml of different lectins. Each glass vial contained 5 ml diet. The lectin solutions were prepared in phosphate buffer (pH 6.8, molarity 0.2 M). The buffer was prepared by mixing 51.0 ml of A [0.2 M solution of mono-basic sodium phosphate (27.8 g in 1000 ml)] and 49.0 ml of B [0.2 M solution of dibasic sodium phosphate (53.65 g of $Na_2HPO_4.7H_2O$ or 71.7 g of $Na_2HPO_4.12H_2O$ in 1000 ml)] diluted to a total of 200 ml with distilled water. Lectins dissolved in phosphate buffer were spread uniformly over the diet surface with a micropipette, and allowed to dry under the table fan in the laboratory for 4 h. One neonate larva was released in each vial and observations were recorded on weight of the larvae five days after initiating the experiment, and larval, pupal, and total development period. Each treatment was replicated three times in a completely randomized design. There were 10 larvae in each treatment. Observations on larval weights were recorded 5 days later, while pupal weights were recorded one day after pupation. Data were also recorded on adult emergence. The data were subjected to analysis of variance.

The weights of the larvae at 5 days after initiating the experiment ranged from 16.54 mg on the artificial diet with buffer to 26.90 mg in diet treated with field bean lectin as compared to 22.68 mg in the untreated control diet (Table1). However, the differences in larval weights in diets with different lectins were not significant. The larval weights were also quite low in the diet treated with phosphate buffer only. This may be because of some effects of the buffer on the pH of artificial diet. However, no adverse effects of the buffer were observed on larval and pupal periods and the pupal weights. The weight of the pupae reared on diet containing garlic lectin II (from transgenic tobacco) was significantly lower (283.81 mg per larva) as compared to those fed on untreated control diet (325.00 mg per larva). None of the lectins tested showed any adverse effect on larval period. Pupal period of the insects reared on diet containing lectins from field bean, pigeonpea, chickpea and garlic, was significantly

Table 1. Bio-efficacy of lectins extracted from grain legumes and garlic on survival and development of legume pod borer, *Helicoverpa armigera* (ICRISAT Patancheru 2002).

Treatment	Dosage (mg per cm²)	Larval weight (mg) (5 DAI)	Pupal weight (mg)	Larval period (days)	Pupal period (days)	Pupation (%)	Adult emergence (%)	Sex ratio (females:males)
Untreated control diet	–	22.68	325.00	14.101	15.633	76.67	46.67	1:1.18
Artificial diet with buffer	–	16.54	317.16	14.500	12.500	73.33	43.33	1:0.86
Field bean lectin	0.032	26.90	305.66	14.258	12.194	66.67	36.67	1:0.34
Pigeonpea lectin	0.032	22.02	312.00	14.222	11.917	60.00	33.33	1:0.56
Chickpea lectin (1.72 mg/ml)	0.032	22.65	306.20	14.333	11.711	80.00	43.33	1:1.56
Chickpea lectin (in 60% $(NH_4)_2SO_4$)	0.032	22.25	304.29	14.222	11.983	60.00	36.67	1:0.75
Chickpea lectin (6 mg/ml)	0.032	24.48	315.46	14.073	11.744	66.67	40.00	1:1.26
Garlic lectin I (from garlic)	0.032	20.95	297.09	14.458	12.056	56.67	33.33	1:1.05
Garlic lectin II (from transgenic tobacco)	0.032	22.83	283.81	14.535	12.622	60.00	33.33	1:1.14
Snowdrop lectin	0.032	24.12	308.57	14.151	12.322	70.00	40.00	1:1.44
Mean		22.54	307.52	14.29	12.38	67.00	38.67	–
SE		±2.311	±11.96	±0.318	±1.144	±6.55	46.95	–
LSD at 5%		6.87	35.55	NS	3.40	NS	NS	–

DAI = Days after initiating the experiment. NS = Non-significant.

shorter than those reared on the untreated control diet.

The differences in percentage pupation and adult emergence were not significant. However, less than 60% pupation was recorded in diets treated with lectins from pigeonpea, chickpea in 60% ammonium sulphate solution, garlic, and garlic lectin extracted from transgenic plants as compared to 76.67% in untreated artificial diet. Adult emergence ranged from 33.33% in diets treated with pigeonpea and garlic lectin to 46.67% in untreated control diet. The sex ratio (males:females) was affected adversely in diets treated with lectins from field bean and pigeonpea.

Anti-insect properties of the plant lectins have earlier been reported against European corn borer, *Ostrinia nubilalis* (Czapla and Lang 1990). The snowdrop lectin (GNA) has previously been shown to be toxic to Homoptera (Rahbe et al. 1995; Powell et al. 1995,1998), Lepidoptera (Fitches et al. 1997), and Coleoptera (Gatehouse et al. 1995; Elden 2000). Snowdrop lectin (2%) inhibited feeding and reduced the weight of spotted pod borer, *Maruca vitrata* larvae (Machuka et al. 1999) and tomato moth (*Lacanobia oleracea)* (Fitches et al. 1997). Such effects of GNA were not observed in the present studies, possibly because of low concentrations used in the present studies.

Lectins have been reported to affect the survival and development of insect pests (Janzen et al. 1976; Shukle and Murdock 1983; Czapla and Lang 1990; Habibi et al. 1993; Gatehouse et al. 1993, 1995; Powell et al. 1995; Law and Kfir 1997). They bind to the glycan receptors present on the surface lining of the insect gut (Pusztai and Bardocz 1996), and interfere with the formation and integrity of the peritrophic membrane of the midgut (Harper et al. 1998), but how that affects the digestive physiology is unknown. Larval weights were slightly greater in diets treated with GNA, chickpea lectin, and field bean lectin. Similar effects of soybean lectin have earlier been reported in case of *O. nubilalis* (Czapla and Lang 1990). Percentage pupation was low (<60%) in diets treated with pigeonpea lectin, chickpea lectin in 60% ammonium sulphate solution, and garlic lectin, while adult emergence was low in diets treated with pigeonpea and garlic lectin. The garlic lectin had an adverse effect of the larval and pupal weights of *H. armigera,* but not on the duration of larval and pupal development. The lectins from garlic and pigeonpea can possibly be deployed in transgenic plants in combination with Bt genes to increase the levels of plant resistance to *H. armigera.*

Acknowledgments. We thank S Narayanchandra and VV Rao for their help in carrying out these experiments, and Directorate General International Cooperation (DGIC), Belgium, for funding this research.

References

Armes NJ, Bond GS and **Cooter RJ. 1992.** The laboratory culture and development of *Helicoverpa armigera.* Natural Resources Institute, Bulletin No. 57. Chatham, UK: Natural Resources Institute.

Czapla TH and **Lang BA. 1990.** Effect of plant lectins on the larval development of European corn borer (Lepidoptera: Pyralidae) and southern corn rootworm (Coleoptera: Chrysomelidae). Journal of Economic Entomology 83:2480-2485.

Elden TC. 2000. Effects of proteinase inhibitors and plant lectins on the adult alfalfa beetle (Coleoptera:Curculionidae). Journal of Entomological Science 35(1):62—69.

Fitches E, Gatehouse AMR and **Gatehouse JA. 1997.** Effects of snowdrop lectins (GNA) delivered via artificial diet and in transgenic plants on the development of tomato moth (*Lacanobia oleracea*) larvae in laboratory and glasshouse trials. Journal of Insect Physiology 43:727-739.

Gatehouse AMR, Hilder VA and **Gatehouse JA. 1993.** Antimetabolic effects of plant lectins and plant and fungal enzymes on the nymphal stages of two important rice pests, *Nilaparvata lugens* and *Nephotettix cinciteps.* Entomologia Experimentalis et Applicata 66:119-126.

Gatehouse AMR, Powell KS, Van Damme EJM and **Gatehouse JA. 1995.** Insecticidal properties of plant lectins. *In* Lectins - Biomedical Perspectives (Pusztai A and Bardocz S, eds.). London, UK: Taylor and Francis.

Goldstein IJ, Hughes RC, Monsigny M, Osawa T and **Sharon N. 1980.** What should be called a lectin? Nature 285:66.

Habibi J, Backus EA and **Czapla TH. 1993.** Plant lectins affect survival of the potato leafhopper (Homoptera: Cicadellidae). Journal of Economic Entomology 86:945-951.

Harper MS, Hopkins TL and **Czapla TH. 1998**. Effect of wheat germ agglutinin on formation and structure of the peritrophic membrane in European corn borer (*Ostenia nubilalis)* larvae. Tissue and Cell 30:166-176.

Hilder VA and **Boulter D. 1999.** Genetic engineering of crop plants for insect resistance: a critical review. Crop Protection 18:177-191.

Janzen DH, Juster HB and **Leiner IE. 1976.** Insecticidal action of the phytohemagglutinin in black beans on bruchid beetle. Science 192:795-796.

