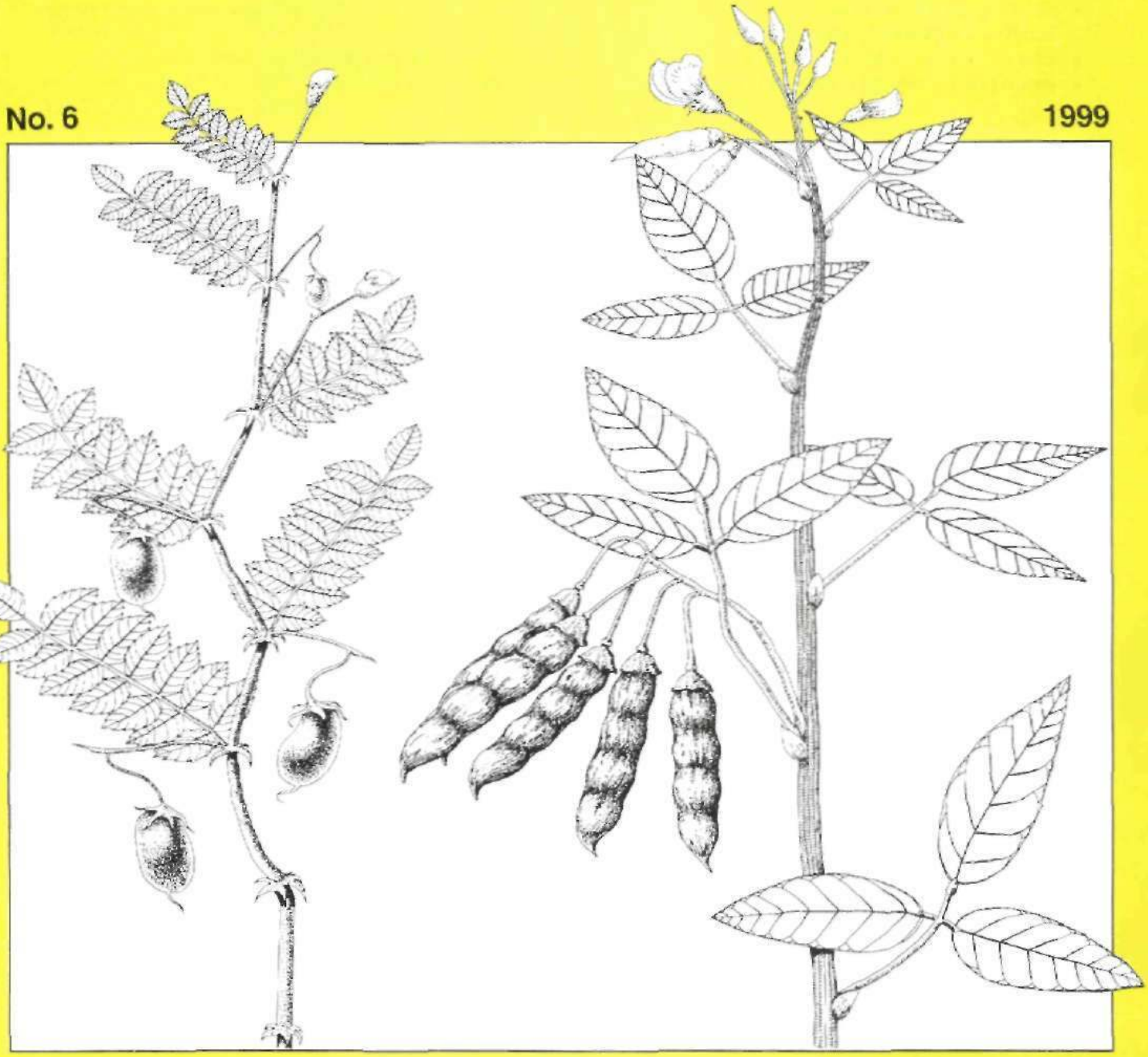
International Chickpea and Pigeonpea Newsletter

No. 6 1999



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 [*Cqjanus 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).
- If necessary, include one or two small tables (and no more). Supply only the essential information; round off the data-values to just one place of decimal whenever appropriate; choose suitable units to keep the values small (e.g., 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-mrn 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. Please 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 and requests for inclusion in the mailing list should be mailed to:

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From the Editor

Welcome to the 1999 issue of the *International Chickpea and Pigeonpea Newsletter* (*ICPN* 6). *ICPN* 6 contains nearly 40 papers covering all aspects of production and utilization of chickpea and pigeonpea. The report on the significant positive effect of seed priming on chickpea yields in Bangladesh is an exciting one. In addition to the wide disciplinary coverage there is also wide geographic coverage with authors from more than 9 countries in Asia, Africa, America, and Europe represented in this issue.

Dr N Said Silim will be the new editor and Dr B Richard Jones will assist him as coeditor for *ICPN* in 2000 and I wish both these colleagues well. I know that both they and *ICPN* will be able to count on the continued support of readers and contributors. Please note the changed mailing address given on the cover verso. I would like to thank the contributors for making the newsletter such an interesting publication. Also I would like to acknowledge the contribution of the following reviewers to the current issue of *ICPN:* V Anjaiah, S Chandra, Y S Chauhan, C T Hash, C Johansen, Jagdish Kumar, P K Joshi, N Mallikarjuna, G V Ranga Rao, L J Reddy, O P Rupela, N P Saxena, K B Saxena, S D Singh, H C Sharma, K K Sharma, S B Sharma, and R P Thakur. I would like to acknowledge the contribution of Library and Documentation Services, 1CRISAT, for compiling the list of publications on chickpea and pigeonpea based on ICRISAT's electronic bibliographic database SATCRIS—the Semi-Arid Tropical Crops Information Service.

We welcome contributions on chickpea and pigeonpea in various production systems and also your suggestions for future issues of *ICPN.*

J V D K Kumar Rao

News

About Chickpea and Pigeonpea Scientists

P K Mukherjee, Scientific Officer E, Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Mumbai, has been conferred with the prestigious Pran Vohra Award for 1998-99 by the Indian Science Congress Association on 5 Jan 1999 at Chennai, India. The award, which carries a citation and a cash prize of Rs 10 000 honors talented young scientists below 35 years, who have made a significant research contribution to agricultural sciences. Mukherjee was recognized for his outstanding work in the biological control of plant diseases.

K S Chhabra, who retired as Senior Entomologist (Pulses), Punjab Agricultural University (PAU), Ludhiana, Punjab, India, after serving PAU for 32 years, has been nominated by the Indian Council of Agricultural Research (ICAR) as a Member of the Research Advisory Committee (RAC) of the Indian Institute of Pulses Research (IIPR), Kanpur for a period of 3 years beginning October 1998.

Chhabra, who retired as Senior Entomologist (Pulses), Punjab Agricultural University, Ludhiana, after 20 years of research on Pulse Entomology, has been reappointed as Professor Emeritus (Entomology) to work on the project "Advances in pest management in grain legume crops—*Vigna* spp and chickpea'' with headquarters at PAU, Ludhiana. The project has been funded by the Department of Science and Technology, Government of India, New Delhi.

M M Pathak, Department of Genetics and Plant Breeding, C S Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India, took over as Economic Botanist (Legumes) effective 18 Dec 1998 in place of M P Gupta, who expired on 13 Dec 1998.

J P Yadavendra, Research Scientist (NARP), has moved from Agricultural Research Station, Gujarat Agricultural University (GAU), Derol, Gujarat, India, to B.A. College of Agriculture, GAU, Anand, Gujarat, India, as Professor and Head, Department of Plant Breeding and Cytogenetics.

AGRITECH '99 - Israel

The 14th staging of the world's leading tri-annual agricultural exhibition, AGRITECH '99, is to be held from 5 to 9 Sep 1999 at Haifa in Israel. AGRITECH 99 offers an established forum in which to meet, do business, and discuss various aspects of business-oriented agroproduction with leading agricultural experts from all over the world.

AGRITECH '99 will cover the most comprehensive and up-to-date agricultural exhibitions including: Irrigation and Fertigation Technology; Water Management—Waste Water Recycling, Filtration, Drinking Water Treatment; Greenhouses—Structures, Equipment, Plastic Sheeting and Automation; Horticulture, Dairy Farming, Sheep and Goat—Computerized Milking Systems, Breeding, Feeding Systems; Integrated Solutions, Biotechnology; Seeds and Propagation Materials—Planting, Tissue Culture and Transplanting Systems, Vegetables, Floriculture, Plasticulture, Fruits and Citrus; Poultry Farming—Breeding Equipment, Feeding Systems and Integrated Solutions, Field Crops; Aquaculture—Breeding Equipment, Feeding Systems and Integrated Solutions; Machinery and Equipment—Advanced Tillage and Minimum Tillage Equipment; Spraying and Harvesting Systems; Sorting, Packing and Transportation Equipment; Chemical and Organic Fertilizer, Food Processing, Computerized Information and Management Systems—Hardware and Software for Agricultural Management and Information Systems, Veterinary and Feeding Systems, and Postharvest Treatment; and Plant Protection—Chemical, Organic and Biological Systems.

For more details contact ORBIT at: (Email) bom@orbit.wiprobt.ems.vsnl.net.in

Bumper Harvest of Pigeonpea in Andhra Pradesh during 1998-99

Pigeonpea is an important grain legume crop under rainfed agriculture in the rainy season in Andhra Pradesh. Annually, it is cultivated on an area of 350 000 ha. In recent years it has been also cultivated in the postrainy season on a small scale (20 000 ha). The production of the crop received a serious setback since 1985 due to the severe incidence of *Helicoverpa* pod borer. Though the yield potential of the crop is around 2.0 t ha^{-1}, farmers have been unable to achieve yields of more than 330 kg ha^{-1}.

However, during the 1998-99 season, pigeonpea productivity in the state was one of the best seen in the past 25 years. As a sole crop, yields ranging from 0.8 to 2.0 t ha^{-1} have been realized; this is close to the potential of the crop. The record yield of the crop during the current season can be attributed to four reasons:

1. Well distributed monsoon rains in the rainy season helped the crop achieve sufficient vegetative growth, even in the light soils. Excess rains did not cause much damage to the crop in black soils. Rather cotton suffered from waterlogging.

2. Due to extended monsoon rains up to late October, the crop did not suffer from terminal moisture stress.

3. *Helicoverpa* incidence was less severe. One reason for the low severity *of Helicoverpa* could be the heavy rains in the rainy season, no rains in the postrainy season and the cool and prolonged winter seems to have helped suppress *Helicoverpa.* Another reason could be the lower level pesticide application in cotton due to rain damage to the crop; consequently, there was lower resistance to pesticide in the *Helicoverpa* population which normally move from cotton to pigeonpea.

4. The intensive campaign launched by Acharya N G Ranga Agricultural University and the Department of Agriculture on IPM of *Helicoverpa* through farmers training programs and on-farm demonstrations.

Submitted by: **M V Reddy** and **C Cheralu** (Regional Agricultural Research Station, Lam, Guntur 522 034, Andhra Pradesh, India)

Views

A Proposal for a Directory of Recombinant Inbred Lines for Chickpea Genome Mapping

Jagdish Kumar[1] and **F J Muehlbauer**[2] (1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India; and 2. USDA-ARS, Department of Crop and Soil Sciences, Washington State University, Pullman, Washington 99164-6434, USA)

A genome map comprising important genes and associated molecular markers would greatly aid the development of high-yielding, stable varieties of chickpea. Simon and Muehlbauer (1997) constructed a *Cicer* map and identified 10 linkage groups consisting of 28 isozyme, 44 RAPD, 9 RFLP, 9 morphological, and 6 other markers. This map is based on studies of F_2/F_3 populations. Since genotypes of early generations are ephemeral, confirmation of the results using the same populations is not possible. Use of recombinant inbred lines (RILs) for the development of such maps is advantageous because data can be recorded from experiments replicated at different locations. Such data can be analyzed and pooled to develop high-density maps. RIL populations have been developed at ICRISAT in India, and USDA-ARS at Washington State University at Pullman, Washington, USA. It would be useful if the information on the available RILs is compiled for use by chickpea researchers worldwide.

We propose to make these RILs (Table 1) available to chickpea researchers for further phenotyping and molecular marker analyses under material transfer agreements, as applicable. The available data already assembled on these lines will be provided electronically. We invite chickpea workers to contribute and share RIL populations they have developed, including available data, with the research community. This approach should expedite the development of a saturated genome map of chickpea.

Ideally, the cross for developing an RIL population should involve a single typical plant or a pure line of each parent. Such parental plant seed should be provided with the RILs for marker studies. About 100 or more lines per population may be enough, but many more may be necessary when analyzing for quantitative trait loci (QTLs).

Reference

Simon, C., and Muehlbauer, F.J. 1997. Construction of a chickpea linkage map and its comparison with maps of pea and lentil. Journal of Heredity 88:115-119.

A Proposal for Chickpea Gene Nomenclature

F J Muehlbauer[1] **and Jagdish Kumar**[2] (1. USDA-ARS, Department of Crop and Soil Sciences, Washington State University, Pullman, Washington 99164-6434, USA; and 2. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India)

Interest in genetics and molecular markers of chickpea (*Cicer arietinum* L) has increased in recent years. Although an integrated linkage map of *Cicer* was published recently (Simon and Muehlbauer 1997), only nine genes were actually located. Many genes that confer various chickpea traits have not been assigned to the eight chromosomes because definite linkages are yet to be established. Allelism tests for presumed new genes also need to be conducted with type lines drawn from earlier studies. Further, where attempts were made to conduct allelism tests, the genetic stocks used in the original studies were either unavailable or showed phenotypes different from those described in

Table 1. Some examples of currently available populations of recombinant inbred lines (RILs) of chickpea.

RIL population	Institution		No. of lines	Major trait
ICCV 2 x JG 62	ICRISAT		116	Fusarium wilt
ICC 4958 x C. *reticulatum*	USDA-ARS at WSU		132	Root volume
C 104 x WR 315	USDA-ARS at	WSU/ICRISAT	184	Fusarium wilt
ICC 4958 x Annigeri	ICRISAT		250	Root volume
ICC 1069 x Syrian Local	ICRISAT		83	Ascochyta blight
FLIP 84-92C x C. *reticulatum*	USDA-ARS at WSU		215	Ascochyta blight
ICCV 2 x ICCV 93929	ICRISAT		92	Fusarium wilt/Chilling

the literature (Kumar 1997). Already a number of studies have allotted new symbols to genes without checking their allelic relationships against those identified for the same traits in earlier studies (Muehlbauer and Singh 1987).

Much work is therefore still needed on the genetics of *Cicer* to identify useful new morphological markers, to construct accurate linkage groups, and to identify a standard karyotype. To achieve these objectives, chickpea geneticists must organize and coordinate efforts on the lines of what has been done for *Pisum* (Blixt et al. 1977). In this note we propose that a Chickpea Genetics Association (CGA) be formed to organize and establish rules for the maintenance and use of genetic stocks and to develop standard nomenclature for chickpea gene symbols.

The *Pisum* Genetics Association (PGA) has developed a policy for the nomenclature of newly discovered genes (Blixt et al. 1977). A worker who identifies a new gene submits the evidence and the proposed symbol to a registration authority. Based on the evidence, this authority registers the new gene, provided the symbol is not already in use. Otherwise an alternative symbol is mutually agreed upon. Approved symbols are then announced in their annual newsletter. The International Chickpea and Pigeonpea Newsletter could perform that function. A small group of knowledgeable chickpea geneticists should act as facilitators to initiate this process.

The following rules for genetic symbols, abstracted from the PGA (Blixt et al. 1977), may be considered:

a. A gene symbol should consist of a base of one to three letters to which superscripts may be appended.

b. Genes that are allelic shall be symbolized with the same base letter(s) so that each gene locus will be designated by a characteristic symbol base.

c. Alleles derived by separate mutational events at a particular locus, but which have identical phenotypes, should be designated by the same symbol.

d. The first pair of alleles reported for a gene locus shall be differentiated by capitalizing the first letter of the symbol for the dominant or partially dominant allele.

e. When more than two alleles exist for a locus, the additional alleles, or those symbolized subsequently to the pair first published, shall be differentiated by adding one or more lower case letters as a superscript to the base (e.g., Cry, Cry^{c}, Cry^{s}). Subscripts, either as numbers or letters, should not be used.

f. Gene pairs with the same or similar effects should be designated with the same letter base differentiated by numerals (e.g. Chi-1, Chi-2, ...). This is the only permitted use of numerals.

g. When feasible, base letters shall be chosen so as to indicate apparent relationships among traits by using common initial letters for all loci in a related group of traits. For example, the wax genes in *Pisum* all begin with the letter w.

h. A hyphen may be used in place of a gene symbol to represent any allele at the indicated locus (for example: A- or A/- represent both A/A and A/a),

Rules for linkage groups and chromosomes, cytoplasmic factors, validity of symbols, type lines, and status of symbols are also described. Of these, type lines are of the most immediate importance to prevent the loss of genes and to provide interested workers with particular genes in the appropriate genetic background to ensure expression.

The following rule for type lines was adopted by the PGA: A type line shall be assigned for each newly described allele and such lines shall be safely maintained, preferably at two or more locations. The type line may be the line in which the character was first isolated and analyzed, but when this is not possible, an appropriate representative line shall be designated. Authors claiming the discovery of a new gene and proposing a gene symbol are expected to make available seed of the mutant to qualified researchers through working collections maintained at national or international genetic resource centers. A symbol without the mutant itself is of no value.

There is a clear need for rules concerning genetic symbolization in chickpeas. This can be achieved by a working committee of chickpea geneticists. It is imperative that such a committee be formed so that clear conventions can be developed and implemented.

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Research Reports

Chickpea

Breeding/Genetics

ICCX 810800—a New High-yielding, Ascochyta Blight-resistant Chickpea Variety for the Low and Mid Hills of Himachal Pradesh, India

K S Panwar, A Singh, and **A Sirohi** (Himachal Pradesh Krishi Vishvavidyalaya, Research Sub-station, Berthin 174 029, Himachal Pradesh, India)

Chickpea is a major postrainy season pulse crop in the low and mid hills of Himachal Pradesh. Ascochyta blight caused by *Ascochyta rabiei* is the disease most commonly responsible for decline in yield (Singh and Sood 1990). Furthermore, a wide fluctuation in climatic conditions and poor adoption of existing varieties result in low average yield. Breeding for high yield and disease resistance is the most effective method to overcome these constraints. The Pulse Research Station, Berthin, Himachal Pradesh Krishi Vishvavidyalaya (HPKV), has identified a small-seeded, ascochyta blight-resistant chickpea cultivar, ICCX 810800, which possesses a stable and a high yield level. It was originally received from ICRISAT in 1991-92 in an Ascochyta Blight Nursery (ABN) as ICCX 810800-3H-BW-BH-1H-1H-BH.

The yields of ICCX 810800 and two other recommended varieties—C 235 and HPG 17—in experimental trials conducted in a randomized block design at Berthin from 1991 to 1996-97 are summarized in Table 1. (Data of 1991-92 and 1995-96 were not considered due to poor plant stand.) In these trials, ICCX 810800 gave an average yield of 1920 kg ha^{-1} as compared to 1020 kg ha^{-1} of C 235 (small seeded) and 1590 kg ha^{-1} of HPG 17 (bold seeded), thus reflecting an 87% yield increase over C 235 and 20% over HPG 17.

Similarly in 10 on-farm trials conducted on farmers' fields in Zone 1 of the state during 1994-95 and 1995—96, ICCX 810800 gave a mean grain yield of 1090 kg ha^{-1} against 640 of C 235 and 900 kg ha^{-1} of HPG 17 (Table 2). The performance of ICCX 810800 has also been tested on farmers' fields under a pilot project of HPKV, Palampur (Zone II) during 1996-97 at six locations. The data revealed that ICCX 810800 gave a mean yield of 680 kg ha^{1} as compared to 500 kg ha^{-1} of C 235 and 370 kg ha^{-1} of HPG 17.

Over a period of 6 years, ICCX 810800 has exhibited stable resistance to ascochyta blight under artificial inoculation (Table 3). The screening was done using a field screening technique developed by Nene et al. (1981). C 235 and HPG 17 are the only recommended varieties for Zone I and both are either susceptible or moderately susceptible to *Ascochyta rabiei;* therefore, ICCX 810800 reported an alternative which exhibited resistance to *A. rabiei* in this region. The line also showed resistance to Ascochyta blight at Ludhiana and moderate resistance at Gurdaspur (Punjab), Hisar (Haryana), R.S. Pura (Jammu and Kashmir), and Sriganganagar (Rajasthan) (Haware et al. 1994). The grain color and grain type of ICCX 810800 are very attractive type and color. Its cooking quality is comparable to C 235. In view of its disease resistance, high grain yield, and better consumer preference,

Table 1. Yield (kg ha^{-1}) of three chickpea varieties at Berthin, Himachal Pradesh, India, postrainy season 1992-97.

Variety	1991/92	1993/94	1994/95	1996/97	Mean	Percent increase in yield over C 235	Percent increase in yield over HPG 17
ICCX 810800	2250	2180	1520	1720	1920	87	20
C 235	1780	700	610	1010	1020		
HPG 17	1980	1660	1350	1370	1590		
CD (0.05)		365	398	601			

1. Not estimated.

Table 2. Performance of ICCX 810800 in farmers' fields in Zone I of Himachal Pradesh, India.

District	Location	Yield (kg ha^{-1})		
		ICCX 810800	C 235	HPG 17
Postrainy season 1994/95				
Bilaspur	Ladhyani	1000	640	800
	Auhar	600	720	720
Una	Una	1025	725	950
Solan	Nalagarh	300	104	186
Mandi	Tatar	1690	-[1]	1520
Postrainy season 1995/96				
Bilaspur	Sunhani	1425	375	700
	Mohin	1290	725	800
	Bargaon	1410	712	770
Una	Badhera	1425	950	1370
Hamirpur	Daberkaluon	750	800	1200
Mean		1090	640	900

1. Not estimated.

Table 3. Reaction of chickpea genotypes to *Ascochyta rabiei* under artificial inoculation at Berthin, Himachal Pradesh, postrainy season 1991-97.

Genotype	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
ICCX 810800	R[1]	R	MR	MR	R	R
C 235	S	S	S	S	S	S
HPG 17	MS	MR	MS	MS	MS	MS

1. Rating scale: R = resistant (<3); MR = moderately resistant (3.1-5); MS = moderately susceptible (5.1-7); and S - susceptible (7.1-9).

ICCX 810800 has proved superior to recommended varieties C 235 and HPG 17 and is thus proposed for release in Zone I of Himachal Pradesh,

References

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Phenotypic Stability among Kabuli Chickpea Genotypes for Three Cooking Quality Attributes

I S Mehla[1], R S Waldia[2], V P Singh[3], and V S Lather[4]
(1. Regional Research Station, Uchani, Karnal, Haryana, India; 2. Krishi Vigyan Kendra, Sonipat, Haryana, India; and 3. Chaudhury Charan Singh Haryana Agricultural University (CCS HAU), Hisar 125 004, Haryana, India)

For wider adaptation, the stability of various parameters of a given genotype is essential. Most studies on chickpea have been confined to the phenotypic stability of morphological characters in the desi types. Similar studies on cooking quality attributes have not attracted attention. Seed mass, volume, and cooking time, which are important attributes of cooking quality in kabuli chickpea (Waldia et al. 1996), have been reported to be positively correlated with each other (Williams et al. 1983; Badshahetal. 1987).

Fifty-five kabuli chickpea genotypes were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA), 1CRISAT, chickpea centres of India, and CCS HAU, Hisar, India. These were grown in four different environmental conditions generated over two years (1993/94 and 1994/95 postrainy seasons) and planting at two sowing dates in each season. Seeds from each genotype were harvested and observations recorded on 100-seed mass (g), seed volume (mL), and cooking time (minutes). The stability parameters, viz., per se performance (X), regression coefficient (pi) and individual mean square deviation from linear regression (S^2 di) of all genotypes for the three cooking quality attributes were computed following the model suggested by Perkins and Jinks (1968). According to this model a genotype is considered to be stable if its ßi and $\bar{S}^2$ di values are both not statistically different from zero.

The results on stability parameters of selected genotypes are presented in Table 1. For 100-seed mass, the genotypes GNG 827, HK 92-97, HK 92-106, HK 92-110, ICARDA-09101, HK 91-111, HK 92-91, and HK 92-95 possessed high seed mass and were stable across the environments. Among the 15 stable genotypes for seed volume, GNG 827, ICARDA-09101 and HK 92-103 also had high seed volume. Therefore, to increase seed mass and volume, GNG 827 and ICARDA-09101 could be used in breeding programs.

For shorter cooking time, the genotypes HK 93-96, HK 92-105, GNG 827, HK 91-163, HK 92-110, HK 92-124, and HK 92-201 were more stable. The genotype GNG 827 seems to have a greater stability for high seed mass, seed volume and shorter cooking time across the environments in which it was grown and therefore, could be useful in crop improvement of chickpea for quality traits.

References

Badshah, A., Ahmed, ML, Aurangzeb, Bibi, N., Mohmmad, T., and Khan, I. 1987. Relationship between physico-chemical characters and cooking time in chickpea *(Cicer arietinum* L.). Pakistan Journal of Scientific and Industrial Research 36:795-798.

Table 1. Stability parameters of important chickpea genotypes for three cooking quality attributes in kabuli chickpea

100-seed mass				Seed volume				Cooking time			
Genotype	$\bar{X}$	ßi	$\bar{S}^2$ di	Genotype	$\bar{X}$	ßi	$\bar{S}^2$ di	Genotype	$\bar{X}$	ßi	$\bar{S}^2$ di
HK 92-91	27.68	0.19	0.61	GNG 827	12.78	0.42*	0.08	HK 91-163	49.58	0.90	1.08
HK 92-95	28.82	-0.42	1.71	ICARDA 09101	12.72	0.34	0.09	HK 92-105	49.75	0.76	0.17
HK 92-97	31.35	0.70**	1.79	HK 92-103	12.91	0.31	0.49	HK 92-110	49.92	2.54**	-0.27
HK 92-106	30.51	0.24	1.34					HK 92-124	48.33	1.75*	0.50
HK 92-110	31.37	0.79	0.59					HK 92-201	45.50	-1.62	1.76
ICARDA 09101	30.33	0.87	1.20					HK 93-96	50.92	-3.29**	1.23
HK 91-111	29.82	-0.55	3.03					GNG 827	54.25	-0.31	1.47
GNG 827	32.29	0.36	2.70								
SE	±1.19	± 0.62			±0.82	±0.60			±2.31	±2.05	

** and * Significantly different from zero at 0.01 and 0.05 level of significance, respectively.

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Bittal 98 (A 16): an Improved Form of the Most Predominant Desi Chickpea Variety C 44

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Bittal 98 or A 16 is an improvement of C44 which is a predominant bold-seeded, high-yielding, blight-tolerant variety covering more than 70% area in the principal chickpea-growing tract of 'Thal' (a rainfed area covered by sand dunes) in Punjab which alone contributes 80% of the chickpea crop grown in the country. C 44 is susceptible to iron-deficiency chlorosis which limits its cultivation in irrigated areas where clay loam soil becomes compact after irrigation/rainfall in the early crop-growth stage. This affects uptake of iron from the soil in varieties susceptible to chlorosis. The primary symptoms of chlorosis are yellowing of young leaves. Severe incidence kills the young shoots and totally destroys plants. Yield losses of 52-100% have been estimated in individual plants affected by chlorosis (Ali et al. 1988c). Varieties resistant to chlorosis have been identified (Ali et al. 1988a) and resistance has been reported to be controlled by a single dominant gene (Ali et al. 1988b; Gowda and Rao 1986) and two recessive genes (Gumber et al. 1997). Since chlorosis can be genetically controlled, we planned to improve C 44 by incorporating resistance to chlorosis, so as to extend its cultivation in the irrigated areas.

A near-isogenic line of C 44, A 16, resistant to chlorosis has been developed by backcrossing using a donor parent C 87 and C 44 as recurrent parent. The cross C 44 x C 87 was made in 1988/89. The Fl was sown in 1989/90, and the Fl male parent was crossed with the recurrent parent. Single plants resistant to chlorosis were selected and crossed with the recurrent parent in BCl to BC3 during 1990/91 to 1992/93. Resistant plants were selected from the BC4 generation during 1993/94. Single-plant progenies were raised and uniform resistant progenies were selected and bulked in 1994/95. The experimental material was sown on clay loam soil at Faisalabad and irrigated twice at seedling stage for full expression of chlorosis. Selections were made for C 44 types possessing resistance to chlorosis and selection pressure was also exerted for bold seeds.

The yield performance of Bittal 98 (A 16) was tested in Station, Multilocation/Adaptation and National Uniform Yield Trials conducted througout the country during 1995/96 to 1997/98. Bittal 98 has a yield potential of 3.3 t ha^{-1} and an average yield of 1.6 t ha^{-1}. It yielded 9.6% higher than C 44 under chlorosis-free conditions at Kalurkot in Thal' and 16.9% under chlorotic conditions at Faisalabad in central Punjab (Table 1). Overall, Bittal

Table 1. Yield performance of A 16 (Bittal 98) in comparison with the control varieties C 44 and Pb 91 in different yield trials conducted during 1995/96 to 1997/98.

Type of trials	Year	No. of trials	Yield (kg ha^{-1})		Percent increase over control
			A 16	C 44	
Station Yield Trials					
Rainfed (Kalurkot)	1995/96	13	995	908	+9.6
Irrigated (Faisalaad)	1995/96	10	2677	2289	+ 16.9
National Uniform Yield Trials	1995/96 to 1996/97	17	1384	1111	+25.6
Weighted average			1581	1340	+ 18.0
Multilocation/Adaptation Yield Trials	1995/96 to 1997/98	14	1565	1455	+7.6[1]
Overall weighted average		54	1577	1370	+ 15.1

1. Pb 91 was used as control.

98 yielded 18% higher than C 44 and 7.6% higher than Pb 91 (a chlorosis-resistant variety released in 1991).

The agronomic requirements of Bittal 98 are the same as those of C 44. It was rated as moderately resistant to Ascochyta blight under artificially created blight epiphytotic conditions in 1995/96 and moderately resistant to Fusarium wilt in simulated wilt-sick plot conditions, during 1997/98. Its 100-seed mass is 28.7 g, 24.8% higher than the 23 g of C 44. Bittal 98 has the boldest seed size among the varieties ever released in the province and has the potential to replace the predominant variety C 44 due to its adaptability under both irrigated and rainfed conditions in Punjab.

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CM 98 (CM 31-1/85): a Very High-yielding, Disease-resistant Mutant Variety of Chickpea

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Ascochyta blight, which causes widespread damage to crops, is the major limiting factor to chickpea production in Pakistan.. The disease caused yield loss of nearly 50% in Pakistan from 1979/80 to 1981/82 (PARC 1981). There is an acute need for varieties resistant to blight and wilt diseases. In Pakistan, in the early days, plant breeding for resistance to blight focussed mainly on the introduction of the exotic resistant line F8 and its subsequent use in the hybridization program by the classical single-cross method. Some blight-resistant varieties like C 12/34, C 612, and C 727 were developed but they were useful for a limited period of time and only in limited areas. The progress in breeding suitable high-yielding blight resistant varieties was slow because: 1) good sources of resistance were not available among the agronomically better local cultivars, and 2) the few available exotic resistant lines were poor in plant type and production, and were restricted in adaptation.

The Nuclear Institute for Agriculure and Biology (NIAB), initiated a program to induct new sources of resistance and to improve resistance against Ascochyta blight through the use of gamma radiation and chemical mutagen. Worthwhile genetic variability has been created both in desi- and kabuli-type chickpea. An Ascochyta blight-resistant and high-yielding variety, C 72, a 15 kR gamma-ray-induced mutant of genotype 6153; was released in 1983 (Haq et al. 1983; 1988). Ascochyta blight-resistant, high-yielding mutant CM 1918, also a derivative of genotype 6153, developed at NIAB, has been approved for commercial cultivation in the North West Frontier Province (NWFP) as NIFA 88 (NIAB 1992). As a result of efforts to induce blight resistance in different genetic backgrounds other than 6153 to produce alternate sources of resistance, mutant CM 88 has been derived from C 72. CM 88, a 10 kR gamma-ray-induced mutant, was released in 1994. The cultivation of resistant varieties has helped greatly to stabilize chickpea production in the country. Since their release no serious blight epidemic has been reported in the country (NIAB 97).

The breeding efforts of the chickpea group at NIAB have resulted in the release of yet another new high-yielding and disease-resistant variety, CM 98. The Punjab Seed Council, in its 21st meeting held on 10 November 1998 at Lahore, approved this variety for general cultivation.

CM 98 was developed by creating genetic variability through the use of gamma radiation in a widely adapted, high-yielding, blight-susceptible variety, K 850. Air-dried seeds of K 850 were exposed to gamma irradiation of 300, 350 Gy to raise the MI generation during 1984/85. Screening of M2 segregating material was done in the Ascochyta Blight Nursery (ABN) at NIAB and disease-resistant mutants were selected from among only those exhibiting a 3-5 rating on a 1-9 scale, where I was no visible lesion and 9 was complete death of the plant. The

Table 1. Yield performance of CM 98 in multilocational trials, Pakistan, 1991-92/1997-98.

Year	Type of trial	No.of locations	Average yield (kg ha^{-1})	
			CM98	Control
1991/92	Cooperative Yield Trials	3	1904	1727
1992/93	Cooperative Yield Trials	4	1957	1773
1993/94	Cooperative Yield Trials	4	2352	1902
1994/95	Cooperative Yield Trials	4	1511	1327
	National Yield Trials	6	1274	1243
1995/96	Cooperative Yield Trials	5	1771	1482
	National Yield Trials	4	2041	1625
	Varietal Yield Trials	2	2305	1722
1996/97	Cooperative Yield Trials	3	1518	1388
	National Yield Trials	7	1258	1022
	Varietal Yield Trials	2	2278	1770
1997/98	Varietal Yield Trials	2	2446	1722
Mean			1885	1559

selected mutants were further screened for 3 years in the ABN and ultimately 13 mutants were selected. During 1989-90 these mutants were evaluated in yield trial conducted at N1AB and five top yielders were selected. During 1990-91, promising mutants were evaluated for yield and disease resistance. The yield performance of CM 98 in various trials conducted from 1991/92 to 1997/98 is summarized in Table 1. In 46 trials conducted at different locations, CM 98 recorded a mean seed yield of 1885 kg ha^{-1} compared with 1559 kg ha^{-1} of the best control varieties (Pb 91 and C 44) reflecting an increase of 20.9%.

CM 98 is resistant to Ascochyta blight and Fusarium wilt under artificially created blight-epiphytotic and wilt-sick conditions. CM 98 is recommended for cultivation in irrigated and *barani* areas of Punjab province.

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Pathology

Effect of Various Sowing Depths on Wilt Incidence of Chickpea in a Wilt-sick Field in Pakistan

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Chickpea wilt caused by *Fusarium oxysporum* f. sp. *ciceri* (FOC) is the second most important disease of chickpea in Pakistan. It has reduced the share of chickpea on irrigated lands from 50% in the 1950s to only 10% in the 1990s. Deep sowing of chickpea is one of several suggested control measures recommended to combat Fusarium wilt (Singh and Sandhu 1973). However, no systematic data is available to correctly assess the impact of this measure. The present study was carried out to investigate the effect of different depths of sowing on the incidence of wilt on chickpea cultivar Aug 424 (a highly wilt-susceptible cultivar) sown in a wilt-sick field.

Chickpea seed was sown on 25 Oct 1995 in a sandy clay loam field (pH 7.5) at five different depths; 5, 10, 15, 22.5, and 30 cm. Interrow spacing was 30 cm and intrarow spacing was 15 cm. Up to 5 cm depth, seeds were sown using a dibbler and at lower depths with a 4.5 cm diameter soil sampler. Soil was taken out using the soil sampler and placed back with the minimum possible disturbance after the seeds were sown. The number of FOC propagules per gram soil was measured in 10 g representative soil samples, taken from a 1-kg composite sample of each depth collected from five different locations in the field. The soil sample was placed in a 250 mL Erlenmeyer flask containing 90 mL distilled sterilized water. The flask was shaken throughly for 5 min and serial dilutions were made. One milliliter aliquot of each dilution was plated on Km medium (Komada 1975). Plates were incubated at ambient temperature (25 + 3°C) in diffused sunlight and the identification of the isolate as *Fusarium oxysporum* was confirmed on carnation leaf agar medium (Fisher et al. 1982) with a slight modification in the technique. Instead of radio sterilization, leaf cuttings were autoclaved at 121°C for 15 min in 2% plain agar medium. The pathogenicity of randomly selected isolates from the wilt-sick field (10 from each depth) was tested by the test-tube inoculation method (Nene et al. 1981). Soil temperature at various depths during the growing season at Faisalabad was recorded by burying the stainless steel stem of dial scale thermometers. Air temperature was recorded by hanging a thermometer in a perforated wooden box placed 3 feet above the soil surface. Seedling emergence was recorded up to the fourth week of Nov 1995, early wilt incidence up to the fourth week of Dec 1995, and late wilt from first week of Jan to fourth week of Mar 1996.

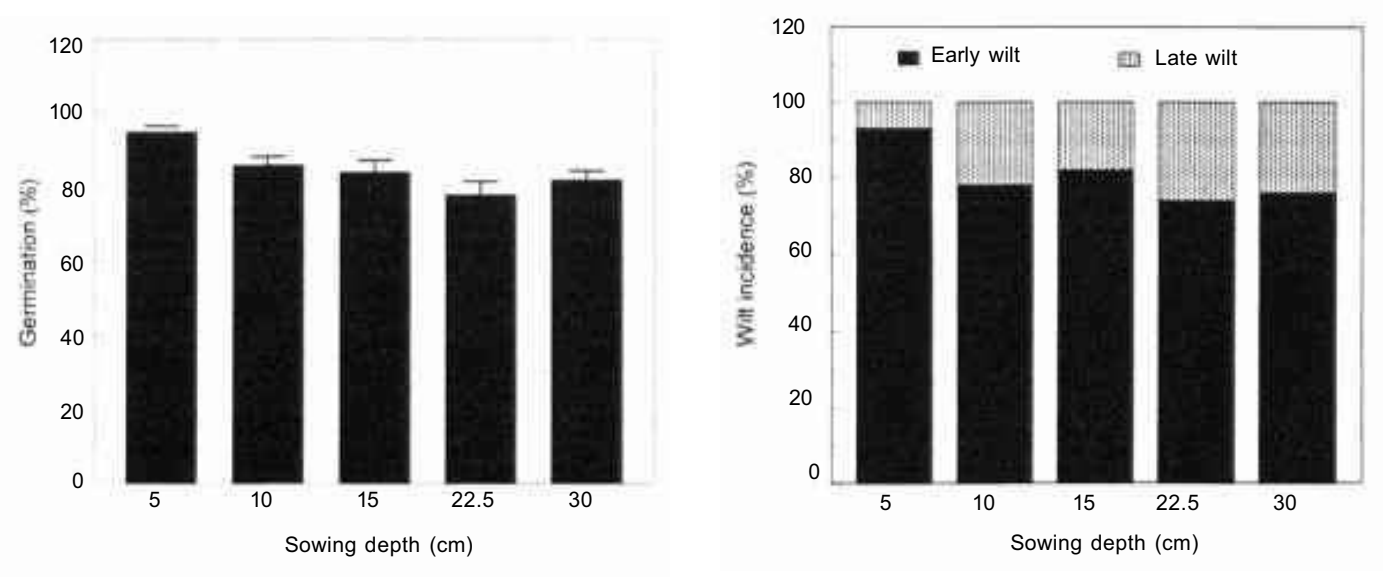

Figure 1. Effect of different sowing depths on germination and wilt incidence in chickpea cv Aug 424 sown in a wilt-sick plot at Faisalabad, Pakistan.

Seedling emergence started one week after sowing from 5 cm depth, a day later in the case of 10 and 15 cm depths, and two days later in the case of 22.5 and 30 cm depths. However, the differences in time to emergence from sowings at 10-30 cm depths were not significant.

Diurnal fluctuations in the temperature of deeper soil were minimal. At depths of 10 cm and below, the soil temperature remained at less than 25°C (25°C is the optimum temperature for the development of chickpea wilt) throughout the growing season, i.e., 1 Nov to Mar end (data not shown). The number of FOC propagules also decreased with increasing depth (Table 1). About 60-90% of the isolates from the wilt-sick field were found to be pathogenic. The ratio of pathogenic isolates recovered from the upper layer was higher and it decreased with increasing depths. Early wilt incidence was quite high at all sowing depths (almost 80% or more). It was comparatively lower in deep sowings (10-30 cm) than in shallow sowings (5 cm); however, the difference among the deep sowings was not significant. The total wilt incidence (early + late) was 100% in all the treatments (Fig. 1) resulting in a total loss of yield.

We observed that at normal sowing depths (5-7 cm) the secondary roots generally originate only from the cotyl region in the early stages of plant growth. The probable infection sites are hypocotyl and 4 mm above the root tips (Beckman 1987). Therefore, at greater sowing depths the probable infection sites are exposed to fewer FOC propagules (Table 1) and unfavorable temperature (less than 25°C). The optimum conditions for wilt-disease development are reported to be: 1000 propagules of FOC g^{-1} soil at 25°C (Bhatti and Kraft 1992). On the basis of these facts, and according to Singh and Sandhu (1973), the wilt incidence (particularly early wilt) in deep sowing should have decreased even in such a highly susceptible cultivar as Aug 424. But in this experiment the wilt incidence was 100% with no yield, and even early wilt incidence was quite high, i.e., 80% or more in all the depths (Fig. 1). Moreover, wilt appeared earlier in deep than shallow sowings.

The plausible explanation for such a high wilt incidence in deep sowings may be due to the production of fresh secondary roots from the collar region (3-10 cm below the soil surface) after 6-7 days of seedling emergence, thus making the susceptible sites available in high FOC inoculum zones. The earlier onset of wilting in deep sowings than in shallow sowings may have been due to etiolytic growth, greater elongation of the epicotyle is required (for emergence of chickpea in deeper sowings than in shallow sowings) which weakened the plant tissue, and needed less fungal biomass to make the plant wilt.

We conclude that deep sowing had no effect on reduction of FOC wilt incidence in a susceptible variety of chickpea.

Table 1. Presence of *Fusarium oxysporum* propagules at various depths in wilt-sick and normal (cultivated) fields, Faisalabad, Pakistan, 1995.

Soil depth (cm)	Fungal propagules g^{-1} of soil in Wilt-sick field	Normal field[1]
0	5×10^3	1.4×10^2
5	2×10^3	2×10^2
10	3.4×10^2	7.5×10^1
15	3.2×10^2	1.2×10^1
22.5	7.1×10^1	-[2]
30	5	-

1. Chickpea was not grown in this field for the last 25 years.
2. No fungal propagule was detected.

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Identification of Resistance to Botrytis Gray Mold in Chickpea

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Botrytis gray mold (BGM) caused by *Botrytis cinerea* Pers. is an important disease of chickpea in northern India, Nepal, Bangladesh, and Pakistan. It has been known to occur in India since 1915 (Shaw and Ajrekar 1915) but assumed significance after an occurrence of an epiphytotic in Nainital *Tarai* in 1967/68. Since then it has caused widespread devastation in parts of northern India (Singh 1985).

There is a dearth of resistant lines that could be used in a hybridization program. Therefore, 419 germplasm lines/cultivars of chickpea were screened for their reaction to BGM during the 1996/97 postrainy season at Pantnagar, Uttar Pradesh, India. Entries were sown on 29 Nov 1996 in a single-row plot of 2 m length. H 208 was used as susceptible control. Interrow spacing was 60 cm and intrarow spacing was 10 cm. Each line was scored for BGM on a rating scale of 1-9, where 1 = highly resistant, 3 = resistant, 5 = moderately resistant, 7 = susceptible, and 9 = highly susceptible. The scoring was done on 9 Apr 1997 when the disease was most severe. Only one genotype, GPC 14, had a score of 1, and 10 lines/cultivars were moderately resistant with a score of 5 (Table 1). Fifty-one lines/cultivars were susceptible and 357 were highly susceptible. Twelve genotypes, including the susceptible control H 208, GPC 14, and 10 with a score of 5 were sown on 26 Nov 1997 to be retested against BGM. There were two replications. The disease severity was recorded on 3 Apr 1998. The mean disease score along with pedigree/identity and origin of these entries and susceptible control are given in Table 1. GPC 14, HIMA and P 6223 were in the resistant category with scores of 2, 3, and 3 respectively. GPC 14 being BGM-free in 1996/97, and with a score of 2 in 1997/98, appears to have good level of resistance to BGM at Pantnagar. This line should be used to incorporate resistance into elite breeding materials.

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Table 1. Pedigrees, origin and BGM scores of 11 promising lines/cultivars of chickpea in 1996/97 and 1997/98 growing seasons at Pantnagar, Uttar Pradesh, India.

Line/cultivar	Pedigree/identity	Origin	BGM score during 1996/97	BGM score during 1997/98
GPC 14	-[1]	-[1]	1.0	2.0
JG 74	ICC 6098	Madhya Pradesh, India	5.0	4.0
ICC 799	P630-2	ICRISAT, India	5.0	6.0
ICC 12275	ICC- 11531 WR	ICRISAT, India	5.0	7.0
ICCV 10	P 1231 x P 1265	ICRISAT, India	5.0	4.0
ICCX 790197	ICC 4 x ICC 506-EB	ICRISAT, India	5.0	5.0
HIMA	ICC 4957	Punjab, India	5.0	3.0
No-501	ICC 4983	Punjab, India	5.0	4.0
P 855	ICC 1025	Algeria	5.0	5.0
P 1357	ICC 1622	Uttar Pradesh, India	5.0	7.0
P 6223	ICC 4631	Uttar Pradesh, India	5.0	3.0
H 208 (Control)	(S 26 x G 24) x C 235	Haryana, India	9.0	7.0

1. Not known.

Screening Chickpea for Resistance to Wilt Disease in Gujarat, India

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Of the many diseases that chickpea crop suffers from, Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri)* is the most destructive, resulting in considerable crop loss every year in Gujarat. Several chickpea lines were screened in a wilt-sick plot to identify wilt-resistant lines at Junagadh. More than 60 diverse chickpea lines developed at Pulses Research Station, Junagadh were tested in a wilt-sick plot for 3 years (1994-96). Each genotype was sown in a 2 m-long plot with interrow spacing of 30 cm and plant-to-plant spacing of 10 cm. There were two replications. JG 62 was used as the susceptible control. The resistance screening technique described by Nene et al. (1981) was used. Observations on seedling emergence were recorded 2 weeks after sowing. Wilt incidence was recorded at monthly intervals till crop maturity.

In all three seasons, average wilt incidence was less than 30% in GCP 9302, GCP 9310, and GCP 9313 (Table 1). The popular varieties Chaffa and Dahod yellow showed 98.3 and 53.2% wilt incidence, respectively. Other varieties developed more than 30% average wilt incidence in all the years. The susceptible check, JG 62 showed 100% wilt in all the 3 years. One of the promising genotypes, GCP 9313, is a desi-type with reddish to brown seeds. Its 100-seed mass is 18.2 g, which is higher than Chaffa (12.8 g) and Dahod yellow (15.9 g). This cultivar has been recommended for cultivation in Gujarat state during 1998 by the Research Council of the Gujarat Agricultural University.

Table 1. Wilt incidence in selected desi chickpea genotypes in a wilt-sick plot at Junagadh, Gujarat, 1994-96.

	Mean wilt incidence[1] (Percentage mortality)			
Entry	1994	1995	1996	Mean
GCP 9302	26.0	26.4	32.2	28.2
GCP 9310	25.7	28.8	29.2	27.9
GCP 9313	26.1	28.1	28.1	27.4
Chaffa	100.0	100.0	94.9	98.3
Dahod yellow	57.8	50.7	512	53.2
JG 62	100.0	100.0	100.0	100.0

1. Average of two replications.

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Nene, Y.L., Haware, M.P., and Reddy, M.V. 1981. Chickpea diseases: resistance screening techniques. Information Bulletin no. 10. Patancheru 502 324. Andhra Pradesh, India: International Crop Research Institute for the Semi-Arid Tropics. 12 pp.

Sources of Resistance to Root-knot Nematodes in Chickpea Germplasm

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The root-knot nematodes (M*eloidogyne incognita* and *M. javanica*) are key nematode pests of chickpea in the Indian subcontinent (Sharma and McDonald 1990). Upadhyay and Dwivedi (1987) reported a 40% yield loss in chickpea due to M. *incognita* in India, while 32.6% yield losses were estimated due to *M. incognita* and M. *javanica* in Gujarat (Anonymous 1997). A cost-effective approach for the management of root-knot nematodes is cultivation of nematode-resistant chickpea cultivars. However, such cultivars have not yet been developed as good sources of resistance to root-knot nematodes have not been identified.

During the 1996/97 postrainy season, 1000 chickpea genotypes received from ICRISAT were screened for resistance to root-knot nematodes (mixed population of *M. incognita* and *M. javanica* pathotype 1) in a nematode-sick field (1 juvenile g^{-1} soil) at the Department of Nematology, Gujarat Agricultural University, Anand. Of 1000 genotypes, 85 genotypes exhibited resistance or moderate resistance (rating of 5 for gall index on a 1-9 scale) and were selected for further testing against M. *incognita* (approximately 2.5 juveniles g^{-1} soil) and M. *javanica* (2.5 juveniles g^{-1} soil) separately in 2 m x 1 m x 0.5 m (depth) micro-plots. The chickpea cultivar Dahod yellow was used as a nematode-susceptible control after every

Table 1. Reaction of chickpea germplasm lines to root-knot nematodes at the Gujarat Agricultural University research farm, Anand, Gujarat, India.

Reaction[1]	Germplasm line response to	
	Meloidogyne incognita	*Meloidogyne javanica*
Moderately resistant	ICC[2] 4007, 4237	ICC 4254, 4331
Susceptible	ICC 4059, 4060, 4105, 4120, 4121, 4122, 4141, 4169, 4181, 4187, 4191, 4192, 4204, 4210, 4212, 4214, 4229, 4231, 4232, 4233, 4234, 4249, 4251, 4252, 4254, 4259, 4269, 4283, 4348, 4352,4418,4419,4434,4649, 4653, 4770, 4844, 4862, 4959	ICC 4007, 4141, 4154, 4187, 4190,4191,4204,4212,4229, 4249, 4259, 4261, 4262, 4264, 4269,4274,4418,4649
Highly susceptible	ICC 4005, 4006, 4008, 4123, 4125, 4133, 4134, 4140, 4142, 4151, 4153, 4154, 4155, 4172, 4173, 4175, 4182, 4185, 4186, 4188, 4189, 4190, 4201, 4203, 4208, 4216, 4221, 4231, 4261, 4262, 4264, 4266, 4270, 4271, 4273, 4274, 4275, 4292, 4293, 4339, 4473, 4537, 4586, 4834, Dahod yellow (Control)	ICC 4005, 4006, 4008, 4059, 4060,4105,4120,4121,4122, 4123,4125,4133,4134,4140, 4142,4151,4153,4155,4169, 4172,4173,4175,4181,4182, 4185,4186,4188,4189,4192, 4201,4203,4208,4210,4214, 4216,4221,4231,4232,4233, 4234, 4237, 4251, 4252, 4266, 4270,4271,4273,4275,4283, 4292, 4293, 4339, 4348, 4352, 4419,4434,4473,4537,4586, 4653, 4770, 4834, 4844, 4862, 4959, Dahod yellow (Control)

1. Resistance was measured on a scale of 1-9 where 1 = 0 galls, highly resistant; 9=100 galls per plant, highly susceptible.
2. ICC = ICRISAT chickpea germplasm accession number.

10 entries in 1997-98. Data were recorded on the number of galls on roots of five randomly selected plants of each genotype at 60 days after sowing. The gall number was rated on a 1-9 scale (1 = no galls on roots and 9 = more than 100 galls root^{-1}). The 85 lines were also tested against an *M. javanica* Race 1 population at Aziz Nagar village, Ranga Reddy district, Andhra Pradesh.