Kranthi KR, Jadhav DR, Kranthi S, Wanjari RR, Ali SS and **Russel DA. 2002.** Insecticide resistance in five major insect pests of cotton in India. Crop Protection 21: 449-460.

Law lJ and **Kfir R. 1997.** Effects of mannose-binding lectin from peanut and pea on the stem borer *Chilo partellus.* Entomologia Experimentalis et Applicata 82:261-265.

Machuka J, Van Damme EJM, Peumans WJ and **Jackal LEN. 1999.** Effects of plant lectins on the development of the legume pod borer, *Maruca vitrata.* Entomologia Experimentalis et Applicata 93:179-186.

Powell KS, Gatehouse AMR, Hilder VA, Van Damme EJM, Peumans WJ, Boonjawat J, Horsham K and **Gatehouse JA. 1995.** Different antimetabolic effects of related lectins towards nymphal stages of *Nilaparvata lugens.* Entomologia Experimentalis et Applicata 75:61-65.

Powell KS, Spence J, Bharathi M, Gatehouse JA and **Gatehouse AMR. 1998.** Immunohistochemical and developmental studies to elucidate the mechanism of action of the snowdrop lectin on the rice brown planthopper, *Nilaparvata lugens.* Entomologia Experimentalis et Applicata 44:529-539.

Pusztai A and **Bardocz S. 1996.** Biological effects of plant lectins on the gastrointestinal tract: metabolic consequences and applications. Trends in Glycoscience and Glycotechnology 8:149-165.

Rahbe Y, Sauvion N, Febvay G, Peumans WJ and **Gatehouse AMR. 1995.** Toxicity of lectins and processing of ingested proteins in the pea aphid, *Acrythosiphon pisum.* Entomologia Experimentalis et Applicata 76:143-155.

Sharma HC. 2001. Cotton bollworm/legume pod borer, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera). Biology and Management. Walingford, UK: Commonwealth Agricultural Bureau International.

Sharma HC, Sharma KK and **Crouch JH. 2004.** Genetic transformation of crop plants for insect resistance: Potential and limitations. Critical Reviews in Plant Sciences 23:47-72.

Shukle RH and **Murdock LL. 1983.** Lipoxygenase, trypsin inhibitor, and lectin from soybeans: Effects on larval growth of *Manduca sexta* (Lepidoptera: Sphingidae). Environmental Entomology 12:787-791.

Van Damme EJM, Peumans WJ, Pusztai A and **Bardocz S. 1998.** A handbook of plant lectins: Properties and biomedical applications. Chichester, UK: John Wiley and Sons.

Publications

SATCRIS Listing

The following 2004 listings and publications have been generated from ICRISAT's electronic bibliographic database SATCRIS - the Semi-Arid Tropical Crops Information Service. Copies of the following entries can be obtained by writing to:

Senior Manager
Library
ICRISAT
Patancheru 502 324, Andhra Pradesh, India
Email: s.srinivas@cgiar.org

Chickpea Publications

Aamil M, Zaidi A and **Khan MS. 2004.** Fungicidal impact on chickpea-mesorhizobium symbiosis. Journal of Environmental Science and Health Part B Pesticides Food Contaminants and Agricultural Wastes 39(5/6): 779-790.

Ahmad F and **Slinkard AE. 2004.** The extent of embryo and endosperm growth following interspecific hybridization between *Cicer arietinum* L. and related annual wild species. Genetic Resources and Crop Evolution 51(7):765-772.

Ahmad N and **Chaudhary MF. 2004.** Studies on the effect of foliar application of 2.4-Dichlorophenoxy acetic acid (2, 4-D) on different growth parameters of chickpea. Sarhad Journal of Agriculture 20(4):613-618.

Ahmad R and **Chandel SF. 2004.** Farmers field evaluation of 1PM module against *H. armigera* infesting chickpea. Archives of Phytopathology and Plant Protection 37(2): 133-137.

Akhter J, Mahmood K, Malik KA, Mardan A and **Ahmad M. 2004.** Effects of hydrogel amendment on water storage of sandy loam and loam soils and seedling growth of barley, wheat and chickpea. Plant Soil and Environment 50(10):463-469.

Alam G. 2004. State of the Indian farmer: a millennium study. Volume 5. Technology generation and IPR issues. New Delhi, India: Academic Foundation; Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. 172 pp.

All M, Singh BB, Kumar S and **Dhar S. (eds). 2004.** Pulses in new perspective: proceedings of the National Symposium on Crop Diversification and Natural Resource Management, llPR, Kanpur, India, 20-22 Dec 2003. Kanpur, India. Indian Society of Pulses Research and Development; Indian Institute of Pulses Research. 546 pp.

Altinbas M. 2004. Stability of seed yield by ranks in winter chickpea. Ziraat Fakultesi Dergisi 41(2):77-88.

Anderson A, Baldock JA, Rogers SL and **Bellotti W. 2004.** Influence of chlorsulfuron on rhizobial growth, nodule formation, and nitrogen fixation with chickpea. Australian Journal of Agricultural Research 55(10):1059-1070.

Ansari MA, Patel BA, Mhase NL, Patel DJ, Douaik A and **Sharma SB. 2004.** Tolerance of chickpea (*Cicer arietinum* L.) lines to root-knot nematode, Meloidogyne javanica (Treub) Chitwood., Genetic Resources and Crop Evolution 51(4):449-553.

Armstrong-Cho C, Gossen BD and **Chongo G. 2004.** Impact of continuous or interrupted leaf wetness on infection of chickpea by *Ascochyta rabiei.* Canadian Journal of Plant Pathology 26(2): 134-141.

Arshad M, Bakhsh A and **Ghafoor A. 2004.** Path coefficient analysis in chickpea *(Cicer arietinum* L.) under rainfed conditions. Pakistan Journal of Botany 36(l):75-82.

Arya RL. 2004. Integrated weed management in chickpea *(Cicer arietinum)* + mustard *(Brassica juncea)* intercropping system under rainfed conditions. Indian Journal of Agronomy 49(2):98-100.

Ashraf MS and **Khan TA. 2004.** Response of chickpea varieties/lines against reniform nematode Rotylenchulus renifomis. Indian Journal of Nematology 34(l):75-79.

Bahti Paziiat and **Strange RN. 2004.** Chemical and biochemical reactions of solanapyrone A, a toxin from the chickpea pathogen, *Ascochyta rabiei* (Pass.) Labr. Physiological & Molecular Plant Pathology 64(1):9-15.

Barhate BC, Bendre NJ, Mhase LB and **Aher RP. 2004.** Effect of rhizobium strains on nodulation and grain yield of chickpea *(Cicer arietinum* L.). Legume Research 27(2): 151-152.

Berger JD, Turner NC, Siddique KHM, Knights EJ, Brinsmead RB, Mock I, Edmondson C and **Khan TN. 2004.** Genotype by environment studies across Australia reveal the importance of phenology for chickpea *(Cicer arietinum* L.) improvement. Australian Journal of Agricultural Research 55(10):1071-1084.

Bhargava S and **Bhargava AK. 2004.** Effects of neem oil on growth characteristics of *Cicer arietinum* and control of Pod Borer. Advances in Plant Sciences 17(2):713-716.

Boominathan P, Shukla R, Kumar A, Manna D, Negi D and **Verma PK. 2004.** Long term transcript accumulation during the development of dehydration adaptation in *Cicer arietinum.* Plant Physiology 135(3): 1608-1620.

Borja R, Rincón B, Raposo F, Dominguez JR, Millán F and **Martin A. 2004.** Mesophilic anaerobic digestion in a fluidised-bed reactor of wastewater from the production of protein isolates from chickpea flour. Process Biochemistry 39(12):1913-1921.

Burli AY, More SM, Gare BN and **Dodake SS. 2004.** Studies on genetic variability and heritability in chickpea under residual soil moisture condition. Journal of Maharashtra Agricultural Universities 29(3): 353.

Celik S, Basman A, Yalcin E and **Koksel H. 2004.** Effects of Irradiation on protein electrophoretic properties, water absorption and cooking quality of dry bean and chickpea. Food Science and Technology Research 10(4): 410-423.

Chand S, Tripathi HN and **Tripathi AK. 2004.** Phosphorus requirement of gram (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) intercropping system under irrigated conditions. Indian Journal of Agricultural Science 74(4): 207-209.

Chand S, Tripathi HN and **Tripathi AK. 2004.** Phosphorus requirement of gram (*Cicer arietinum*) + Indian mustard (*Brassica junced*) intercropping system under irrigated conditions. Indian Journal of Agricultural Sciences 74(4): 207-209.