None of the tested lines were highly resistant or resistant to the root-knot nematodes. Two lines, ICC 4007 and ICC 4237, were identified as moderately resistant to *M. incognita,* and ICC 4254 and ICC 4331 as moderately resistant to *M. javanica* (Table 1). However, these genotypes were found to be susceptible to an *M. javanica* Race 1 population in a farmer's field at Aziz Nagar. The results indicate that resistance to root-knot nematode populations in the four genotypes is probably specific to a limited nematode population. We propose further screening of chickpea germplasm lines to identify sources that are highly resistant to the root-knot nematodes.

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Isolation of Bacteria Possessing Antifungal Activities Against *Ascochyta rabiei,* a Chickpea Fungus

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Chickpea is an important legume crop in the Indo-Pakistan subcontinent and in many other countries. However, its yield per unit area has remained very low. There are many factors which account for the dismally low yield. One very important factor is chickpea's susceptibility to a devastating disease caused by the fungus *Ascochyta rabiei* (Nene 1982). The commercially available cultivars lack genetic resistance against the fungus *A. rabiei.* Thus, there is a great need to protect the crop by using novel strategies to complement conventional control measures involving agrochemical treatments. In biological control studies the bacterium *Bacillus subtilis* has proved effective against bean rust (Baker et al. 1983) and early blight of potato (Vasudeva and Chakravarthi 1954) caused by *Vromyces phaseoli* and *Alternaria solani* respectively. The purpose of the present communication is to describe a method for the isolation of antifungal bacteria that can be used, either as microbial sprays or through genetic engineering techniques, to control chickpea blight caused by *A. rabiei.*

Soil, water, decaying leaves, and grain dust samples were collected from different ecological environments. To isolate antifungal bacteria, 1 g of the sample was added to 50 mL sterile saline solution (0.85% NaCl, pH 7) in a 250ml-conical flask, and incubated with shaking at 30°C. After 4 hours, a 1 mL sample was aseptically transferred to 50 mL LB broth (DIFCO) in a 250 ml conical flask and incubated overnight at 30°C with shaking. Serial dilutions of the growing culture were streaked on LB agar plates and incubated at 30°C for 48 hours. Different types of colonies appeared on these plates. One colony from each plate was transferred aseptically to the 5 mL LB broth in a test tube and incubated with

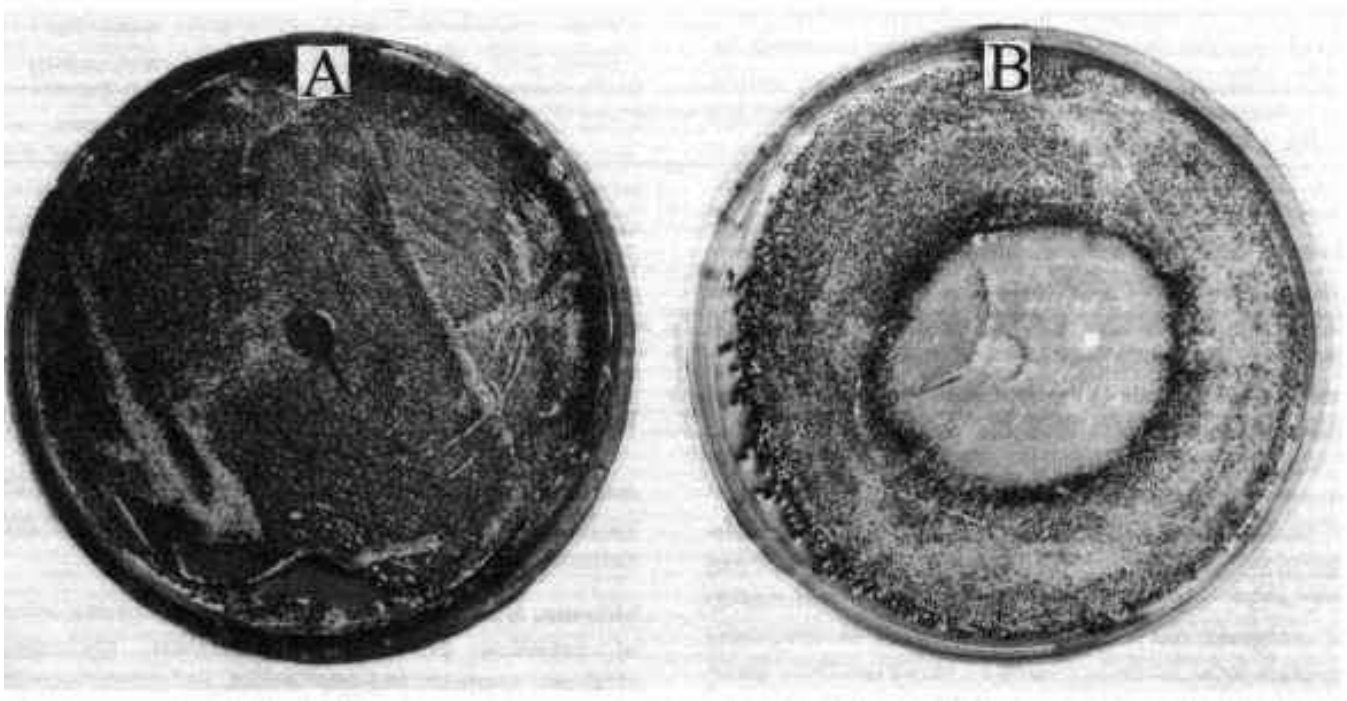

Figure 1. Growth inhibition of *Ascochyta rabiei* in response to crude extract of *Bacillus cereus* protein. A. Control (well contains only sterile distilled water). B. Experimental (well contains 1.5 mg crude protein extract).

shaking overnight at 30°C. Then the culture was multiplied overnight in a 2-liter conical flask containing 500 ml LB broth by leaving it with a shaker at 30°C. The culture broth was centrifuged and the pellet was washed by normal saline solution and resuspended in 4 ml sterile distilled water. The material was sonicated, filter sterilized and the protein concentration was measured with a spectrophotometer at 595 nm with Biorad dye reagent according to the method described by Bradford (1976).

A spore suspension (measuring 200µ1) of *Ascochyta rabiei* (CAMB 5) containing 104 spores mL^{-1} was spread on Czapek dox agar plates (MERCK) and incubated at 22+2°C for 24 hours. Small wells were punched into the agar layer of each plate and 1.5 mg crude protein extract in 50µ1 was added to each well. The plates were incubated at 22+2°C and were monitored daily for 3-5 days. By this method, we obtained three bacterial isolates which inhibited the growth of *A. rabiei.* These were identified as *Bacillus cereus, Enterobacter agglomeranse* and *Klebsiella ozaenae.* Identification of the strains was' done according to Sneath (1986).

The crude protein was tested for heat tolerance at 37°C, 55°C, 70°C, and 100°C for 10 min and it was inactivated at 70°C and 100°C. A comparison of antifungal activity, as judged by the size of the clear inhibition zone (16 cm) in middle of the plate, revealed that *B. cereus* was most active against *A. rabiei* (Fig. 1). The zones of inhibition remained well defined even after weeks of incubation. The observed inhibitory action of the isolates was attributed to its effect on spore germination. This agrees with observation of Pusey and Wilson (1984) who reported that the primary antibiotic action of *B. subtilis* was inhibition of spore germination rather than hyphal growth.

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Entomology

Feasibility of Using *Trichogramma chilonis* Ishii against *Helicoverpa armigera* (Hubner) Infesting Chickpea

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Amongst the important natural enemies of insect pests, *Trichogramma chilonis* (Hymenoptera: Trichogrammitidae), an egg parasitoid, has high potential in the control of *Helicoverpa armigera* in such crops as maize, cotton, sorghum. It also parasitizes some borer pests of rice and sugarcane; but it has only rarely been seen to parasitize eggs on chickpea and pigeonpea (Romeis et al. 1996). The present investigation was undertaken to evaluate the feasibility of using *T. chilonis* by the mass-release method to control *H. armigera.*

Field trails were conducted during 1994-96 at the College of Agriculture, Nagpur, on a chickpea crop sown on 0.1 ha field. *Trichogramma chilonis* produced at Biocontrol Laboratory, Department of Entomology, College of Agriculture, Nagpur, was released at weekly intervals throughout the field. Four releases of 1.0 lakh ha^{-1} (Balasubramanian 1993) were undertaken, the first release coinciding with egg initiation by the pest

To evaluate the feasibility of the parasitoid, *H. armigera* eggs were collected twice a week from the released field

and kept individually in the laboratory to observe the emergence of the parasitoid. It was revealed that none of the 1763 eggs collected during the growing seasons of 1994-96 from chickpea was parasitized. However, Balasubramanian et al. (1989) reported a high level of parasitism by different species on *Helicoverpa armigera* eggs on chickpea after only one release of the exotic *T. pretiosm* Riley.

The negligible parasitism may be because the parasite either failed to survive in the dry environment that persisted in the chickpea field or was killed by the acidic secretions of the leaves of the chickpea plant. Therefore, future investigations should focus on the plant parts/ secretions in chickpea responsible for the negligible effect of this potential parasitoid.

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Incidence of *Helicoverpa armigera* (Hubner) on Wild and Cultivated Species of Chickpea

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Chickpea, an important postrainy season pulse crop in Punjab, suffers considerable damage from the pod borer *Helicoverpa armigera* (Hub.) (Singh et al. 1990). The pest is active throughout the year and completes 7-8 generations in Punjab, with two periods of peak larval activity (Chhabra and Kooner 1993). Peak *H. armigera* populations coincide with the peak period of fruiting bodies of pulse crops. The first peak is in March/April which coincides with the peak of pod formation in chickpea, the other peak in October coinciding with the peak of pigeonpea fruiting. In the present investigation, larval incidence was studied on different wild species and cultivated genotypes of chickpea in order to identify a genotype resistant to *H. armigera.*

The studies were conducted on the experimental fields of the Department of Plant Breeding, Punjab Agricultural University, Ludhiana during the 1993/94 and 1994/95 crop seasons. Four wild species of chickpea: *Cicer echinospermum,* C. *judaicum, C. pinnatifidum,* and *C. reticulatum,* and five cultivated genotypes: GG 830, GL 1014, GL 1302, GL 90133, and ICC 5264 E 10 (kabuli) were studied along with standards PBG 1 and L 550 (kabuli) and susceptible control KPG 173-4. The test material was sown in the first week of November in randomized block design with three replications. All the test entries were surrounded by rows of susceptible control and kept free from insecticides throughout the crop season. Five plants of each genotype in each replication were tagged at random to periodically assess the larval population. The observations were recorded from standard weeks 1 to 15, initially once a week (up to standard week 7) and later on twice a week when the larval population started increasing.

The larval population was quite low during 1993/94 compared to the population in 1994/95. The peak larval population in the first year was observed during standard weeks 11 to 14. The larval population was low on wild species as compared to the cultivated genotypes. The larval population on the cultivated genotypes GL 104, GG 830, and GL 90133 was significantly lower than on the test variety L 550 and the susceptible control (Table 1).

During the second year of field testing, the population level in the wild species was again significantly lower than in the cultivated genotypes. It was 0.53 to 0.81 larvae plant^{-1} on the wild species and 1.03 to 1.54 larvae plant^{1} on the cultivated genotypes. However, the peaks in both the wild species and cultivated genotypes were recorded at 14-16 standard weeks. During the second year of testing, GL 1014 maintained its superiority over the others (Table 1).

From the mean larval population during both years it is evident that wild species (except *C. reticulatum)* had a significantly lower larval population compared to the cultivated genotypes except GL 1014 which was at par with C. *pinnatifidum* and *C. judaicum.* However, among the cultivated genotypes GL 1014 harboured significantly

Table 1. Mean larval population of *Helicoverpa armigera* (Hubner) on different wild and cultivated species of chickpea at Punjab Agricultural University Experimental Farm, Punjab, India, 1993/94 and 1994/95.

Specie55/Genotype	Mean larval population plant^{-1}					
	1993/94[1]		1994/95[2]		Mean	
Wild species						
Cicer judaicum	0.16	(1.08)[3]	0.62	(1.27)	0.39	(1.18)
C. pinnatifidum	0.14	(1.07)	0.70	(1.30)	0.42	(1.19)
C. echinospermum	0.11	(1.05)	0.53	(1.23)	0.32	(1.14)
C. reticulatum	0.11	(1.05)	0.81	(1.34)	0.46	(1.20)
Cultivated species (C. *arietinum)*						
GG 830	0.17	(1.08)	1.17	(1.47)	0.67	(1.28)
GL 1014	0.15	(1.07)	1.03	(1.42)	0.59	(1.25)
GL 1302	0.19	(1.09)	1.14	(1.46)	0.67	(1.28)
GL 90133	0.17	(1.08)	1.21	(1.48)	0.69	(1.28)
ICC 5264 E 10 (kabuli)	0.20	(1.09)	1.23	(1.49)	0.71	(1.29)
PBG I	0.20	(1.09)	1.47	(1.57)	0.83	(1.33)
L 550 (kabuli)	0.26	(1.12)	1.42	(1.55)	0.84	(1.34)
Susceptible control (KPG 173-4)	0.29	(1.14)	1.54	(1.59)	0.92	(1.36)
CD (5%)	(0.04)		(0.14)		(0.09)	

1. Mean of 22 observations on 15 plants.
2. Mean of 29 observations on 15 plants.
3. Figures in parentheses are $\sqrt{n+1}$ transformations.

lower larval population compared to the susceptible control (Table 1).

This study indicates that wild species have greater resistance to Helicoverpa than the cultivated genotypes, as evidenced by the larval population. These findings confirm the observations of Pundir et al. (1992), where the two wild species, *C. reticulatum* and C. *echinospermum* were seen to possess resistance against such insect pests as bruchids and leaf miners. In this investigation it was observed that the standard variety L 550 (kabuli) was preferred over the desi varieties, which agreed with the studies conducted by Kaushik and Naresh (1984) wherein they recorded that the average population density of *H. armigera* was higher on the kabuli variety L 414 compared to the desi variety H 208. In the present investigation GL 1014 was found to be superior to the other test genotypes and was on par with the wild species. The findings confirm the work of Chhabra and Kooner (1994) where GL 1014 was identified as a resistant genotype on the basis of 8 years of field testing.

Among the wild species *C. echinospermum* and *C. reticulatum* are very similar to the cultivated species (C. *arietinum)* in terms of pod and seed size. Thus these species could be used in the breeding program for the development of chickpea cultivars resistant to *H armigera.*

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Response of Chickpea to Seed Priming in the High Barind Tract of Bangladesh[1]

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The Barind Tract comprises uplifted weathered alluvium of high clay content, which is not subject to annual flooding by the major river systems in northwestern Bangladesh. The undulating or High Barind Tract (HBT) covers some 2200 km^2 to the west of this region (Edris 1990). The traditional cropping system of this area is predominantly rainy season rainfed transplanted *aman* (t. *aman)* rice, which is transplanted in July and harvested in October-November. The bunded fields were invariably left fallow for the remainder of the year. However, on-farm research initiated in the 1980s by the On-Farm Research Division of the Bangladesh Agricultural Research Institute, and carried forward by them, has developed and demonstrated technology that permits cultivation of winter (postrainy season) crops to follow rice (Kumar et al. 1994). Essentially, this involves seed bed preparation and sowing of the postrainy season crop soon after harvest of rice while the soil surface retains sufficient moisture to ensure adequate crop establishment. Seedling roots penetrate the then moist plow-pan layer and can then extract residual soil moisture from deeper layers after the surface soil and plow-pan layer dries out. If shorter-duration varieties of postrainy season crops are used they can reach maturity before the residual subsoil moisture is exhausted. Also, if shorter duration *t. aman* rice varieties are used, or the rice is transplanted earlier than normal or directly seeded, rice maturity can be reached at an optimum sowing time for postrainy crops (their late sowing, in late November or early December, retards vegetative growth and root penetration and hence they face a greater degree of terminal drought stress).

Chickpea (*Cicer arietinum* L.) has proven to be particularly suited to growing after rice in this system because of its strong rooting characteristics and because of the availability of shorter-duration improved varieties, as compared to traditional local landraces now used. The area of chickpea in the HBT in the 1984/85 season was around 1200 ha but in 1997/98 it was estimated to be 9000-10 000 ha (Musa et al. 1998). Chickpea yields in the HBT are usually more than the national average due to low incidence of botrytis gray mold disease in this region. However, yields in most farmers' fields normally remain below 1 t ha^{-1} due mainly to crop establishment problems and terminal drought and heat stress.

In on-farm trials in western India, it has been reported that seed priming increases yields of chickpea and other rainfed crops (Harris et al. 1999). The priming process simply involves soaking the seeds overnight (for about 8 h), surface drying them, and then sowing within the following day. This treatment hastens germination, enhances crop establishment and promotes seedling vigor (Harris et al. 1999). It was therefore considered worthwhile to evaluate seed priming for its efficacy for chickpea grown in the harsh conditions of the HBT.

On-farm trials were conducted under dryland conditions at 30 locations in the Ataher, Amnura and Nachole soil series of the HBT. About 0.13 ha of land at each location was divided equally for the following two treatments: 1) non-primed, where normal dry seeds were sown; and 2) primed, where seeds were soaked in water overnight, surface dried, and then sown within that day. Farmers were appropriately trained in this methodology. The chickpea variety Barichola-2, recently released for cultivation in Bangladesh was used as the test crop and sown at the seed rate of 50 kg ha^{-1}. Several participating farmers applied P_2O_5 at 40 kg ha^{-1}, as triple superphosphate, and K_2O at 20 kg ha^{-1}, as muriate of potash. No fungicidal seed dressing or *Rhizobium* inoculation was used. Fertilizer was applied at the time of land preparation, by power tiller or bullock-drawn plow followed by laddering (leveling). Seed was hand broadcast in each treatment plot at the same time followed by a final laddering. The sowing date for the different locations ranged from 19 Nov to 13 Dec 1998, Intercultural operations for weed control were done as needed and some farmers applied need-based sprays of insecticide to control *Helicoverpa armigera* pod borer.

During the crop growth period, observations were made on such parameters as emergence, early growth vigor and pest and disease incidence. Plots with the priming

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Table 1. Summary of data from 30 locations on effect of seed priming on chickpea performance in the High Barind Tract of Bangladesh, 1998/99 season.

Variable	Mean primed	Mean non-primed	Increase associated with priming (%)	Probability (paired t-test, 2-tailed)	Significance[1]
Emergence, plants m^{-2}	36.7	30.2	21	1.51E-08	***
Early growth, plant height (cm)	10.5	8.6	22	1.47E- 12	***
Plant height at harvest (cm)	36.4	33	10	1.17E-07	***
No. of diseased plants m^{-2}	1.1	2.0	-45	2.87E-05	***
Pod borer damage, damaged pods m^{-2}	3.6	4.1	-13	0.366	ns
No. of unfilled pods $plant^{-1}$	3.4	4.4	-21	0.1287	ns
No. of plants at harvest m^{-2}	30.6	25.0	22	2.56E-07	***
No. of pods m^{-2}	1493	1074	39	4.09E-05	***
1000 grain mass (g)	117.7	111.3	6	0.0734	ns
Grain yield (t ha^{-1})	1.63	1.11	47	1.96E-05	***
Residue yield (t ha^{-1})	2.0	1.53	31	2.94E-05	***

1. *** = Significant difference at $P<0.001$; ns = difference not significant.

treatment were harvested during 20 Mar to 4 Apr for the different locations, and plots without primed seed were harvested during 25 Mar to 7 Apr 1999. The primed seed plots were harvested 3-7 days before their respective non-primed ones, but dates of physiological maturity for each plot were not recorded. Data on yield and yield components for each plot were collected and analyzed, initially by a paired two-tailed "t" - test using all 30 locations.

Rainfall continued until mid-November in 1998, thus delaying maturity and harvest of rice and consequently sowing of chickpea crops. However, from 22 Nov, there was no effective rainfall recorded for the entire chickpea growth period. Thus the chickpea crops in this study grew entirely on residual stored soil moisture.

Seed priming resulted in earlier emergence of seedlings, by 1-3 days, and significantly increased (mean across 30 locations) plant stand and initial growth vigor (Table 1). There was much less incidence of soil-borne disease, mainly caused by collar rot (*Sclerotium rolfsii*) and *Fusarium* spp. in primed plots than in non-primed plots (Table 1). There also appeared to be less pod borer damage and fewer unfilled pods in primed plots, but the effect was not significant when all 30 locations were considered (Table 1). Although not all plots were examined, primed plots generally seemed to have better nodulation, by natural rhizobia. Nodule number per plant ranged from 7 to 51 in primed plots and from 6 to 18 in non-primed plots. It was also noted that nodulation was generally better in plots in lower catena soils (Nachole soil series) than soils higher in the catena (Ataher and Amnura series); biomass and grain yields followed a similar trend.

Priming of seeds resulted in an overall 47% grain yield advantage, with all yield contributing factors measured showing positive effects of priming (significantly for all parameters except 1000 grain mass) (Table 1). This is only the first year of the seed priming study in this region but the results indicate dramatic effects on grain yield from such a simple and low-cost technology. Confirmation of the effect is required in subsequent years, when the weather pattern will inevitably differ. The present season was characterized by an initial fully charged soil profile, with no replenishment from winter rain. It would be of interest to determine priming effects when there would be less surface soil moisture initially and when winter rains make a significant contribution to crop growth.

The effect of seed priming on grain yield and its components appears to have its origins in the better and faster seedling establishment, perhaps finally allowing some escape of terminal drought and heat stress, and of pod borer damage to some extent. The positive effects of seed priming on disease control and nodulation are intriguing and deserve more in-depth study to understand

the mechanisms involved. Soil-borne diseases are likely to assume greater importance as chickpea cultivation in the Barind increases and knowledge of mechanisms to alleviate them would be valuable.

Possible synergistic effects of seed priming with other easily applied seed treatments need to be examined. Such treatments would include fungicide application for soil-borne disease control, *Rhizobium* inoculation to enhance low populations of native rhizobia, and lime/phosphate/trace element pelleting to alleviate effects of the acid surface soil and nutrient deficiencies.

Notwithstanding further studies on mechanisms of priming effects and possible synergies with other seed treatments, after one more year of confirmation of the priming effect it should be possible to recommend and demonstrate the effect on a large scale in the Barind region, and perhaps elsewhere on difficult post-rice soils in Bangladesh and adjacent areas of India. The effect of priming on other post-rice crops besides chickpea also needs to be ascertained.

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Comparison of Yield and Economics of Irrigated Chickpea Under Improved and Local Management Practices

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Chickpea is the main postrainy-season crop of the Bundelkhand agroclimatic zone in Madhya Pradesh, India covering 28% of the total cultivated area (132 400 ha). Traditionally, chickpea is grown as a rainfed crop under monocropping systems. In recent years, it has been introduced into multiple-cropping systems under limited irrigation. The area and production of chickpea under limited irrigation is gradually increasing. However, the productivity of chickpea continues to be low (1.3 t ha^{-1}). Of the several reasons for low productivity, a major one is nonadoption of improved technology, i.e., suitable varieties, recommended balanced fertilizer use, control of pod borer, and irrigation. The results of several field experiments at the Zonal Agricultural Research Station, Tikamgarh have clearly shown that with improved management the grain yield of chickpea is 3.0-3.5 t ha^{-1}. There is obviously large gap between the yield (1.3 t ha^{-1}) in farmers' fields and the productivity at the research station. Therefore, we decided to demonstrate the available improved chickpea technology to farmers in the Bundelkhand Zone of Madhya Pradesh.

Field demonstrations were conducted under a frontline demonstration program of the Indian Council of Agricultural Research (ICAR) during 1990/91, 1992/93, 1995/96, 1996/97, and 1997/98. A total of 124 field demonstrations were conducted on farmers' fields in Tikamgarh district of Madhya Pradesh in sandy loam to clayey soils. The plot size ranged between 0.4 to 2.0 ha^{-1}. Local practices include sowing seed by the broadcast method, use of the local variety, and the application of 50 kg ha^{-1} diammonium phosphate (DAP) alone as a basal. The recommended package of practices in demonstration plots is described below. The chickpea variety, JG 315 was sown in rows 30 cm apart with a seed rate of 75 kg ha^{-1}. The seeds were treated with thiram at the rate of 3 g kg^{-1} seed and *Rhizobium* culture at 10 g kg^{-1} seed. The

Table 1. Yield (t ha^{-1}), cost of cultivation (Rs ha^{-1}), and net return (Rs ha^{-1})[1] of chickpea grown using improved and local management practices, Tikamgarh District, Madhya Pradesh, India, 1990/91-1997/98 postrainy seasons.

Year	No. of farmers	Yield in farmers' field			Local practices	District average	Cost of cultivation[2]		Net ruturn	
		Highest	Lowest	Average			Demon-stration	Local practices	Demon-stration	Local practices
1990/91	23	1.95	1.40	1.67	1.00	0.98	3295	2670	7143	3830
1992/93	27	2.75	1.90	2.35	0.95	1.03	4446	2980	13217	4145
1995/96	24	2.05	1.45	1.67	1.05	1.09	6870	4920	9730	5480
1996/97	25	2.50	1.60	1.87	1.18	1.15	7300	4800	13336	8257
1997/98	25	2.60	1.60	2.16	1.35	1.39	7390	4850	12050	7300

1. Sale rate (Rs t^{-1}) of chickpea: Rs 6250 (1990-91), Rs 7500 (1991-92), Rs 10 000 (1995-96), Rs 10 000 (1996-97), Rs 9000 (1997-98).
2. 1 US$ = Rs 42.

basal dose of fertilizer consisted of 20 kg ha^{-1} N in the form of DAP, 60 kg ha^{-1} of P in the form of single super phosphate (SSP), and 20 kg ha^{-1} K as muriate of potash. Chickpea was sown between 19 Oct and 8 Nov and was harvested 10-17 March. The fields were irrigated prior to sowing, followed by irrigation at the preflowering and grain-filling stages. Two sprays of monocrotophos at a concentration of 1.5 ml L^{-1} water were given to control pod borer 20 days after incidence of pest.

Table 1 shows the yield of chickpea under improved and local practices. In comparison to local practices, there was an increase of 68, 149, 59, 58, and 60 percent in productivity of the demonstration plots in the corresponding years. The higher comparative yield in chickpea was attributed to the use of improved varieties, proper fertilizer management, and plant protection measures.

The economic analyses of results were worked out on the basis of prevailing market rates (Table 1). The data indicate that demonstration plots of chickpea gave net returns of Rs 7143, 13217, 9730, 13336, and 12050 ha^{-1} compared to Rs 3830, 4245, 5980, 8257, and 7300 ha under local practice in the same seasons (1 US$ = Rs 42). There was an increase of 85% in the net return in 1990/91, 218% in 1992/93, 62% in 1995/96, 61% in 1996/97, and 60% in 1997/98,

We conclude that growing the chickpea variety JG 315 under improved management practices including proper seed rate, better method of sowing, recommended fertilizer, plant protection measures, and irrigation proved more productive and remunerative than that grown under traditional practices.

Responses of Some Tunisian Chickpea (*Cicer arietinum)* Varieties to Salinity in Nutrient Solution

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Chickpea is the most important food legume in Tunisia. It is cultivated on nearly 30 000 ha, accounting for 33% of the total cropped area under legumes. Average yields are around 0.7 t ha^{-1}. Reasons for low yield include environmental stresses (drought, salinity, mineral deficiencies), improper agronomic management (no fertilizer applications, and biotic factors (various diseases and insect pests).

Chickpea is sensitive to salinity (Maas and Hoffman 1977). Screening for salt tolerance in 160 chickpea genotypes showed that only one cultivar (cv L-550) was able to tolerate a concentration of 50 mM NaCl (Lauter and Munns 1986). Previous studies by Ashraf and Waheed (1993) on several chickpea accessions have confirmed this sensitivity and showed that higher concentrations (80 mM), were lethal to this species. In spite of the known salt sensitivity of chickpea, it may be useful to screen local germplasm in order to identify some salt-tolerant varieties to improve adaptation of this crop to areas with moderate levels of salinity.

Table 1. Change in water content (mL g^{-1} dry mass of leaves) and in shoot/root (S/R) ratio with plant age and salt concentration, means of 10 replications.

			At 39 DAS			
	At 18 DAS[1]		Control		Salt	
Variety	S/R	H_2O	S/R	H_2O	S/R	H_2O
Amdoun 1	1.5 ± 0.2	5.0 ± 0.1	6.7 ± 1.4	4.9 ± 1.2	6.1 ± 1.1	3.7 ± 1.2
ILC 482	1.9 ± 0.2	5.4 ± 0.2	5.0 ± 0.3	5.3 ± 0.1	4.2 ± 0.2	3.0 ± 0.6
INRAT 88	1.6 ± 0.1	4.8 ± 0.1	4.5 ± 0.5	4.8 ± 1.0	4.8 ± 0.2	1.8 ± 1.1
Kesseb	2.1 ± 0.2	5.1 ± 0.2	4.7 ± 0.6	5.1 ± 0.4	4.9 ± 0.7	2.1 ± 1.1
V.F.	1.5 ± 0.3	5.1 ± 0.4	5.0 ± 0.5	4.6 ± 2.1	5.8 ± 1.1	1.0 ± 0.5
Chettoui	1.7 ± 0.1	6.2 ± 0.2	4.4 ± 0.5	5.7 ± 0.3	4.3 ± 0.5	2.3 ± 0.8

DAS = Days after sowing.

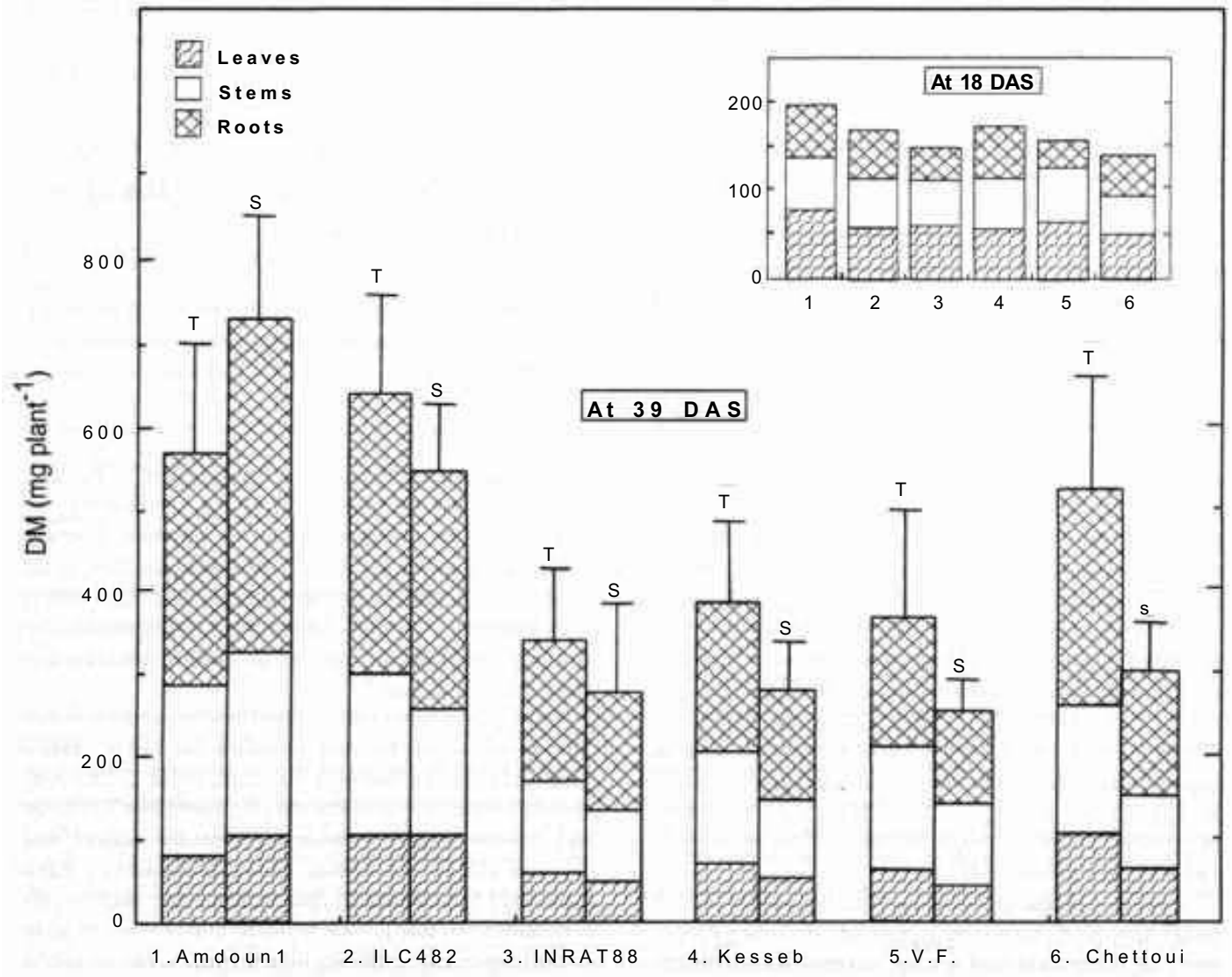

Figure 1. Dry mass (DM) at final harvest (39-day-old plants). DM at salt application is presented in the inset (initial harvest, 18-day-old plants). The treatments zero (T) and 35 mM (S) are means of 10 replications. Bars indicate + SE of mean; differences between varieties are significant at the P = 0.05 level.

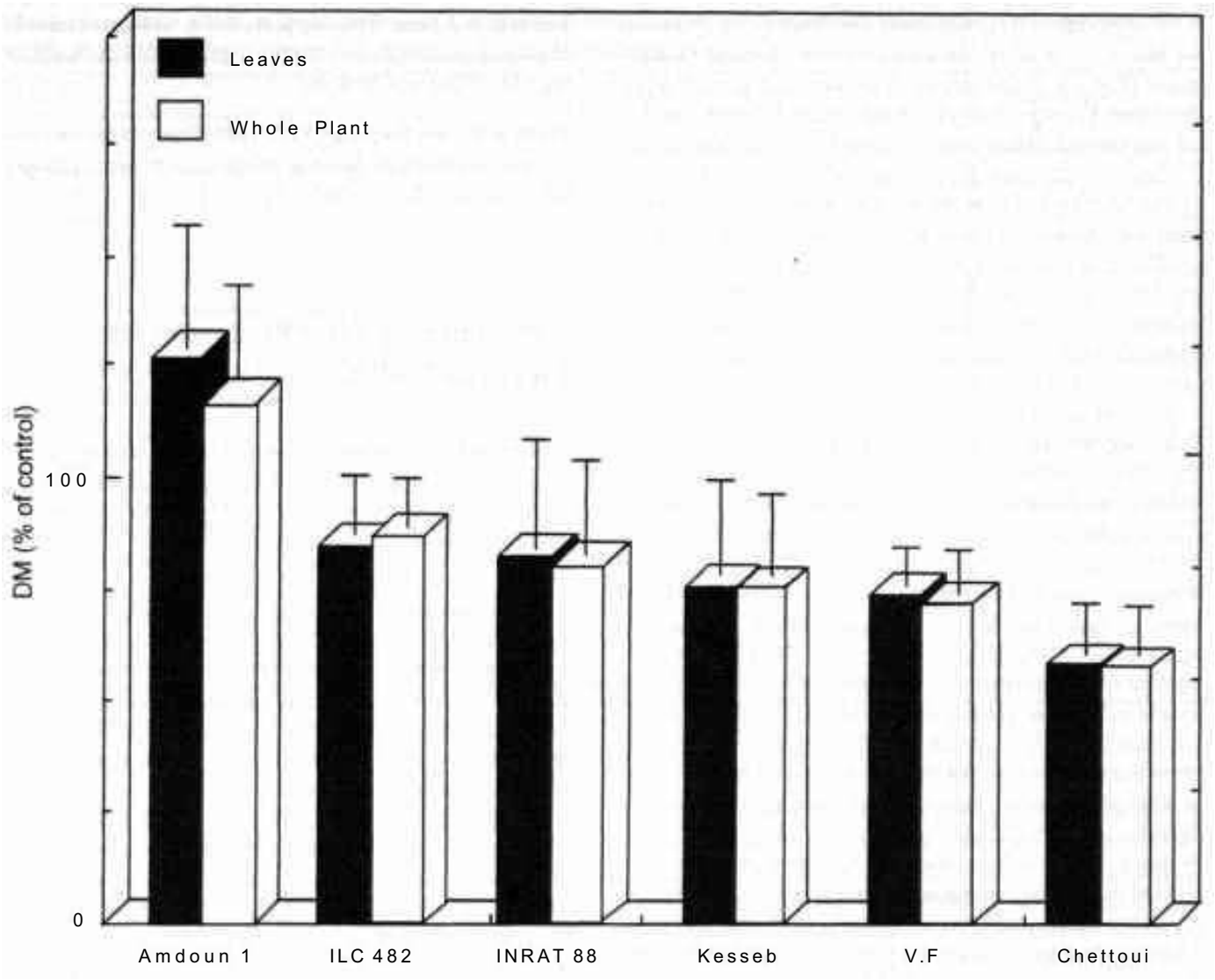

Figure 2. Dry mass (DM) of plants expressed as percentage of control at final harvest. Values are means of 10 replications. Bars indicate ± SE of mean; differences between varieties are significant at the *P* = 0.05 level.

Five Tunisian chickpea varieties and one French variety (control) were used in this study. The seeds were provided by the INRAT Laboratory of Food Legumes and were designated as Amdoun 1, Chettoui, Kesseb, INRAT 88, ILC 482, and V.F. (French Variety).

The experiment was conducted under controlled conditions (photoperiod 12 h, efficient radiance 250 µmol m^{-2} s^{-1}, diurnal temperature of 26°C and night temperature of 18°C, mean relative humidity of 65% during the day, and 95% in the night). The seedlings were transplanted on perforated lids that fitted well on pots filled with distilled water. After 11 days, the seedlings-were transferred to 220-mL pots containing Long Ashton nutrient solution (Hamza 1977) which was diluted five times (T/5).

When the plants were 18 days old, they were grouped into three lots: the first one was harvested at the time of transfer to nutrient solution (initial harvest), the second was maintained on T/5 medium, and the third one was maintained on the same medium to which was added NaCl, 35 mM. The final harvest was made 3 weeks after the plants were transfered to saline medium, i.e., 39 days after sowing (DAS). The number of replications was 10 plants per treatment and per variety.

At 18 DAS (initial harvest on T/5 medium), the Amdoun 1 variety produced more dry matter whereas Chettoui produced the least (frame in Fig. 1). At the final harvest, Amdoun 1 and ILC 482 proved to be the best developed on control medium followed by Chettoui, Kesseb, V.F., and INRAT 88 (Fig. 1).

The growth of Amdoun 1 was stimulated in the presence of NaCl, 35 mM, as indicated by the increase in leaf mass (Fig. 1). However, in other varieties growth was inhibited, Chettoui being the most affected. The dry mass of salt-treated plants was expressed as a percentage of control (Fig. 2), to compare varietal differences in response to salt. Amdoun 1 was the most tolerant (120% of control) and Chettoui the most sensitive (about 50% of control).

The water content of the leaves was similar in all varieties, and varied little during the treatment period (Table 1). In the presence of salt, water content was reduced in all varieties but to a relatively lower extent in Amdoun I and ILC 482.

For the six chickpea varieties, shoot/root ratio (S/R) increased with time. There were large differences among the cultivars: in the presence of salt, S/R decreased only for the two most tolerant varieties (Amdoun I and ILC 482). Our results agree with those of Kuiper et al. (1988).

The superior performance of the Tunisian variety Amdoun 1 would be attributed to the vigor of its rooting system (decreased S/R in presence of salt) and to an appropriate water supply to its aerial parts (the water content in the leaves was higher than in other varieties). The effect on leaf growth was affected in the behavior of the plant as a whole. In fact, the effect on leaves appeared to be the main reason for the sensitivity of Chettoui.

Our results confirmed chickpea sensitivity reported by other authors (Lauter and Munns 1986; Ashraf and Waheed 1993) and showed an important intraspecific variability for this character. In presence of 35 mM of NaCl, Amdoun I showed a high level of tolerance while Chettoui was very sensitive. These results suggest that the genotype Amdoun I could be tried in those areas of Tunisia with moderate levels of salinity.

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A Preliminary Field Evaluation of Chickpea Nodulation Variants

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Legume productivity can be maximized by selecting host plants which have enhanced symbiotic N_2 fixation. Such high-nodulating (HN) lines have been reported in chickpea (Rupela 1994) and pigeonpea (Rupela and Johansen 1995; Dudeja and Khurana 1996). While it is pertinent to take into account the agronomic evaluation of such host-plant selections, the superiority of HN selections over unselected bulk cultivar (UC) of chickpea could not be established at Hisar due to the susceptibility of the nodulation variants of chickpea to fusarium wilt (Khurana and Dudeja 1996; Dudeja et al. 1997). Therefore in the present study HN selections of chickpea cultivars ICC 5003 and ICC 4948 were evaluated in the field, attempting to avoid the occurrence of wilt disease by sowing later than normal (mid-Oct to mid-Nov), with deep seed placement (15 cm, compared with the normal depth of 7.5-10 cm). The experiment was sown on 4 Dec 1995 at CCS Haryana Agricultural University Farm. The soil was sandy loam of pH 7.5 (H_2O 1:2) and contained 4.2 mg g^{-1} organic carbon, 10 mg g^{-1} P (Olsen) and 0.65 mg g^{-1} total N. One set of seeds was sown with N while in the other set, 100 kg N ha^{-1} in the form of urea was added a month prior to sowing, so that the soil was completely mineralized by the time the experiment was sown. The mineral nitrogen content at the time of sowing was 14-16 mg g^{-1} in plots without exogenous nitrogen and 29-30 mg g^{-1} in the urea-applied plots. The experiment was conducted in triplicate in 7.2 m^2 plots arranged in factorial complete randomized design with plant-to-plant spacing of 8-10 cm and row-to-row spacing of 30 cm. The trial was completed on residual moisture. Nodulation was observed in 5 plants $plot^{-1}$ 60 days after

Table 1. Nodule biomass and grain yield of chickpea nodulation variants of cultivars ICC 5003 and ICC 4948 under two N-fertility levels at HAU, Hisar, India, postrainy season 1995.

Cultivars	Nodulation variants	Nodule biomass[1] (mg plant^{-1})			Grain yield (kg ha^{-1})		
		Nl	N2	Mean	Nl	N2	Mean
ICC 5003	UC[2]	1219	974	1096	1309	1471	1390
	LN	1152	819	986	1212	1427	1319
	HN	1450	997	1223	1470	1601	1536
CD at 5% for nodulation variants		103					85
Nitrogen level		84					70
Interaction between nodulation variants and nitrogen level		145					121
ICC4948	UC	1123	879	1001	1564	1794	1679
	LN	626	532	579	1543	1970	1757
	HN	1273	1075	1174	1821	1981	1901
CD at 5% for nodulation variants					35		102
Nitrogen level					28		84
Interaction between nodulation variants and nitrogen level					49		146

1. Nl = no added nitrogen; N2 = exogenous 100 kg N ha^{-1}.
2. UC = unselected bulk cultivar; LN =low nodulating; HN = high nodulating.

sowing and grain yield was recorded at harvest. Plants were also monitored for wilt occurrence.

Nodule biomass was highest in the HN selections of both the cultivars as compared to the UC or low-nodulating (LN) selection (Table 1). The LN selection formed fewer nodules and thereby produced less nodule biomass than the unselected bulk cultivar, indicating the stability of the selections. With the increase in soil nitrogen level after the addition of 100 kg N ha^{-1}, nodulation and nodule biomass were remarkably reduced in ail the nodulation variants. Under normal fertility level, where no fertilizer N was added, an increase of 12.3% in yield was observed in ICC 5003 HN selection over its unselected bulk cultivar. Similarly, another HN selection of ICC 4948 yielded 16.4% more grains than the unselected parent cultivar but these increases were statistically nonsignificant. However, the overall mean yield of LN selections of ICC 4948 yielded 1.3% and and ICC 5003 yielded 7.4% less than the unselected cultivars. Grain yield of all the nodulation variants was observed to increase with the increase in the soil N-fertility level. The HN selections of ICC 5003 and ICC 4948 yielded 8.9% and 13.2% higher than the respective bulk cultivars under high N-fertility level. The yield of ICC 4948 LN selection was on par with its HN selection while the LN selection of ICC 5003 yielded almost the same as its unselected bulk cultivar under high N-fertility level. This was also evident from the percentage increase in grain yield at the N2 level as compared to N1 level as shown in Table 1. The increase was maximum in the LN selections (17.7 and 27.7%) and minimum in HN selections (8.9 and 8.8%) of both cultivars. The overall mean yield of the HN selections of ICC 5003 and ICC 4948 was 10.5% and 13.2% higher than the respective unselected bulk cultivars. Wilt was not observed in any of the nodulation variants. Thus, if there is no incidence of wilt, the HN selections are superior over the unselected bulk and LN selections. This is contrary to the earlier report where HN selections were found not superior to UC due to their susceptibility to wilt (Khurana and Dudeja 1996; Dudeja et al. 1997). Therefore while making selections for high nodulation, wilt-resistant/tolerant cultivars should be used as a base. These HN selections could fix more nitrogen, and enhance soil fertility, thereby possibly benefitting the succeeding crop.

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Chickpea Root Nodulation and Yield as Affected by Micronutrient Application and *Rhizobium* Inoculation

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Mineral nutrient deficiencies limit nitrogen fixation by the legume-*Rhizobium* symbiosis in many agricultural soils and as a result seriously depress legume yields below their maximum potential (O'Hara et al. 1988). Nutrient limitations to legume production result not only from deficiencies of the more common macronutrients such as phosphorus, potassium, and sulphur but also of micronutrients such as molybdenum, boron, iron, etc. (O'Hara et al. 1988). In a nitrogen-deficient soil, legume growth and symbiotic nitrogen fixation are strongly inter-dependent. Molybdenum, and, particularly boron deficiencies, affect the production of chickpea, cereal, oilseed, and vegetable crops in some agroecological zones especially in the light-textured soils of Rangpur, Bangladesh (Miah et al. 1992).

An experiment was conducted in the light soil of Tobacco Research Station, Rangpur, Bangladesh during the postrainy season of 1993/94 to study the effect of rhizobial inoculum and micronutrients (Mo and B) on the growth, yield, and economic performance of chickpea. The experiment was laid out in randomized complete block design in four replications with eight treatments: 1. Control, 2. Phosphorus (P) + Potassium (K) + Molybdenum (Mo), 3. Phosphorus + Potassium + Boron (B), 4. Inoculum, 5. Phosphorus + Potassium + Molybdenum + Inoculum, 6. Phosphorus + Potassium + Boron + Inoculum, 7. Nitrogen (N) + Phosphorus + Potassium + Molybdenum + Boron, 8. Phosphorus + Potassium + Molybdenum + Boron + Inoculum. The soil of the experimental site was collected before sowing from 0-15 cm depth. The soil was sandy loam in texture, with pH 7.7, organic matter 1.8%, exchangeable Ca (12.2), Mg (0.43), K (0.38), me 100 g-1, NH_4-N (37), available P (21), S (23), B (0.1), Cu (4), Fe (47), Mn (2), Zn (2) mg g^{-1}. Nitrogen (50 kg N ha^{1}) as urea, phosphorus (50 kg P_2O_5 ha^{-1}) as triple superphosphate, potassium (50 kg K_20 ha^{-1}) as muriate of potash, molybdenum (1 kg Mo ha^{-1}) as sodium molybdate, boron (1 kg B ha^{-1}) as solubor were applied at sowing. The initial *Rhizobium* population of the soil was 3.1 in-$\log_{10}$ g^{-1} of soil. Peat-based inoculant (Strain RCa-220) was applied at the rate of 70 g kg^{-1} of seed during sowing. The *Rhizobium* population of the inoculant was 7.10 cells in $\log_{10}$ g^{-1} of inoculant and each seed contained 1.15 x 10^5 rhizobia. The plot size was 4 m x 3 m at an interrow spacing of 30 cm and intrarow spacing of 10 cm. The chickpea variety Nabin was sown 25 Nov 1993 and harvested 31 Mar 1994. The plants were sampled for inoculation 60 days after sowing.

Table I shows that there was a significant increase over control in nodule number, nodule mass, shoot mass, stover yield, and seed yield due to rhizobial inoculation in the presence of phosphorus, potassium, molybdenum and boron. Molybdenum or boron application with

Table 1. Effect of rhizobial inoculum and micronutrient (Mo and B) on nodulation, dry matter mass at 60 days after sowing and final yields of chickpea at Rangpur, Bangladesh, 1994.

	At 60 DAS		At maturity			
Treatment	Nodule number plant^{-1}	Nodule mass (mg plant^{-1})	Shoot mass (mg plant^{-1})	Stover yield (t ha^{-1})	Seed yield (t ha^{-1})	Seed increase over control (%)
Control	1	2	0.94	1.08	0.50	-
PKMo	2	6	1.06	1.19	0.52	4.4
PKB	2	6	0.98	1.44	0.53	5.6
Inoculant	5	17	1.08	1.82	0.65	30.2
PKMo + Inoculant	8	24	1.22	2.22	1.00	100.6
PKB + Inoculant	8	23	1.08	2.42	1.21	141.4
NPKMoB	1	4	1.20	1.59	0.82	64.6
PKMoB + Inoculant	9	31	1.32	2.75	1.52	204.0
SE	±0.152	± 1.58	±0.056	±0.099	±0.068	
CV (%)	6.8	22.7	10.1	11.0	10.2	

phosphorus, potassium and *Rhizobium* also resulted in higher nodule number, nodule mass, stover yield, and seed yield than all the other treatments except PKMoB + Inoculum. *Rhizobium* without any chemical fertilizers also gave a significantly higher nodule number and mass than the uninoculated control. Inoculation significantly increased nodulation and seed yield of chickpea. The highest seed yield (1.52 t ha^{-1}) was recorded in the treatment PKMoB + Inoculum where the percentage seed increase was 204 over the control. Similar findings were also observed by Bhuiyan et al. (1996). The benefit-cost ratio (BCR) for only Inoculum treatment was higher (details not presented). The highest BCR (23.00) was achieved with the Inoculum only treatment followed by PKMoB + Inoculum (7.10), PKB + Inoculum (6.49), PKMo + Inoculum (3.53), and NPKMoB (1.20), indicating that better economic performance results from inoculation with micronutrients in chickpea.

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Studies on Allelopathy and Medicinal Weeds in Chickpea Fields

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Studies on allelopathy

The term "allelopathy" includes all biochemical interactions (inhibitory and stimulatory) among plants, including microorganisms (Narwal 1994). With allelopathy, the factors responsible for the harmful effects of any weed on crops can be easily explained. Weeds compete with crops for moisture and nutrients and also suppress the growth of crops by secreting specific lethal allelochemicals. Chickpea is an important postrainy crop in the Chhattisgarh region of India. The allelopathic effects of some weeds on

germination and seedling vigor of chickpea have been reported (Oudhia et al 1998). *Abutilon indicum, Euphorbia hirta, Ageratum conyzoides, Parthenium hysterophorus, Lantana camara,* and *Aeschynomene americana* are some common field and roadside weeds found in this chickpea-growing region. A pot study was conducted at the Department of Agronomy, Indira Gandhi Agricultural University (IGAU), Raipur (India) to evaluate the allelopathic potential of these weeds on germination and seedling vigor of chickpea.

Fresh samples of leaves of selected weeds were collected at random at the vegetative stage in the winter. To prepare extracts, the crushed leaves were allowed to decay for 24 h in distilled water in the ratio of 1:10 w/v (weed material: water). The extracts were allowed to decay at room temperature (28±2°C) following which the extract was taken using a sieve (2 mm mesh). The bioassay experiment was done in earthen pots filled with neutral clay loam soil. Chickpea seeds were soaked in different extracts for 24 h. As a control, chickpea seeds were also soaked in distilled water for the same duration. After soaking, 15 seeds of chickpea variety JG 74 were sown in each pot. The experiment was laid out in a randomized block design with four replications; the experiment was repeated twice. Germination was recorded at 3,5,7,9, and 11 days after sowing (DAS) and root and shoot lengths were noted at 11 and 22 DAS.