Chang KF, Hwang SF, Gossen BO, Turnbull GD, Howard RJ and **Blade SF. 2004.** Effects of soil temperature, seeding depth, and seeding date on rhizoctonia seedling blight and root rot of chickpea. Canadian Journal of Plant Science 84(3): 901-907.

Chen W, Coyne CJ, Peever TL and **Muehlbauer FJ. 2004.** Characterization of chickpea differentials for pathogenicity assay of ascochyta blight and identification of chickpea accessions resistant to *Didymella rabiei.* Plant Pathology 53(6):759-769.

Chiaiese P, Ohkama-Ohtsu N, Molvig L, Godfree R, Dove H, Hocart C and **Fujiwara T. 2004.** Sulphur and nitrogen nutrition influence the response of chickpea seeds to an added, transgenic sink for organic sulphur. Journal of Experimental Botany 55(404): 1889-1901.

Cho S; Chen W and **Muehlbauer FJ. 2004.** Pathotype-specific genetic factors in chickpea (*Cicer arietinum* L.) for quantitative resistance to ascochyta blight. Theoretical & Applied Genetics 109(4):733-739.

Clarke H, Khan T and **Siddique K. 2004.** Pollen selection for chilling tolerance at hybridisation leads to improved chickpea cultivars. Euphytica 139(1): 65-74.

Clarke HJ and **Siddique KHM. 2004.** Response of chickpea genotypes to low temperature stress during reproductive development. Field Crops Research 90(2/3): 323-334.

Clarke HJ, Khan TN and **Siddique KH. 2004.** Pollen selection for chilling tolerance at hybridisation leads to improved chickpea cultivars. Euphytica 139(1): 65-74.

Coskuner Y and **Karababa E. 2004.** Leblebi: a roasted chickpea product as a traditional Turkish snack food. Food Reviews International 20(3):257-274.

Dahiwalkar SD, Sarguru SA, Andhale RP and **Berad SM. 2004.** Response of chickpea to surge flow irrigation. Journal of Maharashtra Agricultural Universities 29(1):100-101.

Dar WD. 2004. ICRISAT - Using biotechnology to improve crop productivity in the semi-arid tropics of Asia and sub-Saharan Africa. Advanced Biotech 3(6): 16-19.

Deshmukh RB, Mhase LB, Patil JV, Deshmukh DV and **Jamadagni BM. 2004.** 'Virat' a kabuli chickpea for Maharashtra. Journal of Maharashtra Agricultural Universities 29(3):247-249.

Deshmukh RB, Patil JV and **Chaudhari GB. 2004.** Comparison of selection methods in chickpea. Legume Research 27(3): 193-196.

Devaranavadgi SB, Hunashal CS, Wali SY, Patil MB and **Bellakki MA. 2004**. Allelopathic effects of some tree crops on chickpea in dryland ecosystem. Journal of Maharashtra Agricultural Universities 29(2): 154-156.

Dubey SC. 2004. Reaction of chickpea genotypes against *Fusarium oxysporum* f. sp. *ciceri* causing vascular wilt. Indian Phytopathology 57(2): 233-233.

Ferreira MB, Pedro E, Santos JM, dos Santos MCP and **Carlos MLP. 2004.** Latex and chickpea (*Cicer arietinum)* allergy: first description of a new association. Allergie et Immunologie 36(10): 366-371.

France, European Association for Grain Legume Research. 2004. Proceedings of the 5th European Conference on Grain Legumes and 2nd International Conference on Legume Genomis and Genetics: Legumes for the Benefit of Agriculture, Nutrition and the Environment: their Genomics, their Products, and their Improvement, Dijon, France, 7-11 June 2004. Paris, France; Dijon, France: European Association for Grain Legume Research; INRA Genetics and Ecophysiology of Legumes Unit. 198 pp.

Garg N and **Jasleen. 2004**. Variability in response of chickpea (*Cicer arietinum* L.) cultivars to salt stress in germination and early growth of the seedlings. Indian Journal of Plant Physiology (New Series) 9(1):21-28.

Giron-Calle J, Vioque J, del Mar Yust M, Pedroche J, Alaiz M and **Millan F. 2004.** Effect of chickpea aqueous extracts, organic extracts, and protein concentrates on cell proliferation. Journal of Medicinal Food 7(2): 122-129.

Gossen BD and **Miller PR. 2004.** Survival of *Ascochyta rabiei* in chickpea residue on the Canadian prairies. Canadian Journal of Plant Pathology 26(2): 142-147.

Goutam U, Anand RC and **Sharma HR. 2004.** Evaluation of biomix vis-a-vis multiple inoculant in chickpea. Annals of Agri Bio Research 9(2): 151-154.

Gontam U, Anand RC, Banga RS and **Sharma HR. 2004.** Compatibility of diazotrophs with herbicides in chickpea under field conditions. Annals of Agri Bio Research 9(2):155-157.

Grundy PR and **Sequeira RV. 2004.** Evaluating legume species as alternative trap crops to chickpea for management of *Helicoverpa* spp. (Lepidoptera: Noctuidae) in central Queensland cotton cropping systems. Bulletin of Entomological Research 94(6): 481-486.

Gull M, Hafeez FY, Saleem M and **Malik KA. 2004.** Phosphorus uptake and growth promotion of chickpea by co-inoculation of mineral phosphate solubilising bacteria and a mixed rhizobial culture. Australian Journal of Experimental Agriculture 44(6):623 -628.

Gupta DK, Rai UN, Sinha S, Tripathi RD and **Nautiyal BD. 2004.** Role of Rhizobium (CA-1) inoculation in increasing growth and metal accumulation in *Cicer arietinum* L. growing under fly-ash stress condition. Bulletin of Environmental Contamination and Toxicology 73(2): 424-431.

Gupta DK, Tohoyama H, Joho M and **lnouhe M. 2004.** Changes in the levels of phytochelatins and related metal-binding peptides in chickpea seedlings exposed to arsenic and different heavy metal ions. Journal of Plant Research 117(3): 253-156.

Gupta SC. 2004. Response of gram (*Cicer arietinum*) to types and methods of microbial inoculation. Indian Journal of Agricultural Science 74(2): 73-75.

Hemmat A and **Eskandari I.** 2004. Tillage system effects upon productivity of a dryland winter wheat—chickpea rotation in the northwest region of Iran. Soil and Tillage Research 78(1): 69-81.

Ibarz A, González C and **Barbosa-Cánovas. 2004.** Kinetic models for water adsorption and cooking time in chickpea soaked and treated by high pressure. Journal of Food Engineering 63(4): 467-472.

ICRISAT. 2004. Production and productivity trends of ICRISAT mandate crops. Patancheru 502 324, Andhra Pradesh, India:. International Crops Research Institute for the Semi-Arid Tropics. 14 pp.

ICRISAT. 2004. Sowing seeds of success: ICRISAT research impacts 1997 -2003. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 32 pp.

Jat RS and **Ahlawat IPS. 2004.** Effect of vermicompost, biofertilizer and phosphorus on growth, yield and nutrient uptake by gram (*Cicer arietinum*) and their residual effect on fodder maize (Zea mays). Indian Journal of Agricultural Science 74(7): 359-261.

Jimenez-Gasco MM, Navas-Cortes JA and **Jimenez-Diaz RM. 2004.** *Fusarium oxysporum* f. sp. ciceris/Cicer *arietinum* pathosystem: a case study of the evolution of plant-pathogenic fungi into races and pathotypes. International Microbiology 7(2):95-104.

Kahlon TS and **Shao Q. 2004.** In vitro binding of bile acids by soy bean (*Glycine max),* black eye bean (*Vigna unguiculata),* garbanzo (*Cicer arietinum)* and lima bean (*Phaseolus lunatus).* Food Chemistry 86(3):435-440.

Kaur S, Brar KS and **Shehnmar M. 2004.** Effect of different chickpea cultivars on parasitization of *Helicoverpa armigera* (Hubner) by Campoletis chlorideae Uchida. Journal of Biological Control 18(1):69-72.

Kesnamma E and **Jayalakshmi SK. 2004.** Effect of salicylic acid, spermine and cinnamic acid on some defense enzymes of chickpea (*Cicer arietinum* L.) CV JG 62. Journal of Plant Biology 30(4): 13-20.

Khan 1A and **Alam SS. 2004.** Biochemical changes in chickpea roots after inoculation with virulent and hypovirulent. Isolates of *Fusarium oxysporum* f. sp. ciceris. Pakistan Journal of Scientific and Industrial Research 47(1): 25-28.

Khan IA and **Alam SS. 2004.** Purification of phytotoxin from culture filtrates of *Fusarium oxysporum* f.sp. ciceris and its biological effects on chickpea. Pakistan Journal of Botany 36(4):871-880.

Khan MR, Khan SM and **Mohiddin FA. 2004.** Biological control of Fusarium wilt of chickpea through seed treatment with the commercial formulation of Trichoderma harzianum and/or Pseudomonas fluorescens. Phytopathologia Mediterranea 43(l):20-25.

Khan MS, Zaidi A and **Aamil M. 2004.** Influence of herbicides on Chickpea-Mesorhizobium symbiosis. Agronomie 24(3): 123-128.

Khatik SK, Deshmukh KK, Sharma GD and **Dwivedi BS. 2004.** Effect of FYM, rock phosphate and bio-fertilizer on utilization of phosphorus by gram (*Cicer arietinum)* and its transformation in soil. Journal of Nuclear Agriculture and Biology 33(l):39-48.

Khawar KM. 2004. Hairy root transformation in Turkish chickpea (*Cicer arietinum* L) cultivars. Biotechnology and Biotechnological Equipment 18(3): 51-54.

Krishna S, Sharma AP and **Bhushan C. 2004.** Nitrogen and sulphur nutrition of chickpea (*Cicer arietinum* L.) grown under semi-arid conditions of central Uttar Pradesh. Legume Research 27(2): 146-148.

Krishnamurthy L, Serraj R, Kashiwagi J, Panwar JDS and **Rao YK. 2004.** Multilocation analysis of yield and yield components of a chickpea mapping population grown under terminal drought. Indian Journal of Pulses Research 17(1): 17-24.

Kulkarni SS, Patil JV and **Gawande VL. 2004.** Heterosis studies in chickpea (*Cicer arietinum* L.). Journal of Maharashtra Agricultural Universities 29(3):272-275.

Kumar J, Yadav SS and **Kumar S. 2004.** Influence of moisture stress on quantitative characters in chickpea *(Cicer arietinum* L.). Indian Journal of Genetics and Plant Breeding 64(2): 149-150.

Kumar R, Jalali BL and **Chand H. 2004.** Interaction between Va-mycorrhizal fungi and soil-borne plant pathogens of chickpea. Legume Research 27(1): 19-26.

Kumari SG, Makkouk KM, Attar N and **Ghulam W. 2004.** First report of chickpea chlorotic dwarf virus infecting spring chickpea in Syria. Plant Disease 88(4):424.

Landa BB, Navas-Cortés JA and **Jiménez-Díaz RM. 2004.** Influence of temperature on plant-rhizobacteria interactions related to biocontrol potential for suppression of fusarium wilt of chickpea. Plant Pathology 53(3):341-352.

Landa BB, Navas-Cortes JA and **Jimenez-Diaz RM. 2004.** Integrated management of fusarium wilt of chickpea with sowing date, host resistance, and biological control. Phytopathology 94(9): 946-960.

Laranjo M, Machado J, Young J, Peter W and **Oliveira S. 2004.** High diversity of chickpea Mesorhizobium species isolated in a Portuguese agricultural region. Fems Microbiology Ecology 48(1): 101-107.

Li L, Tang C, Rengel Z and **Zhang FS. 2004.** Calcium, magnesium and microelement uptake as affected by phosphorus sources and interspecific root interactions between wheat and chickpea. Plant and Soil 261(l/2):29-37.

Li SM, Li L and **Zhang FS. 2004.** Acid phosphatase role in chickpea/maize intercropping. Annals of Botany 94(2):297-303.

López-Bellido L, López-Bellido RJ, Castillo JE and **López-Bellido FJ. 2004.** Chickpea response to tillage and soil residual nitrogen in a continuous rotation with wheat: 1. Biomass and seed yield. Field Crops Research 88(2/3):191-200.

López-Bellido RJ, López-Bellido L, Castillo JE and **López-Bellido FJ. 2004.** Chickpea response to tillage and soil residual nitrogen in a continuous rotation with wheat: II. Soil nitrate, N uptake and influence on wheat yield. Field Crops Research 88(2/3):201-210.

Mali M and **Singh PP. 2004.** Physico-chemical characterization of paper mill leachate and its impact on seedling growth of *Cicer arietinum.* Journal of Industrial Pollution Control 20(1): 59-66.

Meares CA, Bogracbeva TY, Hill SE and **Hediey CL. 2004.** Development and testing of methods to screen chickpea flour for starch characteristics. Starch -Stuttgart 56(6):215-224.

Meena HS, Kumar J and **Yadav SS. 2004.** Inheritance of seed colour in chickpea *(cicer arietinum* L.). Indian Journal of Genetics and Plant Breeding 64(2):151-152.

Mhadhbi H, Jebara M, Limam F and **Aouani ME. 2004.** Rhizobial strain involvement in plant growth, nodule protein composition and antioxidant enzyme activities of chickpea-rhizobia symbioses: modulation by salt stress. Plant Physiology and Biochemistry 42(9):717-722.

Mhase DVDLB. 2004. Evaluation of chickpea genotypes for drought tolerance. Indian Journal of Pulses Research 17(l):47-49.

Mishra DN. 2004. Economics and efficacy of some bio-pesticides to manage *Helicoverpa armigera* (Hubner) on chickpea under mid western plain zone of UP. Environment and Ecology 22(3):404-406.

Mishra JS and **Singh VP. 2004.** Interference of small canary grass *(Phalaris minor)* in latesown gram *(Cicer arietinum).* Indian Journal of Agricultural Science 74(5):268-270.

Moinuddin and **Khanna-Chopra R. 2004.** Osmotic adjustment in chickpea in relation to seed yield and yield parameters. Crop Science 44 (2):449-455.

Muzquiz M, Welham T, Altares P, Goyoaga C, Cuadrado C, Romero C and **Guillamon E. 2004.** Effect of germination on seed trypsin inhibitors in *Vicia faba* and *Cicer arietinum.* Journal of the Science of Food and Agriculture 84(6):556-560.

Nayyar H and **Chander S. 2004.** Protective effects of polyamines against oxidative stress induced by water and cold stress in chickpea. Journal of Agronomy and Crop Science 190(5):355-365.

Nazirkar RB, Rasal PH, Pawar KB, Jadhav SK and **Jadhav BR. 2004.** Response of phosphocomposts on the yield and soil properties of *kharif* sorghum followed by chickpea. Journal of Maharashtra Agricultural Universities 29(2):237-239.

Nestel P, **Cehun** M and **Chronopoulos A. 2004.** Consumption of chickpeas and plasma glucose. Nutrition Research Newsletter 23(3): 13-14.

Nestel P, Cehun M and **Chronopoulos A. 2004.** Effects of long-term consumption and single meals of chickpeas on plasma glucose, insulin, and triacylglycerol concentrations. American Journal of Clinical Nutrition 79(3):390-395.

Oweis T, Hachum A and **Pala M. 2004.** Water use efficiency of winter-sown chickpea under supplemental irrigation in a Mediterranean environment. Agricultural Water Management. 66(2): 163-179.

Padmaja CK. 2004. Effects of coir waste along with NPK on the growth and yield of chickpea *(Cicer arietinum).* Journal of Ecotoxicology and Environmental Monitoring 14(4):315-318.

Pant H, Pandey G and **Shukla DN. 2004.** Effect of different concentrations of biocontrol agents on root-knot disease of

chickpea and its rhizosphere microflora. Pakistan Journal of Nematology 22(1): 103-110.

Putaud C, **Lacoponi E** and **Raccuia** S. 2004. Physico-chemical characteristics, water absorption, soaking and cooking properties of some Sicilian populations of chickpea (*Cicer arietinum* L.). International Journal of Food Sciences & Nutrition 55(7):547-554.

Patel M M. 2004. Adoption behaviour of chickpea growers towards integrated pest management. Indian Journal of Pulses Research 17(1): 67-69.

Perlik A. 2004. Spicy potatoes and kale with chickpeas. Restaurants and Institutions 114(14): 29-29.

Pinto G and Esin A. 2004. Kinetics of the osmotic hydration of chickpeas. Journal of Chemical Education 81(4): 532-536.

Poddar RK, Singh DV and Dubey SC. 2004. Integrated application of Trichoderma harzianum mutants and carbendazim to manage chickpea wilt (*Fusarium oxysporum* f sp ciceri). Indian Journal of Agricultural Science 74(6):346-248.

Poddar RK, Singh DV and Dubey SC. 2004. Management of chickpea wilt through combination of fungicides and bioagents. Indian Phytopathology 57(1): 39—43.

Polowick PL, Baliski DS and Mahon JD. 2004. Agrobacterium tumefaciens-mediated transformation of chickpea *(Cicer arietinum* L.): gene integration, expression and inheritance. Plant Cell Reports 23(7):485-490.

Qureshi AS, Shaukat A, Bakhsh A, Arshad M and Chafoor A. 2004. Assessment of variability for economically important traits in chickpea *(Cicer arietinum* L.). Pakistan Journal of Botany 36(4): 779-786.