The extracts of different weed leaves produced different allelopathic effects on the germination and seedling vigor of chickpea (Table 1). At 3 DAS, maximum germination was noted under the control (water) that was at par with the germination produced by leaf extracts of *Abutilon, Lantana* and *Euphorbia.* Leaf extracts of *Aeschynomene* lowered the germination to the minimum. At 5,7,9, and 11 DAS, all extracts excluding that of *Parthenium* resulted in comparable germination. *Parthenium* leaf extract lowered the germination to a minimum and resulted in rates of 10.6% at 5 DAS,

Table 1. Evaluation of allelopathic effects of some problematic weeds on the germination and seedling vigor of chickpea.

	Germination[1] (%)					Root length[2] (cm pl^{-1})		Shoot length[2] (cm pl^{-1})	
Treatment[1]	3 DAS	5 DAS	7DAS	9DAS	11 DAS	11 DAS	22 DAS	11 DAS	22 DAS
T1	45.0 (42.1)	72.3 (58.2)	75.6 (60.4)	77.1 (61.3)	77.1 (61.3)	12.7 (-8.5)	18.6 (-10.3)	9.7 (+15.7)	12.2 (-5.5)
T2	7.7 (16.6)	10.6 (19.0)	13.3 (21.3)	27.4 (31.5)	27.4 (31.5)	6.6 (-52.6)	0.0 (-100.0)	4.3 (-48.8)	0.0 (-100.0)
T3	30.4 (33.2)	51.9 (46.0)	62.0 (51.9)	70.8 (57.2)	70.8 (57.2)	11.4 (-17.9)	16.9 (-18.5)	5.4 (-35.4)	9.3 (-28.3)
T4	39.5 (38.9)	81.0 (64.1)	90.7 (72.2)	96.9 (79.8)	96.9 (79.8)	11.7 H6.1)	21.0 (+1.4)	6.2 (-25.5)	12.9 (-0.1)
T5	2.9 (9.8)	32.0 (34.4)	50.2 (45.1)	72.9 (58.6)	72.9 (58.6)	14.1 (+1.2)	16..8 (-19.0)	7.5 (-10.4)	12.6 (-2.4)
T6	0.2 (0.0)	33.4 (35.3)	49.9 (44.9)	72.4 (58.3)	72.4 (58.3)	13.6 (-2.3)	17.5 (-29.7)	6.9 (-18.1)	12.3 (-4.7)
T7	51.7 (45.9)	73.7 (59.1)	76.9 (61.2)	84.1 (66.5)	84.1 (66.5)	13.9	20.7	8.4	13.0
LSD (0.05)	29.8	33.5	27.0	27.7	27.7	5.4	13.7	4.2	8.8

1. Figures in parentheses indicate angular value.
2. Figures in parentheses indicate % stimulation/inhibition over control.

Tl *Abutilon* leaf extract; T2 *Parthenium* leaf extract; T3 *Lantana* leaf extract; T4 *Euphorbia* leaf extract; T5 *Ageratum* leaf extract; T6 *Aeschynomene* leaf extract; T7 Control (water).

Table 2. Medicinal weeds in chickpea fields of Chhattisgarh region of Madhya Pradesh, India.

Scientific name	Common	Family name	Medicinal uses	Remarks[1]
Melilotus alba and *M. indica*[2]	Senji	Leguminoseae	Discutient and emollient, externally as fomentation, poultice, or plaster for swelling	M,m
Spilanthes acmella	Akarkara	Compositeae	For diseases of the mouth	M
Vicia sativa	Zillo	Leguminoseae	Emollient used as a poultice	M
Chenopodium album	Bhathua	Chenopodiaceae	For hook worm, leucoderma and skin problems	M,m
Sphaeranthus indicus[1]	Mundi	Compositeae	For respiratory diseases	M,m
Cynodon dactylon	Doobi	Gramineae	Whole plant juice as astringent, decoction of root as diuretic	M,m
Cyperus rotundus[2]	Motha	Cyperaceae	Root is useful in leprosy, thirst, fever, diseases of the blood, billouseness, dysentry, intense itching, epilepsy, ophthalmia	M,m
Medicago denticulata	-[u]	Leguminoseae	As antidote to venom	M
Parthenium hysterophorus	Gajar ghas	Compositeae	Root decoction useful in dysentry	M
Vicoa vestata	Takla	Compositeae	-[n]	-
Angallis arvensis	Krishna neel	Primulaceae	For diseases of respiratory organs and genitals, also in hydrophobia	M
Euphorbia heterophylla	Duddhi	Euphorbiaceae	For respiratory diseases	M,m
Gomnphrena decumbens	-[u]	Amaranthaceae	–[n]	-
Lathyrus sp.	Khesary	Leguminoaceae	A reputed drug in homeopathic systems of medicine; oil from the seed is a powerful but dangerous cathartic	M
Launea sp.	Jangli palak	Compositeae	Used as lactagogue	M
Oxalis corniculata	Khatti-buti	Oxalidaceae	For skin diseases	M,m
Sonchus arvensis	-[n]	Compositeae	Used as laxative and diuretic, root and leaves used as a tonic and febrifuge	M
Vernonia baldwini	-[n]	Compositeae	Useful in treatment of asthma, bronchitis and constipation	M
Tridax procumbens	Bhengra	Compositeae	For all types of bleeding	M,m
Blumea lacera[2]	Kukurmutta	Compositeae	For bronchitis, fevers, thirst and burning sensation	M,m
Cirsium arvense	Kama van	Compositeae	-[n]	-

1. M = weeds with medicinal properties; m = weeds used in Chhattisgarh as medicinal plants.
2. weeds with heavy demand in national and international drug markets.

a = not known.

13.3% at 7 DAS, 27.4% at 9 DAS, and 27.4% at 11 DAS. The inhibitory allelopathic effects of *Parthenium* leaf extract might be due to the presence of lethal allelochemicals such as parthenin, coronpillin, caffeic acid, p-coumaric acid, alkaloids, and sesquiterpenes in the extracts. The lethal effects of these allelochemicals have already been reported (Narwal 1994) in other crops.

With regard to root elongation, different extracts produced inhibitory allelopathic effects except *Ageratum* leaf extract at 11 DAS and *Lantana* leaf extract at 22 DAS. The lowest root elongation was noted under *Parthenium* leaf extract at 11 DAS, whereas at 22 DAS, all the plants died. In case of shoot elongation, all extracts (except *Abutilon* leaf extract at 11 DAS) produced inhibitory allelopathic effects at 11 and 22 DAS but these results were at par with the control (except *Parthenium* leaf extract). The allelopathic effects of *Lantana* leaf extract have been reported on many crop (Narwal 1994). In most early studies, the allelopathic effects of *Lantana* were studied only up to 11 DAS and it was concluded that *Lantana* is harmful to crops. This study revealed that at 11 DAS, *Lantana* leaf extract inhibited root and shoot elongation but at 22 DAS, a recovery in seedling growth was observed. The recovery may be due to a reaction of the plant defence system in response to allelochemicals. This recovery was not observed in case of *Parthenium* leaf extract and the plants died. The study therefore suggested that to explain the allelopathy of any weed on a specific crop, experiments on germination should be extended up to at least 20-25 DAS for greater accuracy. The study also revealed that chickpea fanners must be made aware of lethal allelopathic effects of the obnoxious weed, *Parthenium hysterophorus.*

Studies on medicinal weeds

Weeds compete with crops for light, moisture, and nutrients. Since the inception of agriculture, weeds have been recognized as potential pests. Weeds in general reduce crop yields by 31.5% (22.7% in winter and 36.5% in summer and rainy season) (Bhan et al. 1998). Ancient Indian literature cites evidence that every plant on this earth including weeds is useful for human beings, animals and also for other plants (Oudhia and Tripathi 1999a). The medicinal potential of many common problematic weeds have been reported (Oudhia and Tripathi 1999b). Second studies conducted by the Department of Agronomy, IGAU, Raipur, India, revealed that weeds with medicinal and industrial uses are a boon to farmers (Oudhia and Tripathi 1999a). Farmers can earn additional income by selling different plant parts of weeds through cooperatives to national and international drug retailers (Oudhia and Tripathi 1999b and 1999c). Uprooting productive use of weeds will not only serve the interests of ecofriendly management but also allow farmers to recover the cost of weeding. To achieve these targets, it is essential to survey crop fields to identify all the medicinal flora. Due the lack of any information regarding medicinal weed flora in the chickpea fields in Chhattisgarh, a survey was conducted by the Department of Agronomy, IGAU, Raipur, in 1996/98.

A detailed ethnobotanical survey was done in the entire Chhattisgarh region. The study was conducted in selected districts: Raipur, Bilaspur, Durg, Rajanadgaon, Bastar, and Sarguja. From each selected district, two blocks and from each selected block, a random sample of four villages was taken. A proportionate sample of villagers from each selected village was taken to make a total sample size of 100 respondents. The data were collected through personal interviews following a well prepared interview schedule. To determine the recorded medicinal uses of common weeds in chickpea fields, reference literatures of ayurveda, homoeopathy, unani, allopathy, and other systems of medicine were used. The weeds were collected through intensive visits to the target villages every 15 days. Visual observations were made both on crop fields and wastelands.

The survey revealed that out of 21 problematic weeds in chickpea fields of Chhattisgarh, 18 were weeds possessing valuable medicinal properties. The medicinal properties of these 18 weeds have been well documented in the literature. Some of the important medicinal properties of these weeds are given in Table 2. The study also revealed that of these 18 medicinal weeds, the villagers were using 9 weeds to treat health problems. Of a total of 21 weeds, 5 weeds were idendified as having the potential to provide additional income to the farmers. These weeds were *Chenopodium album, Sphaeranthus indicus, Cyperus rotundus, Melilotus alba/indica,* and *Blumea lacera.* It was noted that there is a heavy demand for the different plant parts of these weeds in national and international drug markets. The study suggested that there is a strong need for: a. documentation of valuable knowledge about medicinal weeds in chickpea fields; b. identification of suitable market; and c. formation of cooperative societies. These targets can be achieved by the joint efforts of governmental, nongovernmental agencies and local people.

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Biotechnology

Isolation of Putative Disease Resistance Gene Clones from Chickpea and Pigeonpea

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One of the major biotic constraints to crop yields is plant disease. It is essential to understand the development of disease and to implement control measures, irrespective of whether the causative agent is a fungus, bacterium or virus. Of the several disease-control measures available, making use of the genetic basis of disease resistance is the most important. Recent advances in molecular biology have paved the way for the genetic dissection of disease resistance.

The basis for the plant recognition system has been the classic genetic work of Flor (1971), according to which a single disease-resistance gene [R] in the plant recognizes the biotype of the pathogen with the corresponding complementary avirulence gene (Avr). Resistance genes are often present as gene clusters of different specificities in the plant genome. Recently several of these disease-resistance genes have been cloned. The availability of cloned disease-resistance genes permits studies of resistance-gene structure and function. The molecular cloning of disease-resistance genes will also have a major impact on agricultural practice. The two most common methods used for cloning have been chromosome walking (map-based cloning) and transposon tagging. Several recent reviews describe the developments in the study of disease-resistance genes (Baker et al. 1997; Hammond-Kosack and Jones 1997).

The majority of R genes cloned so far share DNA sequences encoding conserved amino acid motifs irrespective of whether they confer resistance to bacterial, fungal, viral, or nematode pathogens. In general, R genes can be grouped into five major classes based on their structural features (Baker et al. 1997) which are leucine-rich repeats (LRR), nucleotide binding site (NBS), and a serine/threonine protein kinase. These are considered to be

components of a signal transduction pathway. The first class encodes cytoplasmic receptor-like proteins that contain LRR domain and a nucleotide binding site (NBS), e.g., *RPS2* and *RPM1* from *Arabidopsis thaliana* conferring resistance to the bacterial pathogen *Pseudomonas syringae,* which has the Avr genes *AvrRps2* and *AvrRpmI*. In this class are included others like the *N* gene from tobacco, *L6* and *M* from flax whose amino-terminal domain shows homology to the *Drosophila* developmental gene Toll and the mammalian immune-response gene encoding the interleukin-1 receptor (IL-IR). The second class contains only a serine-threonine kinase, e.g., *Pto,* which confers resistance to the bacterial pathogen *P. syringae pv.* tomato containing *Avr Pto.* The third class encodes a putative transmembrane receptor with large extra cytoplasmic LRR domains, e.g., includes *Cf-2* and *Cf-9* from tomato which confer resistance to different races of *Cladosporium fulvum.* The fourth class encodes a putative transmembrane receptor with an extracellular LRR domain and an intracellular serine-threonine kinase domain, e.g., the rice *Xa 21* gene, which confers resistance to the bacterial pathogen *Xanthomonas oryzae* pv. *oryzae.* The fifth class does not fit into any of the above classes and has an enzymatic function which is carried out without the involvement of the *Avr* component, e.g., the HM1, which confers resistance to the fungal pathogen *Cochliobolus carbonum* race 1. *HM1* encodes a reduced form of nicotinamide adenine dinucleotide phosphate (NADPH)-dependent reductase that inactivates toxin produced by *C. carbonum.*

The sequence similarity among the resistance genes from different plant species has made it possible to isolate such resistance-gene candidates (RGCs) from any plant species of interest using polymerase chain reaction (PCR) with oligonucleotide primers to the conserved domains of the resistance-gene classes mentioned above. This method has been successfully used to identify resistance-gene candidates in a variety of species including soybean, potato, and lettuce (Leister et al. 1996; Kanazin et al 1996; Shen et al. 1998).

We used the degenerate oligonucleotide primers designed to the conserved motifs in the NBS region to amplify DNA fragments from chickpea and pigeonpea. These fragments were cloned, sequenced, and screened for homology in the database. We report here the identification of several such disease-resistance gene candidates.

DNA was isolated from chickpea (cultivars - Annigeri, and JG 62) and pigeonpea (cultivars ICP 7119 and ICP 2376) by the standard protocol using alkyl trimethyl ammonium bromide (CTAB). The degenerate primers used were designed from the motifs within sequence encoding the NBS as described (Shen et al. 1998). PCR was performed with the different primer combinations using the cyclesμ described (Shen et al. 1998) in a total volume of 35μl. PCR products from different genotypes of a species were pooled and cloned into pGEM vector (Promega). About 12-16 clones were sequenced from each successful amplification consisting of about 80 clones using the Applied Biosystems model 377 PRISM automated sequencer. DNA homology searches were performed via the National Centre for Biotechnology Information web site (www.ncbi.nlm.nih.gov) using the BLAST algorithm.

Of the 13 combinations of pairs of primers tested on templates from pigeonpea and chickpea genomic DNA samples, only six yielded amplification products. The fragments obtained were approximately the expected size of 0.5kb with multiple templates and these products were cloned and sequenced. The BLAST search indicated that many of the isolated clones had DNA sequence similarity to the NBSs of known resistance genes. The maximum number of clones were obtained using the primers designed by Shen et al. (1998). The DNA sequence homology of the different families of RGC sequences was classified at 85% and 60% levels of DNA sequence similarity. Sequences with greater than 60% similarity were considered to belong to the same family. Based on similarity in nucleotide sequence these resistance-gene candidate clones could be put into 14 classes or families of RGCs, 8 in pigeonpea (RGCPP) and 6 in chickpea (RGCCP) (Table 1). Comparison of the deduced amino acid sequences of the RGC sequences to products of known resistance genes revealed that the RGC sequences are as similar to each other as they are to resistance

Table 1. Resistance-gene candidates (RGCs) isolated from chickpea and pigeonpea.

	Number of RGCs isolated[1]	
Primer combination	Chickpea	Pigeonpea
GLPL3-AA[2]	5/20	-
GLPL3-AG[2]	-	-
GLPL4-AG[2]	-	1/6
GLPL4-GA[2]	1/8	-
s1-as1[3]	-	4/5
s2-as3[3]	-	2/8
LM 637-LM 638[4]	-	1/1

1. No. of families based on less than 60% DNA sequence homology per total number of RGC clones isolated.
2. Shen et al. 1998.
3. Leister et al. 1996.
4. Kanazin et al. 1996.

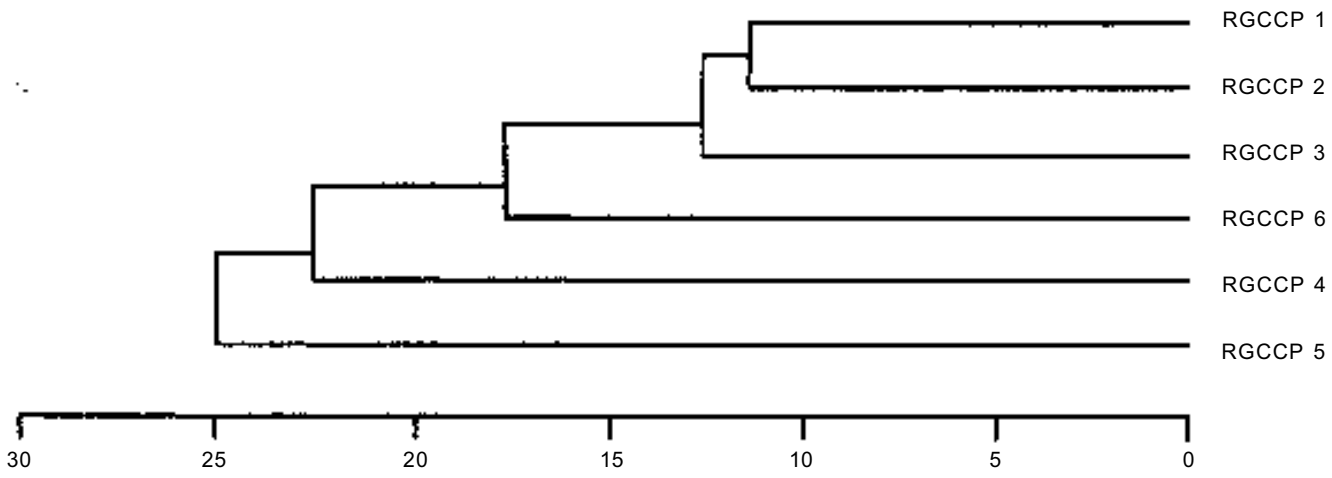

Figure 1. Phlyogenetic relationship of RGCCP genes based on the amino-acid sequence.

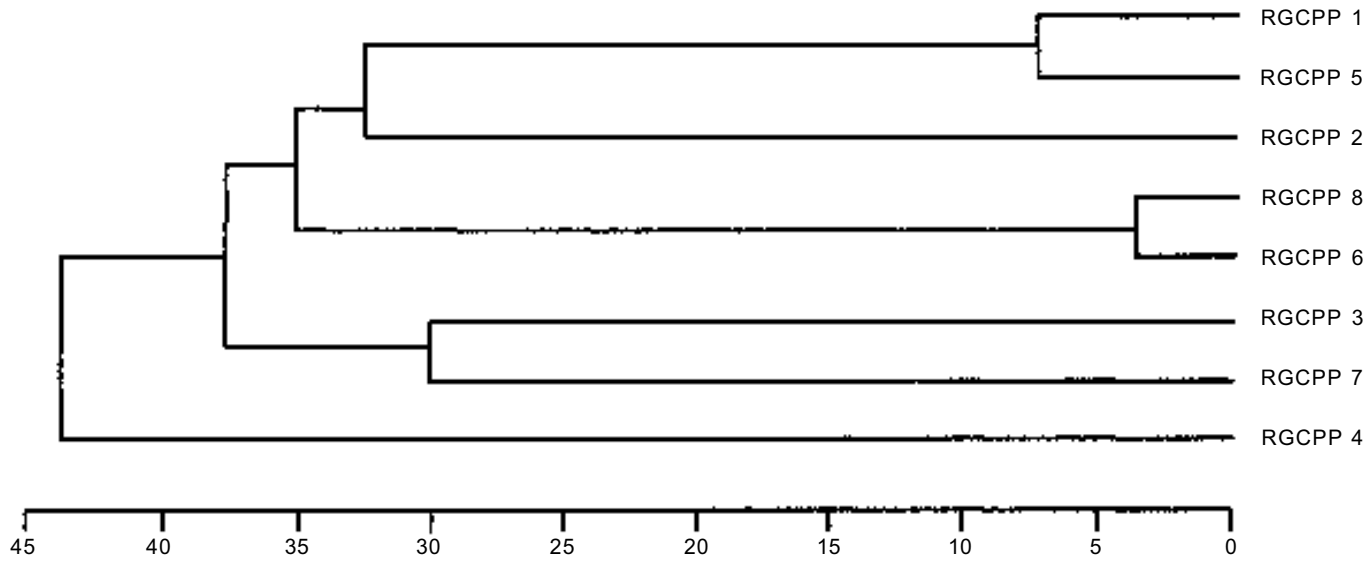

Figure 2. Phylogenetic relationship of RGCPP genes based on the amino-acid sequence.

genes from other species. A phylogenetic tree constructed based on the amino acid sequence revealed the homology among the different RGCs (Figs. 1 and 2). In both chickpea and pigeonpea the majority of the RGCs showed higher homology to *N* and *L6* resistance genes than *RPS2* and *RPM* (data not shown). In pigeonpea, one of the RGCs (*RGCPP5)* showed high homology to *Prf* from tomato. Two of the RGCs (*RGCPP4* and *RGCPP8)* showed both amino acid and nucleotide sequences quite different from the others. All the RGCs isolated from chickpea gave only monomorphic bands when hybridized with DNA from 10 of the elite cultivars on a Southern blot with *Eco*RI (data not shown). Definite proof that these sequences are resistance genes requires the isolation of full-length resistance gene clones and transgenic complementation. These also can be mapped to determine their relative position but at present no linkage map is available for these two legumes. With the availability of NILs or RILs differing for disease resistance the utility of these clones as markers for resistance will be revealed.

This PCR approach with degenerate oligonucleotide primers has great potential to amplify numerous resistance genes from diverse species. With the isolation of more

resistance genes, it is becoming possible to design primers that will be highly selective in amplifying resistance genes.

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Improved Efficiency in Chickpea Tissue Culture: Effects of Presoaking and Age of Explants on In Vitro Shoot Proliferation

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Genetic transformation and creation of elite germplasm require an efficient plant regeneration system. Chickpea (*Cicer arietinum* L.), a major grain legume, is susceptible to virulent strains of *Agrobacterium* (Mohapatra and Sharma 1991; Islam et ah 1994), but the lack of high-frequency regeneration has deterred the production of transgenic plants. In-vitro regeneration of plantlets from shoot meristems, immature cotyledons, and leaflet-derived callus has been reported in chickpea (Suhasini et al. 1994). We have found that benzyladenine (BA) with indoleacetic acid (IAA) or naphthaleneacetic acid (NAA) are effective growth regulators for shoot organogenesis from hypocotyl explants (Islam et al. 1994). However, only 6-8 shoots were obtained for each regenerating explant. This report describes the benefits of presoaking the hypocotyl explants in liquid B5 basal medium containing 5-15 µM BA for 24-60 h duration on their regenerative ability.

Table 1. Main effects of various treatments on percent cultures showing regeneration and average number of shoots per regenerating explant.[1]

Treatment	Cultures showing shoot formation (%)	Average number of shoot per explant
Effect of BA concentrations[2]		
BA 5 µM	60 a[5]	6.3 c
BA 10 µM	79 b	14.7 a
BA 15 µM	81 b	10.6 b
Effect of presoaking[3]		
Unsoaked	55 b	6.4 b
24 h soaking	60 b	6.8 b
36 h soaking	58 b	7.7 b
48 h soaking	85 a	12.8 a
60 h soaking	80 a	13.2
Effect of age of explants[4]		
7-day-old	85 a	22.0 a
14-day-old	75 b	6.8 b
21-day-old	60 c	2.8 c

1. The experiment was repeated twice and each treatment consisted of 12-15 explants.
2. Values for BA (benzyladenine) are the means of two sets of experiments, five presoaking periods and three ages of explants.
3. Values for presoaking are the means of two sets of experiments, three BA concentrations and three ages of explants.
4. Values for age of explants are the means of two sets of experiments, three BA concentrations and five presoaking periods.
5. Mean separation in groups within columns by Duncan's Multiple Range Test, 5% level.

Seeds of chickpea cultivar Nabin were collected from the Bangladesh Agricultural Research Institute, Ishrudi. Seedlings were raised in vitro from surface-sterilized seeds on hormone-free B5 (Gamborg et al. 1965) basal medium. Hypocotyl explants (0.5-0.6 cm) excised from these seedlings of three different ages (7, 14, and 21 days old) were soaked in liquid B5 basal medium containing 5, 10, or 15 µM BA and 3% sucrose for 24, 36, 48 and 60 h. The soaked explants were cultured on standard shoot-inducing medium B5+5 µM BA+1 µM NAA (Islam et al. 1994). All cultures were incubated at 26 ± 1°C under a light intensity of 60-70 m mol m^{-2} S^{-1} and were provided 16 h illumination per day by warm white fluorescent tubes.

The adventitious shoot regeneration ability for various treatments is presented in Table 1. Such factors as BA concentration, length of the presoaking period, and age of explants significantly affected the regeneration ability. The results clearly demonstrated that presoaking of explants prior to culture on shoot-inducing medium is highly beneficial. The unsoaked explants produced fewer shoots than the presoaked explants. Concentration of BA affected shoot formation ability and 10 µM BA was highly effective. Presoaking for 24 and 36 h did not affect the explants significantly and a minimum of 48-60 h presoaking was found to be beneficial. Most (85%) of the explants produced multiple shoots and the highest number of shoots (12.8 per explant) was produced by explants presoaked for 48 h. An average of 22 shoots developed from 7-day-old hypocotyl, whereas reduced or poor regeneration was observed from 14- and 21-day explants.

Other reports support the findings of the present study that presoaking of explants in BA prior to culture is beneficial and even essential in mulberry (Jian and Datta 1992). The present study demonstrated that it is possible to enhance the shoot-regeneration ability of chickpea by presoaking hypocotyl explants. The degree of morphogenetic potential depends upon the BA concentration, length of presoaking period, and age of explants at the time of placement in the culture-regeneration medium.

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Pigeonpea

Breeding/Genetics

A Floral Mutant in Pigeonpea

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A typical pigeonpea flower has a papilionaeous corolla with standard, wings, and boat-shaped keel petals and a superior subsessile ovary with a single pistil. In 1997, a floral mutant was observed in an open-pollinated population of variety BDN 1 at the Agricultural Research Station, Badnapur. This mutant has obcordate leaves. The flowers have zygomorphic papilionaeous corolla. The standard petal is erect and spreading, biauriculate, with two callosities. Wing petals are light yellow, symmetrical, with a callosity. Keel petals are more greenish than other petals, widely open, free, and thread like; thus the gynoecium is well exposed to pollinators. The mutant flower structure therefore may encourage cross pollination and pod setting (Fig. 1). These observations concur with those reported earlier by Singh et al. (1942). The flower structure of the mutant plant varies from mono to bi- or sometimes tricarpellate subsessile ovaries with 10 diadelphous stamens (Fig. 2).

The pollen grain of the mutant flowers when tested in 2% acetocarmine solution was found fertile. But the pod set on these plants was very poor and occurred only on the monocarpellate flower. Most bi- and tricarpellate flowers dropped. These observations were different from those reported by Venkateswarlu et al. (1981).

The mutant may be of some value in hybridization as the gynoecium is widely exposed. Flower buds from the mutant were emasculated and pollinated with BDN 2, BSMR 175, BSMR 736, and Daithana local, and hybrid seed were obtained. The reciprocal crosses were also successful. Crosses with bi- or tricarpellate flower' vere unsuccessful. An inheritance study of the mutant is planned.

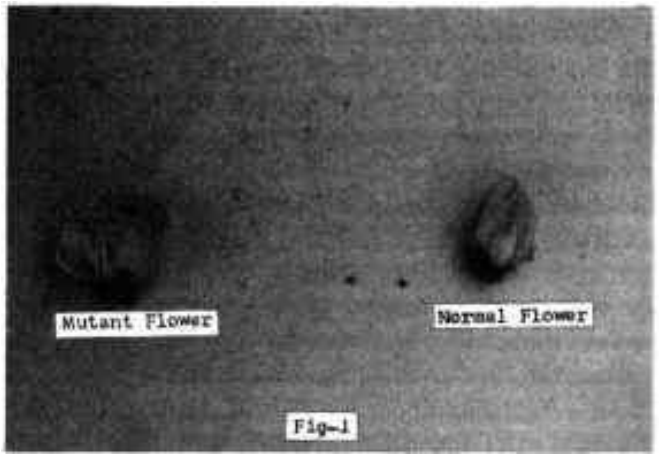

Figure 1. Normal and mutant flowers of BDN 1.

Figure 2. Flower structure of mutant plant.

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AKPH-4101: a Short-duration Pigeonpea Hybrid for the Central Zone of India

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Though pigeonpea is generally regarded as a self-pollinated crop, it exhibits outcrossing up to 70% (Saxena et al. 1990). Hybrid pigeonpea has become a reality with the discovery of stable genetic male sterility (Reddy et al. 1978) coupled with the reports of the presence of non-additive genetic variation, and sufficient heterosis for yield (Soloman et al. 1957, Patel and Patel 1992).

The first short-duration pigeonpea hybrid ICPH 8 was released in 1991 (Saxena et al. 1992).

Table 1. Yield (t ha^{-1}) of AKPH 4101 in the All India Coordinated Trials, Central Zone, 1993-96.

	Grain yield (t ha^{-1})			
Entries	AVT[1]-2 95-96 (6)[3]	AVT-1 94-95 (1)	IET[2] 93-94 (2)	Weighted mean
AKPH-4101	1.95	1.10	1.21	1.69(9)
UPAS 120	1.23	0.90	0.49	1.76(8)
ICPH 8 (Control)	1.69	-	0.57	1.41(8)
% Increase over				
UPAS 120	64			
ICPH 8	25			

1. AVT = Advanced varietal trial.
2. IET = Initial evaluation trial.
3. Figures in parentheses represent number of trials.

Source: AICPIP Plant Breeding Report, Kharif, 1995/96.

Work on developing pigeonpea hybrids has been going on at Akola since 1988 with the objective of exploiting heterosis in short- and medium-duration pigeonpeas. AKPH-4101 is an F_1 hybrid of Akms-4 x AK-101. It has been identified for rainy-season cultivation in the Central Zone of India by the All India Coordinated Research Project on Pigeonpea of the Indian Council of Agricultural Research (ICAR) in its annual group meet held in May 1997 at Sardar Krishinagar, Gujarat. The hybrid has been found to be 64% superior in grain yield over UPAS-120 and 25% over ICPH 8 (Table 1). AKPH-4101 has indeterminate flowering, semi-spreading branches, medium bold, reddish brown seeds, and matures in 140 to 145 days. It is also suitable for intercropping with early-maturing (65 to 75 days) legumes like mung bean cultivars K-851 or Kopergaon in the Central Zone of India.

The disease reaction of AKPH-4101 against fusarium wilt, sterility mosaic and *Phytophthora* stem blight in different coordinated trials observed during 1995/96 is given in Table 2. AKPH-4101 expressed better tolerance against fusarium wilt at Badnapur and Sehore. It is susceptible to sterility mosaic disease. AKPH-4101 expressed better field reaction against *Phytophthora* than the control ICP 7119. Being an early-maturing hybrid, it escapes drought stress at flowering and maturity.

The seeds of this hybrid contain 21.2% protein with 70.8% dhal recovery. The time required to cook whole kernels was 24 minutes. Its average 100-seed mass is 8.3 g.

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Table 2. Percentage incidence of fusarium wilt, sterility mosaic, and *Phytophthora* stem blight in pigeonpea hybrid AKPH-4101, Central Zone, India, 1993-96.

	Fusarium wilt		Sterility mosaic		Phytopthora blight	
Location	AKPH 4101	ICP 2376	AKPH 4101	ICP 8863	AKPH 4101	ICP 7119
Badnapur	34	100	91	71	-	-
Rahuri	100	100	100	100	45	64
Sehore	21	81	-	-	8	90

Source: AICPIP consolidated report on pigeonpea, postrainy-season pulses group, Tamil Nadu Agricultural University, Coimbatore, 11-13 May 1996. pp. 23, 42 and 66.

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Extent of Natural Outcrossing in Pigeonpea in Gujarat

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In pigeonpea, only a part of the flower's life cycle is cleistogamous. This condition is known as preanthesis cleistogamy. Consequently, a considerable degree of natural cross-pollination due to insects has been reported in India and other countries. The outcrossing ranges from 5-70% depending upon the abundance of bee species acting as pollen vectors and other location-specific environmental factors (Williams 1977, Bhatia et al. 1981, Saxena et al. 1990). The outcrossing mechanism helps in the production of large-scale hybrid seed but constrains the development of pure lines and the maintenance of the purity of released cultivars.

An experiment was conducted to study the extent of natural outcrossing at three locations: Sardar Krushinagar and Aseda in North Gujarat, and Junagadh in the Saurashtra region during the 1991/92 rainy season. The rectangular and hexagonal layouts used by Bhatia et al. (1981) were followed to sow pure seeds of ICPL 9175 with dominant purple stem marker and T-15-15 with recessive green stem marker at each location. In the rectangular layout, within each third row, every sixth plant was green-stemmed (T-15-15) and the remaining were purple-stemmed (ICPL 9175).

In the hexagonal layout, within each third row every third plant was green-stemmed (T-15-15) and the remaining were purple-stemmed (ICPL 9175). The interrow and intrarow spacing was 1.0 m and the experimental plot was located at least 250 m away from other

Table 1. Percent natural outcrossing in individual plant progenies at three locations under two sowing methods in Gujarat, India, 1991/92 rainy season.

Plant	Hexagonal layout at location				Rectangular layout at location			
no.	1	2	3	Mean[1]	1	2	3	Mean
1	19.6	10.0	5.1	11.6	5.9	14.3	3.3	7.8
2	21.3	17.9	10.0	16.4	0.0	15.0	16.7	10.6
3	8.2	21.6	14.0	14.6	15.2	16.7	7.8	13.2
4	12.3	9.4	7.8	9.8	15.0	14.6	8.2	12.6
5	17.7	30.3	15.8	21.2	11.1	21.4	22.9	18.5
6	21.2	15.6	0.0	12.2	14.3	7.9	11.1	11.1
7	19.5	7.3	10.6	12.5	18.8	10.5	14.6	13.0
8	10.7	8.3	17.9	12.3	5.8	15.2	24.3	15.1
9	11.3	18.1	17.0	15.5	23.1	19.2	7.0	16.4
10	30.0	0.0	7.8	12.9	9.7	8.0	21.7	13.1
11	32.6	41.0	17.2	30.3	19.3	5.1	5.3	9.9
12	14.0	8.6	8.6	10.7	13.8	5.1	9.5	9.5
13	6.0	0.0	14.7	6.9	21.0	23.3	9.8	18.0
14	17.7	28.6	18.7	21.7	16.7	8.3	11.1	12.0
15	22.2	27.0	23.1	24.1	35.0	11.1	10.9	19.0
16	27.8	0.0	4.4	10.9	17.2	2.4	2.2	7.3
17	13.7	23.4	13.5	16.4	23.8	15.4	14.3	17.8
18	9.4	26.7	5.9	14.0	21.4	5.4	6.0	10.9
19	12.5	0.0	15.9	9.5	7.1	9.3	3.3	6.6
20	20.0	9.4	13.9	14.4	13.2	8.9	1.7	7.9
21	9.4	10.9	34.4	18.1	36.4	15.9	1.7	18.0
22	10.3	6.8	2.3	6.5	16.7	13.1	8.2	12.6
23	20.4	8.3	30.2	19.6	19.6	26.3	4.9	16.9
24	19.2	18.9	28.9	22.3	21.0	13.9	8.3	14.4
25	16.1	23,7	29.7	23.2	11.8	14.5	11.1	12.5
26	21.1	15.6	4.0	13.6	12.8	6.9	3.5	7.7
27	13.9	18.4	16.3	16.2	17.5	4.9	7.8	10.1
28	34.2	6.9	20.0	20.4				
29	16.7	35.7	14.3	22.2				
30	25.0	18.7	26.3	23.4				
31	26.0	4.7	25.0	18.6				
32	8.7	14.5	28.3	17.2				
33	23.5	4.3	12.9	13.6				
34	25.0	5.7	20.0	16.9				
35	20.0	25.7	17.9	21.2				
Mean	17.9	14.7	15.8	16.3	15.7	12.1	8.9	12.7

1. 1. Sardar Krushinagar, 2. Aseda, 3. Junagadh; Mean = Pooled over locations.

pigeonpea fields. At the three locations, open-pollinated seeds were collected from an individual green-stemmed plant, T-15-15, in both the sowing methods. The green-stemmed plant progenies were sown during the 1992-93 rainy season at Sardar Krushinagar and were scored for green- and purple-stem plants after 6 to 7 weeks of planting. The average frequency of purple-stemmed plants among the individual green-stemmed progeny gave an estimate of the percentage of natural outcrossing (Table 1).

At Sardar Krushinagar the extent of natural outcrossing varied from 6.0 to 34.2% with an average of 17.9% in the hexagonal design whereas in the rectangular design it varied from 0 to 36.4% with 15.7% mean outcrossing. At the Aseda centre, the range was 0.0 to 41.0% with 14.7% average natural outcrossing in the hexagonal layout. In the rectangular design, these figures varied from 2.38 to 26.3% with 12.1% average at this centre. At the Junagadh location in the Saurashtra region the amount of natural cross-pollination ranged from 0.0 to 34.4% with an average of 15.78% in the hexagonal layout.

In the rectangular design at Junagadh it varied from 1.7% to 24.3% with an average of 8.9%. The pooled data over locations for the hexagonal layout gave a range of 6.5% to 30.3% with a mean of 16.3%. The pooled figures in the rectangular layout ranged from 6.6% to 19.0% with a mean of 12.7% for natural cross-pollination. The results revealed that although the proportion of purple-stemmed plants in the rectangular layout was more than double those in the hexagonal layout, the extent of natural outcrossing was more pronounced in the latter. Further, it could be noticed that crossing by bees on normal fertile flowers is neither constant from location to location nor from plant to plant, thus indicating randomness of bee activity. The procedure adopted did not permit identification of any hybrids that may have resulted from natural intercrossing among the recessive green-stemmed plants. If it is assumed that an equal amount of outcrossing was undetected, the total amount of outcrossing would be considerably greater. Our experience of working with isolated sowings of genetic male-sterile pigeonpea at Sardar Krushinagar indicates that sufficient pod load on the male-sterile plant is obtained at the present rate of natural outcrossing. The observed degree of natural outcrossing seems to be sufficient to support large-scale hybrid seed production in Gujarat using the male-sterility system.

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Pathology

Reaction of Pigeonpea Cultivars to a Sudden Appearance of Macrophomina Stem Canker Disease at Pantnagar, India

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Pigeonpea is attacked by several diseases. Among them, *Phytophthora* blight, fusarium wilt, and sterility mosaic are the most important, while others such as Macrophomina stem canker (*Macrophomina phaseolina*) are relatively less important. However, stem canker can cause considerable loss in years of its epiphytotic occurrence. The sudden appearance of this disease during the 1997/98 rainy season could be attributed to the low temperature and prolonged foggy weather during November and December, factors which adversely affected pod development. With the increase in temperature in February, the severity of disease decreased in late-maturing genotypes, which thus escaped the disease. This outbreak of stem canker was studied to assess the reaction of different pigeonpea lines sown in

Table 1. Reaction of pigeonpea genotypes to Macrophomina stem canker at Pantnagar, Uttar Pradesh, India, rainy season, 1997/98.

Pigeonpea genotypes	Disease score (0-5)[1]	Classification of genotypes
KE-108	0	Highly resistant
Pusa 941, Pusa 945, Pusa 962, Pusa 608, Pusa 610, DPH 95-7, IPA 94-4, AL 259, AL 344, AL 587, AL 600, PHH-9, GAUT 104, GAUT 9001, GAUT 9004, Manak, METH 121, TAT 97-69, WRGE-5, METH 103, PA-3, H 90-10, ICPL 87047, -87154, -86220, -86024, -87098, -87105, -87115, -87154, -88003, -88009, -88023, -89002, -89011, -90035, -87089,-87	1	Resistant
GAUT 97-3E, Pusa 951, DPH 93-4, TAT 14, PHH-7, DPPA 85-7, Pusa 971, H 91-7, TAT 97-48, H 91-19, H 86-1, H 86-4, H 91-7, H 87-24, PA-211, -116, -106, -215, -226, -128, -142, ICPL 84023, -84060, -85024, -85045, -87109, -88027, -88039, -84-4, -288, -1, IMS-1, Pusa 33(s)	2	Moderately resistant
ARG 102, AL 1313, H 82-1, AL 1333, H 83-1, BVVR-22, IPH 732, AF 286, BWR-10, GAUT 92-4, UPAS 120, PA-228, -163, -134, -218, -108, -217, -169, -104, ICPL 84031, -84052, -85010, -86012, -86029,-87119,-88001,-4	3	Moderately resistant
S-31, AF 345, H 86-14, Pusa 33, Pusa 855, PHH-3, T-21, PA-111, -151, -227, -229, ICPL 83024, ICPL 332	4	Susceptible
ICPL 85030, -86005	5	Highly susceptible

1. 0 = highly resistant, 1 = resistant, 2 = moderately resistant, 3 = moderately susceptible, 4 = susceptible, 5 = highly susceptible.

the field at G B Pant University of Agriculture and Technology, Pantnagar, Nainital, Uttar Pradesh, India.

The stems of diseased plants showed spindle-shaped lesions with light gray centres and brown margins at the point of infection. Drooping of the pod-loaded secondary branches was common in the upper part of the affected plants. Scoring for disease was done at podding on the basis of severity of symptoms on stem and branches (Anonymous 1982). The lines were grouped as: highly resistant (1), resistant (38), moderately resistant (33), moderately susceptible (27), and susceptible (15) (Table 1). It was observed that, in general, the late-maturing cultivars/lines were more resistant to this disease than early-maturing lines. However, these lines require some more testing across seasons and locations to identify lines with stable resistance to this disease.

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Entomology

A Braconidae Parasite *(Bracon* sp. near *celer* Szepligeti) on Pigeonpea Pod Fly (*Melanagromyza chalcosoma* Spencer) in Farmers' Fields in Southern and Eastern Africa

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Pod fly *(Melanagromyza chalcosoma* Spencer) is one of the major insect pests affecting, pigeonpea (*Cajanus cajan* [L] Millsp.) in southern and eastern Africa (Lateef 1991, Minja 1997). It is also a common pest in pods of several other legumes grown in the region (Le Pelley 1959). The results of recent surveys in farmers' fields in four major pigeonpea-growing countries in southern and eastern Africa showed that pod-fly damage on seed ranged from 0-46% in Kenya, 0-4% in Malawi, 0-7% in Tanzania, and 0-13% in Uganda (Minja 1997). The small black fly lays eggs through the wall of the developing pod and the maggot feeds by tunnelling the green seed. Two or more larvae often develop and pupate in one locule. In Kenya, up to 40 pupae were observed in a single pod containing an average of 5 seeds (Minja 1997). The brown puparium is formed inside the pod but outside the seed (Reed et al. 1989). These puparia are commonly associated with a single white parasite cocoon in pods, Sithanantham and Reddy (1990) reported the occurrence of the white cocoons in Kenya, Malawi, and Zambia. The distribution and potential of this parasite to control pod fly in the region is not known. Preliminary assessment on the incidence and distribution of the parasite were made during field surveys in 1995 and 1996.

Surveys were conducted in the major pigeonpea-growing areas in Kenya, Malawi, Tanzania, and Uganda. Samples of pigeonpea pods were collected from farmers' fields and research farms. In the laboratory, the pods were opened to determine the pests, associated natural enemies, and seed damage. Records on pod fly included the number of larvae, pupae, and parasite cocoons or imagos in each pod. Fresh cocoons recovered from pods were left in the laboratory for adult emergence. Open cocoons, where the wasp had emerged, were also recorded. The total number of pod flies and parasites were recorded separately for each sample. The number of parasites recorded were expressed as a proportion of the total host and parasite population taken together.

Pod fly and white cocoons of the parasite were recorded in Kenya, Malawi, Tanzania, and Uganda (Table 1). The adult wasps were identified as *Bracon* sp. near *celer* Szepligeti [A.K. Walker, HE det.]. A few adult wasps were also observed laying eggs on green pigeonpea pods in the field in Kenya. Pod fly populations were greater in Kenya than in other countries. Infestations were high in locations where the crop matured late in the season or during the cool weather. However, areas along the ocean coast, i.e., areas below 500 m altitude including the Coastal Province in Kenya, Lindi and Nachingwea in Tanzania, had insignificant pod fly infestations, and no parasites were recorded. These results indicate that there is some degree of association between the host and its natural enemy. The results further show that as the pest population increased, the incidence of the parasite also increased. These results, though preliminary, indicate that the parasite is widespread and it could be an important factor in the management of pod fly on pigeonpea. The biology, ecology, and behavior of the parasite in relation to its host and crop phenology are not known. There is a need to carry out studies on this parasite to fully establish its role and potential in the management of pod fly on pigeonpea.

Table 1. Parasitism (%) *of Bracon* sp. on pigeonpea pod fly *(Melanagromyza* sp.) in Kenya, Malawi, Tanzania, and Uganda, 1995 and 1996 seasons.

Country	No. of fields sampled	Total pod fly population unit^{-1}	Mean parasitism (%)
Kenya	44	755.1	5.2
Malawi	20	13.5	2.6
Tanzania	34	38.2	3.0
Uganda	17	285	2.3

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Adjusting Pigeonpea Sowing Time to Manage Pod Borer Infestation

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In India, pigeonpea [*Cajanus cajan* (L.) Millsp.] accounts for about 16% of the area and 19% of the production of all pulse crops. Pigeonpea is a comparatively recent introduction in Haryana, India. It has become the second most important pulse crop in the state after chickpea as evidenced by increase in area, from 2200 ha in 1976/77 to around 50 000 ha in 1993/94. It is used for both grain and fuel wood.

The grain yield of pigeonpea is considerably reduced by pod borer (*Helicoverpa armigera)* infestation. Chemical control of pod borer is not popular among farmers due to the difficulties of spraying or dusting (plants >2 m in height) and economic costs. Therefore, there is a need to exploit agronomic practices which can reduce the infestation of pod borer. Data from several experiments suggested that early sowing was critical to obtaining higher yields and good economic returns, but it was not clear if it was due to a lower level of pod borer infestation. Therefore, the susceptibility of the short-duration pigeonpea variety Manak to pod borer in relation to different sowing times was studied on farmers' fields in Sonipat District, Haryana, during the 1995 and 1996 rainy seasons.

During the 1995 and 1996 rainy seasons, 15 on-farm trials of > 1000 m^2 area, five each for different sowing times, i.e., first week of May (early sown), mid-May (15th-25th), and mid-June (15th-25th), were conducted. The level of pod damage was recorded on 10 randomly selected plants in each sowing, and yield was recorded from the entire area. The crop was not sprayed with any insecticide.

The early-sown crop had less than 10% pod borer damage (Table I). In contrast, pod damage to pigeonpea sown in mid-May and mid-June was 20-40%. The year x sowing date interaction was not significant. Grain yield decreased with a delay in sowing (Table 1).

Grain yield was negatively correlated with both sowing time (r = -0.98) and pod borer damage (r = -0.93). Pod borer damage was also associated with sowing time (r = 0.99). In the past, the advantage of early sowing had

Table 1. Effect of sowing time on pod damage by *Helicoverpa armigera* and yield of pigeonpea, Sonipat, Haryana, India, 1995 and 1996 rainy seasons.

	Pod damage (%)			Yield (t ha^{-1})		
Sowing time	1995	1996	Mean	1995	1996	Mean
1st week of May (1-7 May)	5	8	6.5	1.70	1.50	1.60
Mid-May (15-25 May)	28	25	26.5	1.10	1.20	1.15
Mid-June (15-25 June)	40	38	39.0	1.00	1.00	1.00
SE	±0.86				±0.061	
SE (interaction)	±1.1				±0.079	

often been attributed to better growth. However, studies conducted by Chauhan et al. (1994) under protected conditions revealed that dry-matter production is not a limiting factor for yield in short-duration pigeonpea in northern India. This study suggests that early-sown (early May) pigeonpea may yield better on account of low pod borer damage. Thus, this could be one of the important components of a pest management strategy to control pod borer in pigeonpea. More such studies need to be conducted in the Indo-Gangetic Plains, to determine how widely such a strategy could effectively control pod borer infestation.

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An Outbreak of Mealy Bug, *Ceroplastodes cajani* (Maskell) in the Nimar Region of Madhya Pradesh, India

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Pigeonpea is an important intercrop with cotton in the Nimar region of Madhya Pradesh, India. The crop is attacked by a complex of pod borers: podfly [*Melanagromyza ohtusua* (Malloch)], pod borer [*Helicoverpa armigera* (Hubner)], and plum moth [*Exelastis atomosa* (Walkr)] (Bindra and Jakhmola 1967, Odak et al. 1976). There is no report on the incidence of mealy bug [*Ceroplastodes cajani* (Maskell)] (Hemiptera: Coccidae) in Madhya Pradesh. Bhatnagar et al. (1984) reported the occurrence of the bug on pigeonpea in other states. The mealy bug was noticed for the first time on 2- to 3-year-old pigeonpea plants (single plant selection from Seoni-7) grown at the research farm of Jawaharlal Nehru Krishi Vishwavidyalaya Campus, Khandwa. The incidence of the pest was noticed from the first week of September 1992 till the last week of December 1992, peaking in the last week of Oct to mid-Dec 1992. The sudden outbreak of the mealy bug might be due to the long dry spell, from September to December, and the high temperature. Patel et al. (1991) and Ganapathy et al. (1994) reported the severe incidence of this pest during November and December in Gujarat and from March to June in Tamil Nadu.

In Madhya Pradesh, the mealy bug infested the main stem rather than branches and leaves. The main stem of the plant was fully covered with the bug's eggshells. The number of eggshells varied from 14 to 52 with an average of 29 per 3 cm. The number of eggs in eachshell varied from 125 to 215 with an average of 181. The freshly laid egg shells were light, greenish black, and covered with a milky powder. The eggs (separated from the eggshell) when kept in the laboratory at room temperature (26 to 28°C), hatched in about 9 days. The eggs were oval, yellowish, and measured 0.341 mm in length and 0.174 mm in width.

The losses caused by the mealy bugs were estimated by recording the number of completely dead and partially dead plants. Mealy bug infested 13.7% of the crop. Six percent of the plants showed complete mortality and 7.7% showed partial mortality. The completely dried plants did not revive after irrigation but partially dried plants revived after proper pruning and irrigation. Two applications of monocrotophos (0.05%) spray and one of diamethoate (0.05%) did not control the mealy bug. Such observations have also been reported by Patel et al. (1971). Since this is the first report of the occurrence of mealy bug on pigeonpea in the Nimar region of Madhya Pradesh, further study is necessary to determine the extent of its incidence in farmers' fields so that losses from pest damage may be minimized through appropriate control measures.

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Evaluation of Some New Insecticides on *Helicoverpa armigera* (Hubner) in Pigeonpea

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The productivity of pigeonpea was only 235 kg ha^{-1} in Andhra Pradesh during 1985/86 to 1989/90 (Anonymous 1997) against a yield potential of about 2000 kg ha^{-1}. The bottleneck in realizing the yield potential in this State is the frequent outbreak of *Helicoverpa armigera* (Hub.) pod borer during the 1986-88 cropping seasons. The major factors responsible include lack of host-plant resistance to pod borer and the development of pod-borer resistance to currently used insecticides consequent to the large-scale use of pyrethroids on cotton, the principal commercial crop in this region (Rao et al. 1990). Farmers of this region are also of the opinion that conventional insecticides do not effectively control the pod borer (Armesetal. 1992).

In order to realize the inherent yield potential of pigeonpea cultivars the single major production constraint, i.e., *H. armigera,* needs to be kept under check. Certain new insecticides were evaluated against *H. armigera* following the failure of the available insecticides. A field experiment was carried out at the Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, India, during the 1990/91 and 1991/92 cropping seasons using pigeonpea variety LRG 30 at a spacing of 90 x 20 cm. Three sprays of the respective insecticides (Table 1) were given at 10-day intervals starting from 50% flowering.

The incidence of *H. armigera* was high during 1990/91, but low during 1991/92 due to the cyclonic rains during October and November 1991. Rao et al. (1990) reported that only the rainfall, among various other parameters, showed a significant negative correlation with the incidence of H. *armigera.*

During 1990/91, the number of *H. armigera* larvae ranged from 10.3 to 17.0 for every five plants, with no significant differences among various insecticides tested. On the other hand, pod damage recorded at maturity, which ranged from 4.4 to 22.9% differed significantly among the treatments Among the insecticides evaluated, certain new substances like sulprofos, quinolphos, carbosulfan, pyraclofos, and ethofenprox, all at 0.1%, were found effective and could protect the crop from *H. armigera* during its bearing period. The remaining insecticides failed to protect the flowering and young pods during the reproductive phase of the crop.