Rai B and Singh TS. 2004. Influence of plant growth promoting fungi on growth and yield of chickpea, pea and mustard. Journal of Mycopathological Research 42(1): 9-14.

Rajesh PN, Coyne C, Meksem **K, Sharma KD, Gupta** V and **Muehlbauer FJ.** 2004. Construction of a Hindlll Bacterial Artificial Chromosome library and its use in identification of clones associated with disease resistance in chickpea. Theoretical and Applied Genetics 108(4): 663-669.

Rajput BS, Mathur CM and **Sonakiya** VK. 2004. Physiological studies on advanced generation short duration deshi chickpea *(Cicer arietinum* L.) genotypes. Advances in Plant Sciences 17(2): 513-518.

Rajput BS, Mathur CM and **Sonakiya VK.** 2004. Studies on phenological attributes and their association with structural attributes in chickpea (*Cicer arientinum* L.). Advances in Plant Sciences 17(2):479-484.

Rao SC, **Ryan J, Al-Amoodi LK, Barbarick KA** and **Roberts** CA. (eds). 2004. Challenges and strategies for dryland agriculture. CSSA Special Publication 32. Wisconsin, USA. Crop Science Society of America; American Society of Agronomy. 455 pp.

Raut VK, Patil JV and **Gawande VL. 2004.** Correlation and path analysis for quantitative traits in chickpea. Indian Journal of Pulses Research 17(1): 82-83.

Ravi R and **Bhattacharya S. 2004.** Flow behaviour of chickpea (*Cicer arietinum* L.) flour dispersions: effect of additives. Journal of Food Engineering 65(4): 619-624.

Ravi R and **Susheelamma NS. 2004.** Effect of the concentration of batter made from chickpea (*Cicer arietinum* L.) flour on the quality of a deep-fried snack. International Journal of Food Science and Technology 39(7): 755-762.

Ravikumar RL. 2004. Effect of gamete selection on segregation of wilt susceptibility-linked DNA marker in chickpea. Current Science 86(5): 642-643.

Reddy SV and **Kumar PL. 2004.** Transmission and properties of a new luteovirus associated with chickpea stunt disease in India. Current Science 86(8): 1157-1160.

Redondo-Nevado J, Aguilar M, Caballero JL and **Pineda M. 2004.** Structural and genomic organization, cDNA characterization and expression analysis of the urate oxidase gene from chickpea (*Cicer arietinum).* Physiologia Plantarum 121(3): 358-368.

Reyes-Moreno C, Cuevas-Rodriguez EO, Milan-Carrillo J and **Cardenas-Valenzuela OG. 2004.** Solid state fermentation process for producing chickpea (*Cicer arietinum* L.) tempeh flour. Physiochemical and nutritional characteristics of the product. Journal of the Science of Food and Agriculture 84(3): 271-278.

Romeis J, Sharma HC, Sharma KK, Das S and **Sarmah BK. 2004.** Potential of transgenic chickpeas for pest control and possible effects on non-target arthropods. Crop Protection 23(10): 923-938.

Rubeena S, Sharma RC and **Pandey GP. 2004.** Effect of natural dyes on the chlorophyll and starch content of gram *Cicer arietinum.* Ecology Environment and Conservation 10(1): 21-26.

Rubio J, Flores F, Moreno MT, Cubero Jl and **Gil J. 2004.** Effects of the erect/bushy habit, single/double pod and late/ early flowering genes on yield and seed size and their stability in chickpea. Field Crops Research 90(2/3): 255-262.

Saikia R, Singh K and **Arora DK. 2004.** Suppression of fusarium-wilt and charcoal rot of chickpea by Pseudomonas aeruginosa RsB29. Indian Journal of Microbiology 44(3):181-184.

Saini VK, Bhandari SC and **Tarafdar JC. 2004.** Comparison of crop yield, soil microbial C, N and P, N-fixation, nodulation and mycorrhizal infection in inoculated and non-inoculated sorghum and chickpea crops. Field Crops Research 89(l):39-48.

Sanap MM, Mungse HB and **Deshmukh DV. 2004.** Growth and yield variation in chickpea for drought tolerance. Journal of Maharashtra Agricultural Universities 29(2): 143-145.

Sánchez A, Mateos I, Labrador E and **Dopico B. 2004.** Brassinolides and 1AA induce the transcription of four a-expansin genes related to development in *Cicer arietinum.* Plant Physiology and Biochemistry 42(9): 709-716.

Sangwan PS and **Raj M. 2004.** Effect of zinc nutrition on yield of chickpea (*Cicer arietinum* L.) under dryland conditions. Indian Journal of Dryland Agricultural Research and Development 19(1): 1-3.

Sarmah BK, Moore A, Tate W, Molvig L, Morton RL, Rees DP, Chiaiese P, Chrispeels MJ, Tabe LM and Higgins TJV. **2004.** Transgenic chickpea seeds expressing high levels of a bean a-amylase inhibitor. Molecular Breeding 14(l):73-82.

Sarna S, Sharma P and **Khurana AS. 2004.** Synergistic effect of combined inoculation of *Azotobacter chroococcum* and Rhizobium sp. in chickpea. Indian Journal of Pulses Research 17(1): 35-37.

Senthil G, Williamson B, Dinkins RD and **Ramsay G. 2004.** Efficient transformation system for chickpea (*Cicer arietinum* L.). Plant Cell Reports 23(5): 297-303.

Sequeira RV. 2004. Recruitment and loss of juvenile stages of *Helicoverpa* spp. (Lepidoptera: Noctuidae) on contaminant plants in chickpea crops. Australian Journal of Entomology 43(2):164-168.

Serraj R, Krishnamurthy L, Kashiwagi J, Kumar J, Chandra S and **Crouch JH. 2004.** Variation in root traits of chickpea (*Cicer arietinum* L.) grown under terminal drought. Field Crops Research 88(2/3): 115-127.

Serraj R (ed.). 2004. Symbiotic nitrogen fixation: prospects for enhanced application in tropical agriculture. New Delhi, India. Oxford and IBH Publishing. 480 pp.

Seungho C and **Muehlbauer FJ. 2004.** Genetic effect of differentially regulated fungal response genes on resistance to necrotrophic fungal pathogens in chickpea (*Cicer arietinum* L.). Physiological and Molecular Plant Pathology 64(2): 57-66.

Shah Z, Muhammad W, Shah SM and **Iqbal MM. 2004.** Yield and N~2 fixation of lentil and chickpea as influenced by tillage and P levels under rainfed conditions. Sarhad Journal of Agriculture 20(2): 243-250.

Sharma KD, Winter P, Kahl G and **Muehlbauer FJ. 2004.** Molecular mapping of *Fusarium oxysporum* f. sp. ciceris race 3 resistance gene in chickpea. Theoretical and Applied Genetics 108(7): 1243-1248.

Sharma SK, Singh D and **Dua RP. 2004.** Genetic divergence in chickpea under saline conditions. Indian Journal of Pulses Research 17(1): 80-81.

Sharma V and **Kumar G. 2004.** Meiotic studies in two cultivars of *Cicer arietinum* L. after EMS treatment. Cytologia 69(3): 243-248.

Sharma V, Kumar G and **Kumar R. 2004.** Comparative mutagenicity of gamma rays and EMS in *Cicer arietinum* L. Journal of Cytology and Genetics. 5(1):21—26.

Siag RK and **Yadav BS. 2004.** Effect of vermicompost and fertilizers on productivity of gram (*Cicer arietinum*) and soil fertility. Indian Journal of Agricultural Sciences 74(11): 613—615.

Siddiqui ZA. 2004. Effects of soil inoculants on the growth, transpiration and wilt disease of chickpea. Journal of Plant Diseases and Protection 111(2): 151-157.

Singh G. 2004. My experiences of ascochyta blight of chickpea: Lead the way towards eradication. Plant Disease Research 19(1): 1-9.

Singh H, Mahajan G and **Singh I. 2004.** Efficacy of different insecticides against the gram pod borer (*Helicoverpa armigera)* on chickpea (*Cicer arientinum).* Legume Research 27(3): 233-234.

Singh N, Singh SK and **Kaur M. 2004.** Characterization of starches separated from Indian chickpea (*Cicer arietinum* L.) cultivars. Journal of Food Engineering 63(4): 441-449

Singh RN, Kumar B and **Singh S. 2004.** Effect of lime and boron application on gram (*Cicer arietinum)* in acid soils of Jharkhand. Journal of the Indian Society of Soil Science 52(3):283-285.

Singh S and **Chand H. 2004.** Effect of extracts of some medicinal plants on spore germination of chickpea wilt pathogen (*Fusarium oxysporum* f. sp. ciceri (Pad.) Synd. and Hans.). Indian Journal of Plant Protection 32(1): 162-163.

Singh S, Saini SS and **Singh BP. 2004.** Effect of irrigation, sulphur and seed inoculation on growth, yield and sulphur uptake of chickpea (*Cicer arietinum)* under late-sown conditions. Indian Journal of Agronomy 49(1):57-59.

Singh SP, Kiran and **Tanwar RS. 2004.** Dissipation of lindane and fenvalerate on chickpea (*Cicer arietinum* L.). Pesticide Research Journal 16(2):57-59.

Singh T. Deshmukh PS and **Kushwaha SR. 2004.** Physiological studies on temperature tolerance in chickpea (*Cicer arietinum* L.) genotypes. Indian Journal of Plant Physiology 9(3):294-301.

Singhai B and **Shrivastava SK. 2004.** Solubility behaviour of five varieties of chickpea (*Cicer arietinum*) seed proteins at different pH. Legume Research 27(1):46-49.

Sriveni M, Rupela OP, Gopalakrishnan S and **Krajewski M. 2004.** Spore-forming bacteria, a major group among potential antagonists isolated from natural sources such **as**

termitaria soil and composts used by organic farmers. Indian Journal of Microbiology 44(2):95-100.

Tae Z, Bo J and **Zhang W. 2004.** Relationship between structure and emulsifying properties of chickpea protein isolates. Food and Fermentation Industries 30(12):204-213.

Tekeoglu M, Isik M and **Muehlbauer FJ. 2004.** QTL analysis of ascochyta blight resistance in chickpea. Turkish Journal of Agriculture and Forestry 28(3): 183-188.

Tewari AN and **Tiwari SN. 2004.** Chemical control of *Asphodelus tenuifolius* infesting gram (*Cicer arietinum*) under rainfed condition. Indian Journal of Agricultural Science 74(12):436-437.

Tewari-Siugh N, Sen J, Kiesecker H, Reddy VS, Jacobsen HJ and **Guha-Mukherjee S. 2004.** Use of a herbicide or lysine plus threonine for non-antibiotic selection of transgenic chickpea. Plant Cell Reports 22(8):576-583.

Thakur HS. 2004. Effect of levels and frequencies of application of fertilizer phosphorus on yield, NPKS content and uptake and phosphorus balance studies of chickpea *(Cicer arietinum).* Indian Journal of Dryland Agricultural Research and Development 19(2): 164-167.

Thakur KS, Keshry PK and **Tamrakar DK. 2004.** Studies on management of collar rot disease *(Sclerotium rolfsii)* of chickpea by use of fungicides. Advances in Plant Sciences 17(2):553-556.

Thomas JE, Schwinghamer MW, Parry JN, Sharman M, Schilg MA and **Dann EK. 2004.** First report of tomato spotted wilt virus in chickpea (*Cicer arietinum*) in Australia. Australasian Plant Pathology 33(4):597-599.

Tippannavar CM, Emmimath VS and **Jahagirdar S. 2004.** Field evaluation of efficient rhizobium strains in combination with reduced levels of N for Bengal gram in northern Karnataka. Indian Journal of Agricultural Research 38(1):77-78.

Tiyagi SA and **Ajaz S. 2004.** Biological control of plant parasitic nematodes associated with chickpea using oil cakes and *Paecilomyces lilacinus.* Indian Journal of Nematology 34(1): 44-48.

Tiyagi SA, Ajaz S and **Azam MF. 2004.** Effect of some pesticides on plant growth, root nodulation and chlorophyll content of chickpea. Archives of Agronomy and Soil Science 50(6):529-533.

Toker C and **Cargirgan MI. 2004.** Use of phenotypic correlations and factor analysis in determining characters for grain yield selection in chickpea *(Cicer arietinum* L.). Hereditas 140(3):226-228.

Toker C, Karhan M and **Ulger S. 2004.** Endogenous organic acid variations in different chickpea *(Cicer arietinum* L.) genotypes. Acta Agriculturae Scandinavica: Section B, Soil & Plant Science 54 (l):41-44.

Toker C. 2004. Evaluation of yield criteria with phenotypic correlations and factor analysis in chickpea. Acta Agriculturae Scandinavica: Section B, Soil & Plant Science 54 (1):45—48.

Udupa SM, Malhotra RS and **Baum M. 2004.** Tightly linked di- and tri-nucleotide microsatellites do not evolve in complete independence: evidence from linked $(TA)_n$ and $(TAA)_n$ microsatellites of chickpea *(Cicer arietinum* L.). Theoretical & Applied Genetics 108(3):550-558.

Vandenberg A and **Warkentin T. 2004.** CDC Desiray dcsi chickpea. Canadian Journal of Plant Science 84(3):795-796.

Varshney JG and **Arya RL. 2004.** Effect of integrated nutrients use and weed-control methods on sole gram *(Cicer arietinum)* and gram + Indian mustard *(Brassica juncea)* intercropping system. Indian Journal of Agricultural Sciences. 74(3):121-125.

Wani AA. 2004. Effect of physical and chemical mutagens on various quantitative traits in chickpea *(Cicer arietinum* L.). Journal of Nuclear Agriculture and Biology 33(2):114-118.

Wouterlood M, Cawthray GR, Scanlon TT, Lambers H and **Veneklaas EJ. 2004.** Carboxyiate concentrations in the rhizosphere of lateral roots of chickpea *(Cicer arietinum)* increase during plant development, but are not correlated with phosphorus status of soil or plants. New Phytologist 162(3):745-753.

Wouterlood M, Cawthray GR, Turner S and **Lambers H. 2004.** Rhizosphere carboxylate concentrations of chickpea are affected by genotype and soil type. Plant and Soil 261(1/2):1-10.

Yadav AS. 2004. Symbiotic effectiveness of nodulation mutants of chickpea *(Cicer arietinum* L.) under pothouse and field conditions. Geobios - Jodhpur 31(4):269-274.

Yadav SS, Kumar J, Turner NC, Berger J, Redden R, McNeil D, Materne M, Knights EJ and **Bahl PN. 2004.** Breeding for improved productivity, multiple resistance and wide adaptation in chickpea *(Cicer arietinum* L.). Plant Genetic Resources 2(3): 181-188.

Zulet MA, Macarulla MT, Portillo MP and **Martinez JA. 2004.** Beneficial outcome in hypercholesterolemia after intake of heat-treated chickpea in rats. Publication-European Association for Animal Production 110:153-158.

Pigeonpea Publications

Alam G. 2004. State of the Indian farmer: a millennium study. Volume 5. Technology generation and IPR issues. New Delhi, India: Academic Foundation; New Delhi, India: Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. 172 pp.

Ali M, Singh BB, Kumar S and **Dhar S.** (eds.). **2004.** Pulses in new perspective: proceedings of the National Symposium on Crop Diversification and Natural Resource Management, IIPR, Kanpur, India, 20-22 Dec 2003. Kanpur, India: Indian Society of Pulses Research and Development; Kanpur, India: Indian Institute of Pulses Research. 546 pp.

Alves SMC, de S abboud AC and de LD Ribeiro R. 2004. Nitrogen and phosphorus balance in soil with organic cultivation of legumes after incorporation of pigeonpea biomass. Pesquisa Agropecuaria Brasileira 39(11): 1111-1118.

Balasubramanian P and **Vadivelu S. 2004.** Screening in sesame L. genotypes for resistance to pigeonpea cyst nematode, Heterodera cajani, Koshy and Swarup, 1967. Indian Journal of Agricultural Research 38(1): 1-7.

Biliore SD and **Joshi OP. 2004.** Screening of pigeonpea, *Cajanus cajan* varieties for their suitability as intercrop in soybean, *Glycine max* L. Journal of Oilseeds Research 21(1):58-61.

Bramel PJ. (ed.). 2004. Assessing the risk of losses in biodiversity in traditional cropping syterns: a case study of pigeonpea in Andhra Pradesh. Patancheru, Andhra Pradesh, India. International Crops Research Institute for the Semi-Arid Tropics. 163 pp.

Chaudhary RG, Dhar V and **Naimuddin. 2004.** Management of phytophthora blight in pigeonpea through cultural methods and fungicides. Indian Journal of Pulses Research 17(1): 50-52.

Chauhan R M, Parmar L D, Patel PT and **Tikka SBS. 2004.** Fertility restoration in cytoplasmic genie male sterile line of Pigeonpea (*Cajanus cajan* (L.) Millsp.) derived from *Cajanus scarabaeoides.* Indian Journal of Genetics and Plant Breeding 64(2):112-114.

Chauhan YS, Apphun A, Singh VK and **Dwivedi BS. 2004.** Foliar sprays of concentrated urea at maturity of pigeonpea to induce defoliation and increase its residual benefit to wheat. Field Crops Research 89(1): 17-25.

Chirwa TS, Mafongoya PL, Mbewe D N M and **Chishala BH. 2004.** Changes in soil properties and their effects on maize productivity following *Sesbania sesban* and *Cajanus cajan* improved fallow systems in eastern Zambia. Biology and Fertility of Soils 40(I):20-27.