Although the pod borer damage was less (4.4-8.2%) in plots receiving diflubenzuron, teflubenzuron at 0.01%, *Bacillus thuringiensis* and triazophos at 0.1%, this was not reflected in terms of yield as the first flush was completely damaged by *H. armigera.* The recorded pod damage was among pods formed from the subsequent flush, by which time the *H. armigera* population had declined.

Grain yield differed significantly among the insecticidal treatments. Sulprofos at 0.1% recorded the highest yield of 640 kg ha^{-1} followed by quinolphos 0.1% (630 kg ha^{-1}), carbosulfan 0.1% (620 kg ha^{-1}), pyraclofos 0.1% (610 kg ha^{-1}), and ethofenprox 0.1% (580 kg ha^{-1}). Grain yield in these plots differed significantly from the untreated control plots while all the other treatments were on par with the control which recorded only 470 kg ha^{-1}.

During the 1991/92 cropping season, due to a lower pest load, none of the treatments differed in terms of such parameters as number of larvae per five plants (1.5 to 3.2%), pod borer damage (2.5 to 3.1%), and yield (911 to 1180 kg ha^{-1}).

In the present study some new insecticides which are not yet in the market showed promise in controlling *H. armigera.* This may be due to nonexposure of the insect to these new products and its present lack of resistance to these insecticides. It may be presumed that *H. armigera* could develop resistance to these new insecticides in due course as in the case of insecticides already available in the market. Hence, sole reliance on insecticides for pest control needs to be discouraged; instead, integrated pest management practices need to

Table 1. Evaluation of some new insecticides on *Helicoverpa armigera* in pigeonpea cv LRG 30 at the Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, India, 1990/91 and 1991/92.

Insecticide	Dose/ concentration (%)	No. of larvae/ 5 plants[1] 1990-91	No. of larvae/ 5 plants[1] 1991-92	Pod borer damage[2] (%) 1990-91	Pod borer damage[2] (%) 1991-92	Grain yield (kg ha^{-1}) 1990-91	Grain yield (kg ha^{-1}) 1991-92
Ethofenprox	0.1	12.2 (3.6)	2.0 (1.7)	19.8 (28.2)	2.7 (9.5)	580	1180
Carbosulfan	0.1	14.2 (3.9)	1.8 (1.7)	6.1 (14.2)	2.8 (9.5)	620	1000
Quinolphos	0.1	10.3 (3.4)	1.5 (1.6)	13.5 (21.5)	2.7 (9.2)	630	1080
Pyraclofos	0.1	11.0 (3.4)	1.8 (1.7)	13.0 (21.1)	3.0(10.0)	610	1180
Sulprofos	0.1	11.0 (3.4)	1.7 (1.6)	13.0 (21.1)	2.9 (9.8)	640	1160
Flucycloxuron	0.01	11.3 (3.5)	2.2 (1.8)	12.0 (21.2)	2.8 (9.6)	540	1120
Diflubenzuron	0.01	13.0 (3.7)	2.8 (2.0)	7.8 (16.2)	2.8 (9.6)	420	970
Flufenoxuron	0.01	10.8 (3.4)	2.5 (1.8)	22.9 (28.5)	2.5 (9.0)	470	1000
Teflubenzuron	0.01	13.8 (3.9)	2.8 (2.0)	4.4 (12.1)	2.9 (9.8)	440	860
Barcillus thuringiemis	0.1	13.7 (3.8)	3.0 (2.0)	8.2 (16.3)	2.9 (9.8)	490	1040
Methamidophos	0.1	10.3 (3.4)	2.3 (1.8)	16.3 (23.7)	3.1 (10.2)	540	1040
Triazophos	0.1	14.0 (3.9)	2.7 (1.9)	7.6 (15.8)	2.8 (9.5)	510	940
Fenpropathrin	0.06	11.3 (3.5)	2.2 (1.9)	12.0 (20.2)	3.0 (9.9)	470	910
Control	-	17.0 (4.2)	3.2 (2.0)	14.7 (22.5)	2.7 (9.5)	470	910
CD (0.05)		NS	NS	(4.1)	NS	100	NS
CV (%)		(8.8)	(10.0)	(12.2)	(15.5)	11.2	15.2

1. Figures in parentheses are $\sqrt{x+1}$ transformed values.
2. Figures in parentheses are $\text{Sin}^{-1}\sqrt{\%}$ values.

be developed to effectively control polyphagous pests such as *H. armigera,*

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Natural Enemies Associated with Arthropod Pests of Pigeonpea in Eastern Africa

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Insect pests are among the major biotic constraints to pigeonpea production in eastern and southern Africa

(Lateef 1991). Results from recent surveys in farmers' fields in four major pigeonpea - producing countries in the region (Kenya, Malawi, Tanzania, and Uganda) showed that insect pest damage on pigeonpea seeds was 25% in Kenya, 15% in Malawi, 14% in Tanzania, and 16% in Uganda (Minja et al. 1996). Important insect pests are pod-boring Lepidoptera *(Helicoverpa armigera* Hubner, *Maruca vitrata* Geyer, and *Etiella zinkenella* Treitschke), pod-sucking bugs (*Clavigralla tomentosicollis* Stai), and pod fly (*Melanagromyza chalcosoma* Spencer). Other pests include flower thrips (*Megalurothrips sjostedti* Trybom), flower [pollen or blister] beetles (*Mylabris* spp. and *Coryna* spp.), aphids *(Aphis craccivora* Koch), termites (*Microtermes* spp.), stem borers (*Sphenoptera* sp. and *Alcidodes* sp.), and red spider mites *(Tetranychus* sp.).

Most of the insect pests reported on pigeonpea also damage other grain legumes in the region (Le Pelley 1959, Materu 1970). Although these pests are common and widespread, little information is available on the natural enemies associated with these pests on pigeonpea in the region. Materu (1970) reported *Hadronotus gridus* Nixon (Hymenoptera: Scelionidae) as an egg parasitoid of *C. tomentosicollis* and possibly C. *horrida* Germ., and *Mormonomyia argentifrons* Walker (Diptera: Tachinidae) as a parasite of *C. horrida* adults in Tanzania. Sithanantham and Reddy (1990) reported *Bracon* sp. near *greeni* (A.K. Walker, IIE) as a parasitoid associated with pigeonpea pod fly *M. chalcosoma* in Kenya, Malawi, and Zambia. The two authors also reported insect-feeding spiders (*Thomisus* and *Xysticus* [Thomisidae], and *Tetragnatha* [Tetragnathidae]) on pigeonpea in Kenya, Malawi, and Zambia. There is a need to establish the status of major arthropod pests and their natural enemies as a first step towards understanding their population dynamics and developing management strategies.

Surveys were conducted in farmers' fields in the major pigeonpea-growing areas in Kenya, Malawi, Tanzania, and Uganda to determine the abundance of common and widespread pests and beneficial species on pigeonpea. Two surveys were carried out in each country during the pigeonpea-growing season in 1995 and 1996.

Table 1. Occurrence of natural enemies associated with major insect pests on pigeonpea in Kenya (1), Malawi (2), Tanzania (3), and Uganda (4).

	Insect pest					
Natural enemy	*Helicoverpa*	*Etiella*	*Clavigralla*	*Melanagromyza*	*Callosobruchus*	*Aphis*
Bracon sp. near *hancocki* Wilkinson, Braconidae [A.K. Walker (HE) det.]	-[1]	1, 2, 3, 4	–	–	–	–
Bracon celer Silvestri, Braconidae	–	–	–	–	–	3,4
Bracon sp. near *celer* Szepligeti, Braconidae [A.K. Walker (HE) det.]	–	–	–	1,2,3,4	–	–
Bracon sp., Braconidae [A.K. Walker (HE) det.]	–	1	–	–	–	–
Campoplex laphygma Wilkar, Ichneumonidae	1	–	–	–	–	–
Cosmoiestes sp., Reduviidae	1	–	1	–	–	–
Dinarmus basalts Rondani, Eulophidae	–	–	–	–	3	–
Euderus sp., Eulophidae [J. LaSalle (IIE) det.]	–	1,2,3,4	–	–	–	–
Linnaemyia spp., Tachinidae	1	–	–	–	–	–
Palexorista sp., Tachinidae	1	–	–	–	–	–

1. Absent

Table 2. General predatory arthropods associated with insect pests on pigeonpea in Kenya (1), Malawi (2), Tanzania (3), and Uganda (4).

Predator	Order	Family	Country
Thornisus sp.	Acarina	Thomisidae	1,2,3,4
Xysticus sp.	Acarina	Thomisidae	1,2,3,4
Tetragnatha sp.	Acarina	Tetragnathidae	1,2,3,4
Adonia variegata Goeze	Coleoptera	Coccinelidae	1,3,4
Callida fuscita Dej	Coleoptera	Carabidae	1
Cheilomenes lunata Fabricius	Coleoptera	Coccinelidae	1,2,3,4
C. posticalis Fairm	Coleoptera	Coccinelidae	1
C. vicina Muls.	Coleoptera	Coccinelidae	1,2,3,4
Exochomus flavipes Thunberg	Coleoptera	Coccinelidae	1,2,3,4
Paederus sabeus Er.	Coleoptera	Staphylinidae	1
Forficula sp.	Dermaptera	Forficulidae	1,2,3,4
Harpactor segmentarius Germar	Hemiptera	Reduviidae	1
H. tibialis Stal	Hemiptera	Reduviidae	1
Anoplolepis custodiers Fred Smith	Hymenoptera	Formicidae	1,3
Camportotus rufoglaucus Emery	Hymenoptera	Formicidae	1,2,3,4
Dorylus sp.	Hymenoptera	Formicidae	1,4
Oecophylla longinoda Latreille	Hymenoptera	Formicidae	1,3,4
Phyllocrania sp.	Dictyoptera	Mantodea	1,2,3,4
Pseudocreobotra sp.	Dictyoptera	Mantodea	1,2,3,4
Eublemma sp.	Lepidoptera	Noctuidae	1,3
Hemerohius sp.	Neuroptera	Hemerobiidae	1,2,3,4

Surveys were timed to coincide with similar pigeonpea growth stages in the four countries. Fields were selected at random. Between 30 to 150 pigeonpea pods were collected from each field. The number of pods sampled from each field depended on farm size, plant population, and fanner cooperation. The pods were examined externally and internally to determine seed damage and to identify arthropods associated with the damage. In the field we recorded insect pests and their natural enemies. Samples of insect pests and emerging natural enemies were collected for further identification. Some pest and natural enemy specimens were sent to the International Institute of Entomology, London, UK, for identification. Observations were also recorded during the research station field trials.

Three major insect pest groups were found to be associated with pigeonpea in Kenya, Malawi, Tanzania, and Uganda. They were: pod-boring Lepidoptera (H. *armigera, M. vitrata* and *E. zinkenella),* pod-sucking bugs (mainly *C. tomentosicollis),* and pod fly (*M. chalcosoma).* The magnitude ofdamage by each group varied across seasons and locations. Natural enemies included Coleopterans, Hymenopterans, Dipterans, and Hemipterans (Tables 1 and 2). Natural enemies of the insect pests were surveyed more frequently in Kenya than in other countries.

Eggs of *Lampides boeticus* Linnaeus (Lepidoptera: Lycaenidae) were observed on the plants, but the population of larvae was quite low. There is a possibility that the list of natural enemies can be added to with more intensive surveys and laboratory rearing of the insects collected in the field. There is a need to study the biology and behavior of some of the natural enemies to establish their population dynamics. Such studies will generate information on their contribution to natural control and the possibility of conserving and augmenting them for pest management in the region.

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Solarization to Protect Pigeonpea Seeds from Bruchid Damage during Storage

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Bruchids [*Callosobruchus* spp.) are important storage pests of grain legumes, known to cause substantial economic losses (Ramzan et al. 1989; Srivastava and Pant 1989). This is one of the reasons farmers are often reluctant to grow legumes. Their produce has to be sold and cleared immediately after the harvest even though the market price may not be very remunerative at that time. Sometimes, even storing seeds for sowing becomes difficult, and farmers are forced to buy seed from other sources. In many developing countries of the semi-arid tropics (SAT), the seed industry is not well developed and the availability of quality seed is a major limitation. As farmers are not able to store their seed under pest-free conditions, these are often damaged by insects, particularly bruchids. Seeds damaged by bruchids do not germinate well and thus affect plant stand and consequently yield. This is especially so when the time between harvest and the next sowing is very long, as is the case with several short-season legumes. For example, the interval between harvest and sowing of the next season's crop of extra-short-duration pigeonpea [*Cajanus cajan* (L.) Millsp.] can be 6-9 months as compared to merely 2 months for long-duration pigeonpea cultivars. Thus, a cost-effective technique needs to be developed to protect seeds from postharvest bruchid damage.

Farmers currently use several chemical and nonchemical methods to protect seeds from bruchid attack. Chemical methods such as fumigation or admixture of insecticides such as malathion, though effective, are hazardous and environmentally unsafe. On the other hand, nonchemical methods do not provide foolproof protection either. Sun-drying in an open yard is a common practice employed by SAT farmers. This process in its current form depends upon a variety of environmental factors such as the prevailing temperature, humidity, and cleanliness of the drying area. The process could be enhanced with a little improvization. As in the case of soil solarization (Chauhan et al. 1988), the effectiveness of the sun's rays in disinfecting seeds may be enhanced substantially if seeds were kept in small polythene bags instead of being spread in the open. This study examined the level of accumulation of temperature in polythene bags and its effect on bruchid survival and infestation in the pigeonpea seed contained in them.

Eight polythene bags of 21 x 28 cm size and 100 mm thickness were each filled with 1 kg seed of a medium-duration pigeonpea variety, ICPL 87119. Twelve adult bruchids (*Callosobruchus maculatus* F) in pairs (male and female) were introduced in each bag and the bags were then sealed using adhesive tape. Four of the sealed bags with seeds and insects were exposed to the sun for a week (maximum outside air temperature 42°C) and the same number was kept in the laboratory at 30-35°C in June 1998. The rise in temperature inside the bag was measured using a mercury thermometer inserted into it. The edges at the contact point between thermometers and bags were also sealed with adhesive tapes so that hot air inside the bag did not escape. Germination was tested in the laboratory at 25°C in three replications in petridishes lined with filter paper, holding 10 mL of distilled water. Ten seeds were placed in each petridish and germination was recorded after 3-4 days.

The temperature in the bags exposed to sunlight began to rise with time of the day until evening (Fig. 1). The maximum recorded temperature was about 65°C. This rise in temperature is comparable to the rise noted in surface layers of soils covered by transparent polythene (Chauhan et al. 1988). Unlike soil, where temperature declines in deeper layers due to close packing of soil particles preventing free air flow, there is considerable space between seeds due to their larger size and often irregular shape. This permits quick and uniform distribution

of hot air in the bag. There was no abrupt rise in the temperature in bags kept in the laboratory (Fig. 1). The difference in temperature between the two treatments was very large after 1200 h and remained high until evening.

Bruchids in all the solarized bags died without laying eggs (Table 1). In contrast, in the bags kept in the laboratory, the bruchids laid a considerable number of eggs. Bruchids were also seen alive in two of the four bags after 5 weeks of storage. In the non-solarized bags, there were dead bruchids which may have completed their life cycle. After 9 weeks of storage, bruchid damage was noted in the non-solarized bags, whereas no damage recorded in the solarized bags (data not shown). This indicated that seed solarization was effective as a means of protecting seeds from bruchid damage. Although we used bags of 1 kg seed capacity, larger bags with more seed are unlikely to yield different results as the surface area to trap solar energy would increase proportionately. The main consideration in fixing the size could be ease of handling and storage.

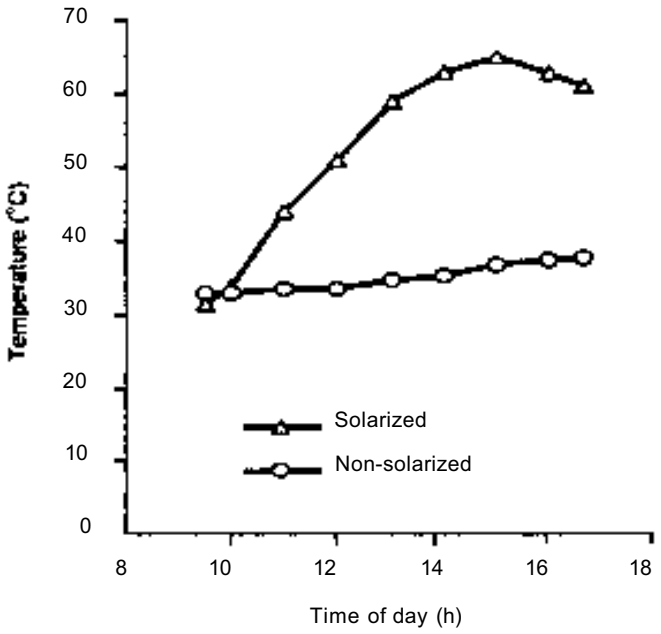

Figure 1. Differences in temperature build-up at different times of the day in polythene bags containing pigeonpea seeds exposed to the sun and kept in shade on a typical sunny day.

Germination was 90% before solarization. Rise in temperature did not adversely affect germination of seeds in solarized bags. For example, germination was 92% immediately after a week-long solarization (Table 1). We recorded up to 89% germination in the solarized bags after 26 weeks of storage (results not shown). Thus rise in temperature in solarized bags was perfectly safe for seeds.

Even though in the present study pigeonpea was used as a test material, we propose that the results on bruchid infestation may be equally applicable to other grain legume crops. However, the effect of high temperature on seed germination needs to be determined for individual crops as sensitivity of crops to high temperature may differ. We also suggest that the storage of seed in transparent polythene bags may also be used to lower seed moisture content immediately after harvest. This can be done by leaving the bags slightly open to allow the moisture to escape through the openings. This may be especially useful in humid environments. The duration of drying can be standardized for local conditions. Seed solarization could have other uses as well. For example, for such crops as groundnut (*Arachis hypogea* L.), reduced moisture in the storage bags with well dried seeds may

Table 1. The effect of seed solarization on bruchid egg laying and survival 5 weeks after storage, and seed germination of pigeonpea cultivar ICPL 87119 immediately after solarization.

	Non-solarized			Solarized		
Bag no.	Egg-laying	Bruchid survival (%)	Seed germination (%)	Egg-laying	Bruchid survival (%)	Seed germination (%)
1	+[1]	0	83.3	-	0	86.7
2	+	8	96.7	-	0	93.3
3	+	0	93.3	-	0	93.3
4	+	33	93.3	-	0	96.7
Mean		10	91.7	0		92.5

1. The + ve sign indicates an abundance and - ve sign a complete absence of eggs.

prevent contamination by *Aspergillus flavus,* a highly carcinogenic aflatoxin-producing fungi (Diener and Davis 1977). Thus, considering the potential advantages, the positive aspects of this low - cost technology need to be systematically researched and disseminated among farmers of the SAT.

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Agronomy/Physiology

Association of Plant Height and Maturity Duration with Seed Yield in Pigeonpea

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Pigeonpea is a minor pulse crop grown in the Punjab province of Pakistan. However, the crop may have good potential and efforts should be made to popularize it among farmers. A study was conducted to collect information about the association of yield with certain morphological traits in order to devise criteria for the selection of genotypes suited to the climatic conditions and cropping systems of the province. Yield is a complex character which can be influenced by its major and minor components. Pandey (1984) reported that seed yield and days to flowering were not associated. Mahmood et al. (1996) reported that yield per plant was positively and significantly correlated with height and days to flowering, but the association between yield and days to maturity was nonsignificant. The present study was undertaken to further evaluate the association of plant height and phonology.

Fifty-five genotypes of ICRISAT origin were evaluated for plant height, days to flowering, days to maturity and yield per plant along with three local controls at the Pulses Research Institute, Faisalabad during the rainy season, 1997. The experiment was sown in a medium loam soil in augmented design with five blocks under irrigated conditions. Each block comprised 11 test entries and 3 controls. The plot size was 5 m x 0.6 m accommodating a single row. The data for the traits mentioned were recorded for 10 guarded plants per entry and were analyzed to calculate correlations following Steel and Torrie (1980).

Plant height varied from 51.55 to 193.30 cm with a mean height of 118.87. Days taken to flowering ranged from 65 to 108 with a mean value of 83.4 and days taken to maturity ranged from 112 to 160 with a mean value of 138.87. Grain yield per plant was in the range of 115 to 1050 g with a mean value of 314.32 g. This showed that the varieties studied differed greatly in terms of mentioned traits.

The correlations between all the plant characteristics being studied were nonsignificant. This indicated that there is no effect of days to maturity and plant height on seed yield in pigeonpea. These traits were inherited independently. These results are in partial agreement

Table 1. Range, mean, standard deviation and coefficient of variability for selected traits of pigeonpea at Faisalabad, Pakistan, rainy season 1997.

Traits	Minimum	Maximum	Mean	SD(±)	CV (%)
Height (cm)	51.6	193.3	118.9	24.6	20.7
Days to flowering	65	108	83.4	9	10.8
Days to maturity	112	160	138.9	13.92	10
Yield per plant	115	1050	314.3	188.45	0.5

with those reported by previous workers (Pandey 1984 and Mahmood et al. 1996). These results depicted that plant height and time to maturity can be reduced without sacrificing the yield,

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Identification of Postrainy Pigeonpea Variety Suitable for the Paddy Fields of South Gujarat, India

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Cultivation of postrainy-season pigeonpea after the rainy-season paddy crop has become popular among farmers of southern Gujarat state (72°54' longitude, 20° 15'N latitude and 10.0 m altitude) due to factors such as the short stature of the plant, low incidence of pests, diseases, and weeds, and higher economic benefits. However, the productivity of pigeonpea grown in paddy fields can be enhanced through the identification of a high-yielding variety or varieties (Desai et al. 1990, Tikka et al. 1995, and Chauhan et al. 1998). For this purpose, a field experiment was conducted for 6 years during 1991/92 to 1996/97 with seven varieties of pigeonpea sown in a randomized block design with four replications at the Pulses Research Station, GAU, Navsari, Gujarat. In all years, the crop was sown during the second week of October with an interrow spacing of 60 cm and 10 cm intrarow spacing. The net plot size of 2.4 m x 4.0 m, i.e., four rows each 4 m long, was maintained and the crop was fertilized with 20 kg N and 40 kg P_2O_5 ha^{-1}. Pod borer damage was controlled with two sprays of endosulphan, one at the time of flowering and the other at pod formation. The crop was harvested in the fourth week of March. The results revealed that the variety C 11 recorded significantly higher seed yield (1900 kg ha^{-1}) compared to other varieties (Table 1). However, this variety yielded on par with Bahar (1640 kg ha-^{1}) and Pusa B 23 (1640 kg ha^{-1}) varieties. Based on the current market prices, the net profit realized with C 11 is Rs 23 030, with Bahar, Rs 19 040, and with Pusa B-23, Rs 19 130 ha^{-1}.

In view of the encouraging results of first 5 years, this trial was conducted during 1996/97 at five research stations located in southern Gujarat and the seed yield obtained with C 11 was comparable with the second yield recorded at Navsari Centre (Table 2).

Simultaneously, 22 demonstrations on farmers' fields comprising 11 each in Surat (4 tehsils) and Valsad (4 tehsils) districts were also taken up with C 11 and BDN 2 (as control). The area under each demonstration was 100 m^2 and all the recommended practices were followed. Overall, 114% higher yield was recorded with C 11 compared to BDN 2 (Table 3). C 11 was also found

Table 1. Seed yield (kg ha^{-1}) of pigeonpea varieties grown at Navsari, Gujarat, postrainy-season 1991-97.

Pigeonpea variety	Year							Percent increase over control
	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	Pooled	
Bahar	1690	1720	2120	1440	1240	1620	1640	28.6
C 11	2170	2500	2140	1770	2150	1690	1900	49.5
DPA 92-2	1860	1210	1870	1650	1270	1550	1570	-
Pusa B-23	1800	1180	1840	1290	2290	1460	1640	29.0
M. A. 91-2	1480	1460	1660	1040	1520	1230	1400	-
Pusa - B 20	1620	1220	2050	1080	900	1100	1240	-
BDN 2	1580	1120	1880	850	1150	1040	1270	-
Mean	1740	1270	1940	1300	1500	1380	1380	
SEm	±119.1	±105.8	±133.9	±129.8	±87.5	±129.8	±121.3	
CV (%)	10.9	16.7	13.8	19..9	11.5	18.7	17.5	

Table 2. Seed yield (kg ha^{1}) of promising pigeon pea genotypes grown at different research stations in southern Gujarat, India, postrainy season, 1996/97.

Pgeonpea variety	Research station						Percent increase over BDN 2
	Navsari	Paria	Vyara	Waghai	Tanchha	Mean	
Bahar	1620	2550	1420	1350	780	1540	37.5
C 11	1690	2730	1660	1770	1240	1820	61.9
Pusa B 21	1640	2240	1020	1150	650	1340	
Pusa B 23	1240	1900	920	830	790	1130	
BDN 2 (Control)	1270	1840	850	1100	560	1120	
SEm	±121.3	±140.4	±44.9	±42.5	±28.5	±78.5	
CV (%)	17,6	12.5	7.7	6.8	19.8	13.9	

Table 3. Results of demonstration trials of postrainy-season pigeonpea grown on farmer's fields, Valsad and Surat districts, Gujarat, India, 1996/97.

District	Taluk	No. of demonstrations	Grain yield (kg ha^{-1})		Percent increase over BDN 2 (control)
			C11	BDN 2	
Valsad	Dharampur	4	1540	630	150
	Vansada	4	1250	500	150
	Navsari	1	1500	800	90
	Chikhli	2	1500	820	80
	Mean	11	1450	6890	110
Surat	Vyara	4	1250	430	190
	Kamrej	1	1400	600	130
	Bardoli	5	1040	530	100
	Mandvi	1	1200	700	72
	Mean	11	1220	560	120

Table 4. Description of promising varieties of postrainy-season pigeonpea C 11 and BDN 2 grown at Navsari, Gujarat, India, 1991-97.