Chougule NP, Giri AP, Hivrale VK, Chhabda PJ and **Kachole MS. 2004.** Identification of amylase inhibitor deficient mutants in pigeonpea *(Cajanus cajan* (L.) Millisp.). Biochemical Genetics 42(5/6): 165-180.

Corzo O and **Fuentes A. 2004.** Moisture sorption isotherms and modeling for pre-cooked flours of pigeonpea *(Cajanus cajans* L. millsp) and lima bean *(Canavalia ensiformis).* Journal of Food Engineering 65(3):443-448.

Dar WD. 2004. ICRISAT - Using biotechnology to improve crop productivity in the semi-arid tropics of Asia and sub-Saharan Africa. Advanced Biotech 3(6): 16-19.

Deshmukh MR, Shah SM, Katade SR, Belhekar AA and **Kashalkar RV. 2004.** Removal of methylene blue and malachite green by agricultural waste material stalks of *Cajanus cajan.* Asian Journal of Chemistry 16(3/4): 1863-1867.

Dharmaraj PS and **Lohithaswa HC. 2004.** ICPL 87119 (Asha): Fusarium wilt and sterility mosaic disease resistant pigeonpea variety for northern Karnataka. Karnataka Journal of Agricultural Sciences 17(2):330-331.

Duhan A, Khetarpaul N and **Bishnoi S. 2004.** HCl-extractability of zinc and copper as affected by soaking, dehulling, cooking and germination of high yielding pigeonpea cultivars. Journal of Food Composition and Analysis 17(5): 597-604.

Duker-Eshun G, Jareszewski JW, Asomaning WA and **Oppong-Boachie F. 2004.** Antiplasmodial constituents of *Cajanus cajan.* Phytotherapy Research 18(2): 128-130.

Durairaj C. 2004. Effect of abiotic factors on the incidence of pigeonpea pod fly and its pupal parasitoids. Indian Journal of Pulses Research 17(1):61-63.

Ferreira EC, Nogueira ARA, Souza GB and **Batista LAR. 2004.** Effect of drying method and length of storage on tannin and total phenol concentrations in pigeonpea seeds. Food Chemistry. 86(1): 17-23.

Fujita K, Kai Y, Takayanagi M, El-Shemy H, Adu-Gyamfi JJ and **Mohapatra PK. 2004.** Genotypic variability of pigeonpea in distribution of photosynthetic carbon at low phosphorus level. Plant Science 166(3):641-649.

Gare BN, More SM and **Jadhav MG. 2004.** Effect of pigeonpea and sorghum intercrop on yield of soybean under rainfed condition in sub-Montane zone of Maharashtra. Journal - Maharashtra Agricultural Universities 29(2): 170-171.

Gautam VS, Kushwaha BB and **Patel RN. 2004.** Performance of intercropping of sorghum with low profile canopy legumes crops under different planting geometries. Indian Journal of Dryland Agricultural Research and Development 19(2): 126-129.

Haseeb A and **Shukla PK. 2004.** Management *of Heterodera cajani, Meloidogyne incognita* and fusarium wilt on pigeonpea

with some chemicals, bio-pesticides and bio-agents. Nematologia Mediterranea 32(2):217-222.

Hasreddy SM and **Khemaling R** (eds.). **2004.** Development of dryland agriculture: problems and prospects. Sedam, Gulbarga, Karnataka, India: Shri Kottal Basaveshwara Bharatiya Shikshana Samiti. 301 pp.

ICRISAT. 2004. Production and productivity trends of ICR1SAT mandate crops. Patancheru, Andhra Pradesh, India International Crops Research Institute for the Semi-Arid Tropics. 14 pp.

ICRISAT. 2004. Sowing seeds of success: ICRISAT research impacts 1997-2003. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 32 pp.

Jat HS and **Ahlawat IPS. 2004.** Production potential and economic viability of pigeonpea *(Cajanus cajan)* + groundnut *(Arachis hypogaea)* intercropping in lndo-Gangetic plains. Indian Journal of Agricultural Science 74(3): 126-129.

Jones AT, Kumar PL, Saxena KB, Kulkarni NK, Muniyappa V and **Waliyar F. 2004.** Sterility mosaic disease - the "green plague" of pigeonpea: advances in understanding the etiology, transmission and control of a major virus disease. Plant Disease 88(5):436-445.

Katiyar PK, Dua RP, Singh IP, Singh BB and **Singh F. 2004.** Multivariate analysis for genetic diversity in early pigeonpea accessions. Legume Research. **27(3):** 164-170.

Kshirsagar RB, Sawate AR and **Bendale TG. 2004.** Effect of pretreatments on quality characteristics of selected varieties of frozen green Arhar/tur *(Cajanus cajan).* Indian Food Packer 58(6): 159-164.

Kumar A. 2004. Flower and pod pests of pigeonpea. Insect Environment 10(1): 12.

Kumar S, Singh B and **Akharu RK. 2004.** Efficacy of some biorational insecticides on larval population of gram pod borer on pigeonpea. Legume Research. 27(l):62-65.

Kumar SM, Kumar BK, Sharma KK and **Devi P. 2004.** Genetic transformation of pigeonpea with rice chitinase gene. Plant Breeding 123(5):485-489.

Lakshmidevamma TN, Gowda MB and **Mahadevu P. 2004.** Character association and path analysis in groundnut *(Arachis hypogaea* L.). Mysore Journal of Agricultural Sciences 38(2):221-226.

Lal RR, Verma P and **Reddy BS. 2004.** Development and evaluation of a low capacity dal chakki for pre-treated pigeonpea *(Cajanus cajan* L.). Indian Journal of Dryland Agricultural Research and Developement. 19(2): 138-142.

Li Z-h, Pan X-z and Zhou C-h. 2004. Variation of quantitative characters on pigeonpea populations of local cultivars in Yunnan Province. Forest Research - Chinese Academy of Forestry 17(5):554-562.

Mahalinga D M, Jayalaksmi SK and **Gangadhara GC. 2004.** Management of pigeonpea wilt through integration of bioagents and resistant source. Plant Disease Research 19(2):181-182.

Mallikarjuna N and **Kalpana N. 2004.** Mechanisms of cytoplasmic-nuclear male sterility in pigeonpea wide cross *Cajanus cajan* x C. *acutifolius.* Indian Journal of Genetics and Plant Breeding 64(2): 115-117.

Matsunaga R, I to O and **Johansen C. 2004.** Varietal differences in carbohydrate accumulation in pigeonpea stems in relation to reproductive development. Japanese Journal of Tropical Agriculture 48(2):63-69.

Mekbungwan A and **Thongwittaya N. 2004.** Digestibility of soybean and pigeonpea seed meals and morphological intestinal alterations in pigs. Journal of Veterinary Medical Science 66(6):627-733.

Mekbungwan A. 2004. Growth performance and histological intestinal alterations in piglets fed dietary raw and heated pigeonpea seed meal. Histology and Histopathology 19(2):381-389.

Mishra A, Dhar B and **Singh RM. 2004.** Nodulation competitiveness between contrasting phage phenotypes of pigeonpea rhizobial strains. Indian Journal of Experimental Biology 42(6):611-615.

Modgil R. 2004. Biological protein quality of insect *(Callosobruchus chinensis* L.) infested pigeonpea. Journal of Food Science and Technology 41(l):60-62.

Morais H, Medri ME, Marur CJ, Caramori PH and **de Arruda Ribeiro AM. 2004.** Modifications on leaf anatomy of *Coffea arabica* caused by shade of pigeonpea *(Cajanus cajan).* Brazilian Archives of Biology and Technology 47(6):863-872.

Mukherjee D. 2004. Effect of kinetin on the regulation of abscission and senescence in pigeonpea. Physiology and Molecular Biology of Plants 10(2):223-231.

Nagaraj KM, Chikkadevaiah and **Kulkarni RS. 2004.** Inheritance of resistance to sterility mosaic virus in pigeonpea *(Cajanus cajan (L.)* Millsp.). Indian Journal of Genetics and Plant Breeding. 64(2): 118-120.

Nahar P, Yadav P, Kulye M, Hadapad A, Hassani M, Tuor U, Keller S, Chandele AG and **Thomas B. 2004.** Evaluation of indigenous fungal isolates Metarhizium anisopliae M34412, Beauveria bassiana B3301 and Nomuraea rileyi N812 for the control of *Helicoverpa armigera* (Hubner) in pigeonpea field. Journal of Biological Control 18(1): 1-8.

Nisha Rekha P, Singhal S and **Pandit AB. 2004.** A study on degradation kinetics of thiamine in red gram splits *(Cajanus cajan* L.). Food Chemistry 85(4):591-598.

Oloyo RA. 2004. Chemical and nutritional quality changes in germinating seeds of *Cajanus cajan* L. Food Chemistry 85(4):497-502.

Onimawo IA. 2004. Effects of germination on the nutrient content and functional properties of pigeonpea flour. Journal of Food Science and Technology 41(2): 170-174.

Pandey N. 2004. Ascendancy of genotype and stress temperature on flowering behaviour in long duration pigeonpea. Legume Research 27(3): 177-182.

Pandey N. 2004. Ascendancy of temperature on pod setting in pigeonpea. Legume Research 27(3): 171-176.

Pandey N. 2004. Line x tester analysis in long duration hybrid pigeonpea. Legume Research 27(2):79-87.

Pendke MS, Lomte MH and **Gitte AU. 2004.** Effects of soil and water conservation practices on runoff, soil loss and yield of pigeonpea. Journal of Maharashtra Agricultural Universities 29(3):319-320.

Prajapati BH, Tikka SBS, Purohit LP and **Chaudhary GK. 2004.** Plot size study from uniformity trial data on pigeonpea under north Gujarat condition. Indian Journal of Pulses Research 17(1):25-27.

Prasad V, Satyavathi VV, Sanjaya V alli K M , Khandelwal, Abha, Shaila MS and **Lakshmi Sita G. 2004.** Expression of biologically active Hemagglutinin-neuraminidase protein of Peste des petits ruminants virus in transgenic pigeonpea [*Cajanus cajan* (L) Millsp.]. Plant Science 166(1): 199-205.

Ramamoorthy K, Lourduraj AC, Alagudurai S and **Kandasamy OS. 2004.** Intercropping pigeonpea (*Cajanus cajan)* in finger millet (*Eleusine coracana)* on productivity and soil fertility under rainfed condition. Indian Journal of Agronomy 49(1):28-30.

Rao MS, Reddy KD, Srivatsava NN, Singh T V K and **Reddy GS. 2004.** Effect of change in microclimate on insect pests and their predators in pigeonpea *(Cajanus cajan).* Indian Journal of Agricultural Science 74(7):399-402.

Rathod PS, Halikatti SI, Hiremath SM and **Kajjidoni ST. 2004.** Comparative performance of pigeonpea based intercropping systems in northern transitional zone of Karnataka. Karnataka Journal of Agricultural Sciences 17(2):203-206.

Reddy GS, Maruthi V and **Vanaja M. 2004.** Effect of soil depth on productivity of mung bean and pigeonpea under rainfed environment. Legume Research 27(1): 1-10.

Reddy KRC, Srivastava PK, Dey PM and **Kayastha AM. 2004.** Immobilization of pigeonpea (*Cajanus cajan*) urease on DEAE-cellulose strips for urea estimation. Biotechnology and Applied Biochemistry 39(3): 323-327.

Rekha PN, Singhal S and **Pandit AB. 2004.** Study on degradation kinetics of thiamine in red gram splits *(Cajanus cajan* L.). Food Chemistry 85(4):591-598.

Sarkar RK and **Pal PK. 2004.** Effect of intercropping rice *(Oryza sativa)* with groundnut *(Arachis hypogaea)* and pigeonpea *(Cajanus cajan)* under different row orientations on rainfed uplands. Indian Journal of Agronomy 49(3): 147-150.

Saxena SK, Bajpai GC, Roy D and **Gangwar LK. 2004.** Intergenotypic competition in pigeonpea. Legume Research 27(2):94-98.

Shafeek MR, El-Zeiny OAH and **Ahmed ME. 2004.** Pigeonpea *(Cajanus cajan)* growth and yield as affected by the interaction between bio and organic fertilizers. Annals of Agricultural Science 49(2):619-630.

Shrivastava GK, Lakpale R, Choubey NK and **Singh AP. 2004.** Productivity and economics of pigeonpea *(Cajanus cajan)* + urdbean *(Phaseolus mungo)* intercropping system under various planting geometry and fertilizer management in rainfed condition of Chhattisgarh. Indian Journal of Agronomy 49(2): 101-103.

Singh DK and **Agrawal RL. 2004.** Nitrogen and phosphorus nutrition of pearl millet *(Pennisetum glaucum)* grown in sole and intercropping systems under rainfed conditions. Indian Journal of Agronomy 49(3): 151—153.

Singh J and **Bajpai GC. 2004.** Pollen germination and pollen tube growth studies in interspecific crosses of pigeonpea *(Cajanus cajan* (L.) Millsp). Indian Journal of Genetics and Plant Breeding 64(2): 153-154.

Singh ND, Sahoo L, Saini R, Sarin NB and **Jaiwal PK. 2004.** In vitro regeneration and recovery of primary transformants from shoot apices of pigeonpea using *Agrobacterium tumefaciens.* Physiology and Molecular Biology of Plants 10(1):65-74.

Singh RP, Singh T, Singh Y and **Singh SR. 2004.** Production potential of pigeonpea *(Cajanus cajan)* plus rice and okra intercopping on rainfed uplands of eastern Uttar Pradesh. Indian Journal of Dryland Agricultural Research and Development 19(2): 168-171.

Sreekant M, Sreeramulu M, Rao RDVJP, Babu BS and **Babu TR. 2004.** Effect of intercropping on Thrips palmi (Karny) population and peanut bud necrosis virus (PBNV) incidence in mung bean *(Vigna radiata* L. Wilczek). Indian Journal of Plant Protection 32(l):45-48.

Sreekanth B, Khetarpal S and **Srivastava GC. 2004.** Nature and mode of regeneration in cotyledonary nodal explants of pigeonpea. Indian Journal of Plant Physiology (New Series) 9(2):132-135.

Srinivasan T, Verma VK and **Kirti PB. 2004.** Efficient shoot regeneration in pigeonpea *Cajanus cajan* (L) Millsp using seedling petioles. Current Science 86(1):30—32.

Suhas Y, Patil BV and **Lingappa S. 2004.** Effect of different adjuvants in enhancing the efficacy of HaNPV against *Helicoverpa armigera* (Hubner) infesting pigeonpea. Indian Journal of Pulses Research 17(1): 103 -104.

Sunidhi Singh P and **Parmar U. 2004.** 14C-Glutamine translocation in the developing pods of pigeonpea *(Cajanus cajan* M. Millsp.) in relation to plant growth regulators. Indian Journal of Ecology 31(1):52-53.

Tomar J, Singh HB, Vivek and **Tripathi SS. 2004.** Integrated weed management in intercropping of mung bean *(Vigna radiata)* and cowpea fodder (*Vigna unguiculata)* with pigeonpea (*Cajanus cajan*) under Western UP condition. Indian Journal of Weed Science 36(1-2): 133-134.

Vaithiyalingan M. 2004. Effect of 2,4-d and casein - hydrolysate on callus induction and differentiation in pigeonpea *(Cajanus cajan).* Journal of Ecobiology 16(2): 119-122.

Venkateswarlu B. 2004. Response of green gram and pigeonpea to Bradyrltizobium-inoculation and soil moisture conservation practice. Indian Journal of Microbiology 44(3):215-218.

Wendt JW and **Atemkeng IMF. 2004.** Soybean, cowpea, groundnut, and pigeonpea response to soils, rainfall, and cropping season in the forest margins of Cameroon. Plant and Soil 263(1/2): 121-132.

Yadav GS. 2004. Evaluation of new insecticides/chemicals against pod borer and pod fly on pigeonpea. Annals of Biology 20(1):55-56.

Notes

RA-00420

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR).

Contact information:

ICRISAT-Patancheru (Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 30713071
Fax +91 40 30713074
icrisat@cgiar.org

Liaison Office
CG Centers Block
NASC Complex
Dev Prakash Shastri Marg
New Delhi 110 012, India
Tel +91 11 25849552/25842553
Fax +91 11 25841294

ICRISAT-Nairobi
(Regional hub ESA)
PO Box 39063. Nairobi, Kenya
Tel +254 20 7224550
Fax +254 20 7224001
icrisat-nairobi@cgiar.org

ICRISAT-Niamey
(Regional hub WCA)
BP 12404
Niamey. Niger (Via Paris)
Tel +227 722529, 722725
Fax +227 734329
icnsatsc@cgiar.org

ICRISAT-Bamako
BP 320
Bamako, Mali
Tel +223 2223375
Fax +223 2228683
icrisat-w-mali@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776
Bulawayo, Zimbabwe
Tel +263 83 8311 to 15
Fax +263 83 8253/8307
icrisatzw@cgiar org

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265 1 707297/071/067/057
Fax +265 1 707298
icrisat-malawi@cgiar.org

ICRISAT-Maputo
c/o INIA Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258 1 461657
Fax +258 1 461581
icrisatmoz@panintra.com

visit us at www.icrisat.org

ISSN 1023-4861

63-2005