Character	C 11	BDN 2
Plant height (cm)	80.8	63.7
Days to 50% flowering	92.3	89.5
Days to 80% maturity	146.5	144.3
Average number of branches plant^{-1}	8.0	5.7
Average number of pods plant^{-1}	91.6	71.2
Average number of seeds pod^{-1}	3.9	3.8
Pod length (cm)	4.9	4.6
100-seed mass (g)	8.7	8.6
Protein content	22.32	21.42
Water absorption g g^{-1}	1.11	1.12
Cooking time (min)	36	40
Dhal recovery (%)	77.7	73.1
Hard seededncss	1.0	1.5
Seed color	brown	white
Yield (kg ha^{-1})	1900	1270

Table 5. Reaction to pod borer and sterility mosaic disease of pigeonpea genotypes C 11 and BDN 2 grown at Navsari, Gujarat, India, postrainy season, 1991-97.

	Year						
	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	Mean
Pod borer damage (%) in							
C 11	3.6	2.1	2.8	5.1	3.3	3.8	3.6
BDN 2 (Control)	16.5	15.5	12.0	20.1	21.6	19.5	17.5
Sterility mosaic (% incidence) in							
C 11	0	0	0.6	0	0.3	0.3	0.2
BDN 2 (Control)	2.3	3.5	8.8	3.9	9.3	7.4	5.9

superior to BDN 2 in terms of varietal description and resistance to pests and diseases (Tables 4 and 5).

The present study strongly indicates that pigeonpea cv C 11 is superior to BDN 2 for postrainy-season cultivation by fanners of the region.

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Optimization of Sowing Time and Spacing in Postrainy-season Pigeonpea Grown in South Gujarat

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The cultivation of postrainy-season pigeonpea in the paddy fields of south Gujarat is a recent introduction. The higher economic returns obtained with pigeonpea in comparison to other postrainy-season crops such as chickpea and mustard sown following rainy-season paddy, has encouraged its adoption, and the area under postrainy-season pigeonpea has been increasing each year. In 1991/92 the area under postrainy-season pigeonpea in south Gujarat was 500 ha; it increased to 4000 ha in 1995/96. The pigeonpea variety C 11 has been recommended for the postrainy season (Anon. 1997). However, there is little information on optimum spacing and sowing time for postrainy-season pigeonpea, and the present investigation aimed to collect that information.

To determine the optimum spacing for postrainy-season pigeonpea, a field experiment with seven varieties and three spacings (25 x 10, 35 x 10, and 45 x 10 cm) was conducted for a period of 3 years (1991/92 to 1994/95) in factorial randomized block design (RBD) at the Pulses Research Station, GAU, Navsari, Gujarat. The results indicated that sowing at closer spacing (S_1 = 25 x 10 cm) was more beneficial than wider spacing (Table 1). The reduction in seed yield over S_1 (25 x 10 cm) with wider spacing was to the extent of 11.3% with S_2 (35 x 10 cm), and 19.0 with S_3 (45 x 10 cm).

Among the pigeonpea varieties tested, the highest yield was recorded with C 11 (1740 kg ha^{-1}) which was followed by Pusa 9 (1680 kg ha^{-1}), and Pusa 17 (1590 kg ha^{-1}). The response of different varieties to varying spacing was conspicuous and when C 11 was sown at closer spacing, the yield was considerably higher (1920 kg ha^{-1}). However, it was at par with Pusa 9, Pusa 17, and MTH 12 varieties at the same spacing.

The other field experiment was conducted to evaluate the effect of date of sowing on pigeonpea yields. Six varieties of postrainy-season pigeonpea were grown at three dates of sowing (D1, third week of October; D2, first week of

Table 1. Mean seed yield (kg ha^{-1}) of pigeonpea varieties grown at different interrow spacing (cm) at Navsari, Gujarat, 1991-94 postrainy-seasons (pooled over 3 years).

	Seed yield at			
Pigeonpea variety (V)	SI (25 x 10)[1]	S2 (35 x 10)	S3 (45 x 10)	Mean
Pusa 9	1880	1680	1480	1680
Pusa 17	1790	1590	1380	1590
MTH 9	1500	1250	1250	1330
MTH 12	1710	1540	1480	1580
BSMR 376	1580	1460	1340	1460
C-11	1920	1710	1600	1740
BDN 2	1490	1300	1090	1300
Mean	1700	1500	1370	

	SEm	CV (%)
V	±137.3	
S	±48.3	
VS	±47.7	
YVS[2]	±65.6	15.3

1. S1, S2, and S3 refer to different interrow spacing; 2. YVS = yield x variety x spacing.

Table 2. Mean seed yield (kg ha^{-1}) of postrainy-season pigeonpea varieties grown at different dates of sowing (D) at Navsari, Gujarat, 1991-94 postrainy seasons (Pooled over 3 years).

Piveonpea variety (V)	Seed yield at D1 (third week Oct)	D2 (first week Nov)	D3 (third week Nov)	Mean
C-11	1700	1260	690	1220
GAUT 88.5	1300	1110	630	1020
GAUT 88.8	1390	1150	680	1080
GAUT 88.9	1230	1100	670	1000
BDN 2	1160	880	720	920
GT 100	1450	1000	820	1020
Mean	1370	1080	700	1050
	SEm		CV (%)	
V	±66.9			
D	±56.1			
VD	±54.9			
YVD[1]	±88.7		14.6	

1. YVD = Year x variety x date of sowing.

November; and D3, third week of November) in RBD for 3 years, i.e., from 91994/95 to 1996/97). The seed yield of pigeonpea was influenced significantly by sowing date and its interaction with varieties (Table 2). With delay in sowing time the magnitude of mean decline in seed yield was to the tune of 20.8% from D1 to D2, 48.7% from D1 to D3, and 35.2% from D2 to D3. Among the combinations, sowing of C 11 in the third week of October produced the highest yield (1705 kg ha^{-1}). We conclude that to secure higher yields of postrainy-season pigeonpea in south Gujarat, the C 11 variety should be sown in the third week of October at inter and intrarow spacings of 25 x 10 cm.

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Performance of Extra-short-duration and Short-Duration Pigeonpea Genotypes in Paddy Fallows under Rainfed Conditions in the Dry Zones of Sri Lanka

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Around 0.2 million ha of paddy lands in Sri Lanka are left fallow during the short rainy *yala* season (Mar-May) due to lack of irrigation water. Experiments carried out in the past have indicated the possibility of cultivating shorter-duration legume crops including pigeonpea in these paddy fallows during the *yala* season under rainfed conditions in the dry zone (Jayawardena and Rathnayake 1992, Jayawardane and Chithral 1996). However, presently available pigeonpea varieties ICPL 2 and ICPL 87 are of 120-140 days' duration and do not very well fit into this season. Therefore, nonavailability of extra-short-duration varieties (100-110 days) is a constraint to the promotion of pigeonpea in fallow paddy lands. Therefore, a set of eight extra-short-duration pigeonpea genotypes ICPL 89020, ICPL 89021, ICPL

84023, ICPL 89027, ICPL 88039, ICPL 90035, ICPL 88013, and ICPL 89014, and two short-duration genotypes, MPG 537 and ICPL 87, were evaluated under rainfed conditions in a major paddy growing area in Mahaweli system 'H' for their performance in the fields vacated by the commercial *maha* paddy crop.

This study was conducted on two farmers' fields in Pahalakalawewa (L1) and Mediyawa (L2) villages in the Eppawala block in the Mahaweli system 'H' of Anuradhapura district which represents the top and middle part of a typical irrigated paddy land of the dry zone. With the onset of "yala" rains pigeonpea was sown at 45 cm x 10 cm spacing. The treatments were arranged in a randomized complete block design with two replications. Each plot measured 2.5 m x 1.5 m.

The experiment was sown on 10 April, 1995 on rice stubbles with the help of bamboo pegs without any land preparation. Immediately after sowing, a total weed killer, paraquat was sprayed at the rate of 3 1 ha^{-1}. Two weeks later the crop was thinned to one plant $hill^{1}$.

One manual weeding was done 4 weeks after sowing. At flowering, one spray of Atabron® (500 mL ha^{-1}) followed by two sprays of Chlorpyryphos (1500 mL ha^{-1}) were given at 10-day intervals to control pod-boring insects. The study was conducted under rainfed conditions. No fertilizer was applied. Data on plant height, days to maturity, and grain yield were recorded. A total of 303 mm of rain was received during the growing season, spread over 14 rainy days. All the pigeonpea lines genninated well and had a good canopy at both locations.

At Mediyawa, all the genotypes were taller and took more time to mature compared to Pahalakalawewa (Table 1), reflecting the better moisture status of the soil at this location. The differences among the lines for plant height and days to maturity were significant at Mediyawa only.

At Pahalakalawewa, the mean yield (0.8 t ha^{1}) was higher than that at Mediyawa (0.63 t ha^{1}); ICPL 90035 (1.2 t ha^{-1}), ICPL 89020 (1.0 t ha^{1}), and ICPL 87 (0.97 t ha^{-1}) were found promising. At Mediyawa, ICPL 89021 (0.911 ha^{-1}), ICPL 84023 (0.79 t ha^{-1}), ICPL 89014 (0.76 t ha^{1}), ICPL 89020 (0.75 t ha^{-1}), and ICPL 89027 (0.75 t ha^{-1}) were promising. There was a large difference in the performance of varieties like ICPL 87 and ICPL 90035 at the two locations. On average, the performance of pigeonpea in paddy fallows was satisfactory and encouraging.

The results suggest that in fallow paddy lands, extra-short-duration pigeonpea can be grown successfully. Considering the growing period, yield, and yield variations, ICPL 89020, ICPL 89027, and ICPL 88039 appear to be

Table 1. Performance of extra-short and short-duration pigeonpea genotypes in paddy fallow lands under rainfed conditions at two locations[1] in Eppawala, Sri Lanka, short rainy season *(yala)* 1995.

	Plant height (cm)		Days to maturity		Yield (t ha^{-1})		
Genotype	L1	L2	L1	L2	L1	L2	Mean
Extra-short-duration varieties							
ICPL 89021	80	105	102	115	0.67	0.91	0.79
ICPL 89020	84	90	100	108	1.01	0.75	0.86
ICPL 84023	89	114	99	112	0.64	0.79	0.72
ICPL 89027	89	94	108	107	0.82	0.75	0.78
ICPL 88039	81	101	101	107	0.71	0.66	0.69
ICPL 90035	98	102	108	115	1.24	0.24	0.74
ICPL 89013	86	111	100	116	0.83	0.41	0.62
ICPL 89014	89	114	101	124	0.85	0.76	0.80
Short-duration varieties							
MPG 537 (Control)	102	123	99	114	0.70	0.67	0.69
ICPL 87 (Control)	96	122	116	123	0.97	0.38	0.67
Mean	89	108	103	114	0.83	0.63	0.73
SE	±3.8	±5.5	±4.6	±3.3	±0.17	±0.13	-
CV (%)	8.8	5.9	4.6	1.1	29.1	23.3	

L1 = Pahalakalawcwe, L2 = Mediyawa.

the most suited to this system. However, more multilocational testing programs need to be undertaken to identify a high-yielding stable genotype.

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Utilization

Study on the Use of Pigeonpea as Pig Feed in China

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Pigeonpea is a perennial shrub that provides food, fuelwood, and fodder. In China, it is cultivated in Yunnan and seven other provinces (Sichuan, Guizhou, Guangxi, Guangdong, Hainan, Fujian, and Jiangxi). Other than the fact that its stems are used to rear *Kerria lacca,* information about the utilization of pigeonpea seed in China is very limited. We report on the use of pigeonpea seed as a pig feed.

The experiment was conducted at the Yunnan Agricultural University in 1991. Twenty four hybrid pigs of Du Chang and Xia Changhe were selected and divided into four groups to be fed with different levels of pigeonpea in the feed, i.e., 0% (contains 10% of soybean cake), 6%, 12%, and 18% of pigeonpea. (Table 1). During the first growth period (20-60 kg), four pigs were selected from each group, their dung collected, and their feed consumption recorded for the digestion experiment. During the second growth period (60-90 kg) the pigs were given larger amounts of pigeonpea, i.e., 0% (7.6% of soybean cake), 7%, 14%, and 21% (Table 1). The pigs in each treatment group were raised in separate enclosures so that they could eat and drink freely. Pigeonpea substituted other substances in the feed at the rate of 1.0 kg for 0.600 kg corn; 0.333 kg bean cake, and 0.067 kg wheat bran. Other constituents in mixed feed were omitted.

At the end of each growth period, pigs were tested once for temperature, breath and pulse rate. Four pigs were selected from each group to be tested for blood; these were then slaughtered, and the organs index and meat samples analyzed at the end of experiment. During the taming and pre-experiment period, the weight gain in each group was not obviously different but the gain was 3-20% above the Chinese standard of 0.6 kg t^{-1}. The weight gain was the highest in the 6% group fed with pigeonpea at 6% in the feed (Table 2). According to the Chinese standards, the expected feed-to-meat ratio was 3.67 : 1, but that of the 0% and 6% group was lower; the 18% group has the highest ratio; and the 12% group was slightly above the standard. Therefore, the optimum level of pigeonpea in mixed feed should be close to 12% for this period (Table 2). The weight gain in each treatment during the 60-90 kg period was not significantly different, but higher than the expected standards (0.75 kg day^{-1}). The feed-to-meat ratio in the 0% and 7% pigeonpea groups were 4.2-7.4%, lower than the Chinese standard, i.e., 4.35 : 1. The 14% pigeonpea group was comparable to the standard, while the 21% pigeonpea group was 18.6% higher than the standard. Therefore, pigeonpea added in feed should be around 14% (Table 2). The results of nutritive composition and digestion rate (Table 3) showed that the digestive rate of fibre in 6%, 12%, 18% pigeonpea groups was higher than in 0% group, but the group did not differ in the digestive rate of energy, protein, fat, and non-nitrogen extract. The digestive energy of every group was higher than that of the expected standard (> 2.900 Mcal kg^{-1}).

Table 1. Rate of pigeonpea seed and soybean cake in mixed feed during different growth periods.

	Amount of constituent (%)			
	20-60 kg period			
Pigeonpea	0.00	6.00	12.00	18.00
Soybean	10.00	8.00	6.00	4.00
	60-90 kg period			
Pigeonpea	0.00	7.00	14.00	21.00
Soybean	7.60	5.27	2.94	0.61

Table 2. Increase in weight of pigs at different levels of pigeonpea in pig feed in China.

	Pigeonpea constituent in mixed feed (%)				Chinese standard
	0	6	12	18	
20-60 kg period (42 days)					
Average daily increase in weight of pig (kg)	0.780	0.784	0.726	0.724	0.600
Average daily consumption of feed (kg)	2.836	2.778	2.701	3.078	
Feed to meat ratio	3.64:1	3.54:1	3.72:1	4.25:1	3.67:1
	Pigeonpea constituent in mixed feed (%)				Chinese standard
	0	4	14	21	
60-90 kg period (32 days)					
Average daily weight increase (kg)	0.891	0.881	0.809	0.703	0.750
Average daily consumption of feed (kg)	3.174	3.551	3.534	3.626	
Feed-to-meat ratio: increase in weight of pig	4.17:1	4.03:1	4.37:1	5.16:1	4.35:1

Table 3. Nutritive composition and digestion rate in feed with different amounts of pigeonpea.

	Pigeonpea constituent in mixed feed (%)				Chinese standard
	0	6	12	18	
Nutritive composition (%)					
Protein	18.30	18.29	18.30	18.29	>14.50
Fat	2.86	2.69	2.52	2.35	>1.50
Fibre	3.62	3.94	4.27	4.56	<7.00
Non-nitrogen extract	69.28	69.09	68.87	68.87	
Ash	5.98	5.98	6.04	6.09	<8.00
Calcium	0.85	1.11	1.15	1.16	0.45-0.70
Phosphorus	0.45	0.45	0.46	0.47	0.35-0.50
Total energy (Mcal kg^{-1})	4.328	4.317	4.306	4.294	
Digestion rate (%)					
Energy	81.67 ± 3.46	83.71 ± 2.10	79.79 ± 0.59	78.87 + 3.05	
Protein	78.98 ± 4.41	78.71 ± 2.53	73.85 ± 3.43	71.64 + 5.17	
Fat	56.28 + 4.37	54.11 ± 3.54	46.69 ± 2.93	45.04 ± 2.33	
Non-nitrogen extract	89.08 ± 2.07	91.03 + 1.35	88.22 ± 0.69	86.78 + 2.30	
Fibre	1757 + 3.11	32.32 ± 11.58	18.92 ±1.81	22.66 + 10.78	
Digestive energy (Mcal kg^{-1})	3.535	3.614	3.436	3.387	>2.900

The results of this experiment indicate that during the experimental period (20 - 90 kg), the average daily increase in the weight of pigs did not differ significantly at 6%, and 7% pigeonpea in the feed, and both of them are better than the national standard of China. The feed-to-meat ratio had an increasing tendency when pigeonpea level in the feed was over 14%. Tests on temperature, breath, pulse, blood index, organ and quality of meat (results of testing not included) indicated that pigs reared with mixed feed containing 6-14% of pigeonpea grew well. So using pigeonpea to partly substitute soybean is feasible, and adding 12-14% pigeonpea in mixed feed appears to be suitable as pig feed.

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Biotechnology

Effect of Sucrose Concentration on In Vitro Regeneration in Pigeonpea

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Pigeonpea is an important pulse crop not only for its nutritive and dietary value, but also for its positive role in improving soil fertility through biological nitrogen fixation. It is also an important source of fodder. Several biotic and abiotic stresses severely limit pigeonpea production. Conventional methods of plant breeding are not very successful in increasing production of pigeonpea due to lack of genetic variation in the primary gene pool, the narrow genetic base of the crop, and the long gestation period required for the development of variety. Hence, biotechnological tools are considered to be a potential option. However, simple, reproducible, and high frequency regeneration is a prerequisite for any biotechnological intervention in the crop improvement program.

The present investigation was carried out to study the effect of sucrose concentration on regeneration frequency of pigeonpea. Three genotypes: Bahar, T 21, and Paras were included in the regeneration studies. Seeds were surface sterilized with 70% ethanol for 2 min, washed thoroughly with distilled water, and dipped for 15 min in Teepol® with 2-3 drops of polyoxyethelene sorbitan (Tween 40) followed by washing with distilled water 2-3 times to remove the Teepol®. These seeds were then dipped in sodium hypochlorite (5%) for 20 min, washed with sterile double distilled water, and soaked overnight. Embryos were excised from sterilized soaked seeds and inoculated into modified MS medium (Murashige and Skoog 1962) supplemented with different sucrose concentrations along with different concentrations of auxin and cytokinin. All the other constituents of MS medium were kept unchanged except the amount of vitamins, which was doubled.

Various combinations of auxin and cytokinin (6-benzylamino purine, 1.0, 5.0, 10.0 mg L^{-1}, and indole 3-acetic acid 0.1, 0.5, 1.0 mg L^{-1}) along with three levels of sucrose (30, 40, and 50 g L^{-1}) were tried (Table 1). All the cultures were grown under cool, white fluorescent light at 25 + 2°C on 3000 lux light intensity. The experiment was laid out in a completely randomized design

Table 1. In vitro regeneration from embryo explant in pigeonpea.

	Mean regeneration (%) in pigeonpea cv		
Hormone Concentration (mg L^{-1})	Bahar	T 21	Paras
MS + Sucrose (30 g L^{-1})			
BAP (1.) + IAA (0.1)	32.1	22.5	47.4
BAP (5.0) + IAA (0.5)	37.0	31.8	18.9
BAP (10) + IAA (1.0)	20.0	28.2	25.1
MS + Sucrose (40 g L^{-1})			
BAP (1.0) + IAA (0.1)	59.0	41.0	35.1
BAP (5.0) + IAA (0.5)	34.9	37.2	39.0
BAP (10) + IAA (1.0)	28.5	14.9	35.1
MS + Sucrose (50 g L^{-1})			
BAP (1.0) + IAA (0.1)	28.8	19.2	18.2
BAP (5.0) + IAA (0.5)	21.4	32.9	26.5
BAP (10) + IAA (1.0)	39.1	47.9	26.0
Mean	33.4	30.6	30.1
	Genotype	Hormone	Sucrose
SE	± 0.9344	± 0.9344	± 0.9344
CD at 5%	2.588	2.588	2.588

(CRD) with three replications. The data were analyzed using standard statistical procedures as described by Gomez and Gomez (1976).

In the cultured embryos, shoot initiation could be observed from the swollen nodal portion. The number of shoots increased after 30 to 40 days of incubation on the same media. Roots were also induced in regenerated shoots after one month on the same culture media. The modified basal medium used with BAP 1.0 mg L^{-1} + IAA 0.1 mg L^{-1} gave a higher shoot induction frequency compared to BAP 5.0 + IAA 0.5 mg L^{-1}. The best regeneration (36.1%), however, was obtained on MS-substituted with 40 g L^{-1} sucrose. Among genotypes, Bahar gave the best performance (33.5%) followed by T-21 (30.7%) and Paras (30.2%). The best shoot formation (33.7%) was obtained on MS + BAP (1.0 mg L^{-1}) + IAA (0.1 mg L^{-1}), irrespective of the genotypes used.

It appears that pigeonpea requires a higher level of carbon source (sucrose) because of the relatively long culture period for shoot initiation and, subsequently, proliferation. Further, it is well known that degradation of sucrose takes place during autoclaving of media (Wang and Hsiao 1995), which further emphasizes the need to increase the concentration of sucrose to meet the requirement of such grain legumes as pigeonpea. This type of an increase in regenerative capacity with increase in concentration of carbohydrates has been reported in other grain legumes, e.g., peas (Loiseau et al. 1995) and alfalfa (Strickland et al 1987). Our results clearly demonstrate that increasing the level of the carbon source (sucrose) in the media can considerably improve the regeneration rate in pigeonpea.

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Agrobacterium-mediated Transformation of Pigeonpea (*Cajanus cajan* L. Millsp.) by Using Leaf Disks

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Improvement of pigeonpea cultivars to combat pests and diseases is effected by the introduction of resistant genes from wild species through interspecific hybridization or by resistant genes from unrelated sources using genetic engineering (transformation) techniques. Genes for stress tolerance (glycerol-3-Phosphate acyl transferase), pest tolerance (Bt toxin genes and Protease inhibitor genes) were successfully introduced into many crop plants through *Agrobacterium tumefaciens-mediated* transfer. Successful regeneration and transformation are necessary for the production of transgenic plants. There have been several reports regarding regeneration of whole pigeonpea plants from leaf callus (Kumar et al. 1983, 1994; Leela and Eapen 1994; Ramesh and Baldev 1994). The use of wild types of *A. tumefaciens* strains (Rathore and Laxmi Chand 1997) induced tumor formation in several cultivars of pigeonpea. Sagore et al. (1997) reported *A. tumefaciens-mediated* transfer of pigeonpea embryo axis, using reporter gene. We successfully carried out the transfer of GUS reporter gene mediated by *Agrobacterium-in* pigeonpea leaf disks.

Agrobacterium-mediated transfer of leaf disks of pigeonpea cultivar ICPI 5164 was done using the LBA4404 pBAL2 *Agrobacterium* strain (Dr K Veluthambi's Lab) carrying Kanamycin antibiotic selection marker and GUS reporter gene under promoter 35S. The strain has an intron from the castor bean Catalase gene in the GUS reporter gene for further confirmation of expression in eukaryotes.

The tolerance limit of pigeonpea tissue to Kanamycin was determined in three sets of experiments using concentrations of 0, 25, 50, 75, 100, 150, 200 mg L^{-1} of Kanamycin supplemented in shooting medium. The shooting medium contained the basal medium of Murashige and Skoog (1962) supplemented with 10 µM BAP (Benzyl amino purine) and 0.1µM IAA (Indole

Table 1. Number of leaf disks callusing after 3 weeks on different concentrations of Kanamycin (g mL^{-1}).

Experiment	0	25	50	75	100	150	175	200	No. of leaf disks used per conc.
I	20 (83.3)[1]	16 (66.7)	13 (54.2)	4 (16.7)	2 (8.3)	0 (0)	0 (0)	0 (0)	24 (100)
II	21 (87.5)	14 (58.3)	13 (54.2)	3 (12.5)	1 (4.2)	1 (4.2)	0 (0)	0 (0)	24 (100)
III	20 (83.5)	15 (62.5)	14 (58.3)	2 (8.3)	1 (4.2)	0 (0)	0 (0)	0 (0)	24 (100)

1. Figures in parentheses are percentages.

acetic acid). It was prepared following the protocol described by Leela and Eapen (1994); only the IAA concentration was changed. Of three consecutive experiments done to determine Kanamycin tolerance, 75 mg L^{-1} was found to be the optimum tolerance limit (Table 1). However, the percentage of leaf disks was low compared to 50 mg LA This result is in concurrence with the concentration limit published by Sagare et al. 1997.

The *Agrobacterium* cocultivation experiments were carried out in two sets each time. In one set, leaf disks preincubated on shooting medium for two days were used and in the other set, freshly cut leaf disks were used and these disks were cultured on shooting medium supplemented with acetosyringone (100 mM).

Agrobacterium strain culture of I O.D. (Optical density at 600 nm) was used for cocultivation. The leaf disks were transferred to shooting medium after being treated with *Agrobacterium* I O.D. culture for 10 minutes. The leaf disks were transferred on to selection medium (Kanamycin in shooting medium) after 2 days and 4 days from cocultivation medium. The selection medium contained Cefotaxime 250 mg L^{-1} to kill the *Agrobacterium.* About 40% of the leaf disks showed signs of callusing after 2 weeks on slection medium.

The leaf disks and callus from three sets of experiments were checked for stable expression of GUS activity after 20 days, 10 days, and 3 days after being transferred to the selection medium. A histochemical assay for Beta-glucuronidase (GUS) was done following the protocol used by Hiei et al. (1994). The results indicated that *Agrobacterium-mediated* transfer can be successful in all treatments (Table 2). Four-day cocultivation gave a relatively larger number of transformed calluses (47.8%) than two-days cocultivation. Acetosyringone-supplemented medium gave a higher percentage (45.5% of calli) of stable transformants than the one without Acetosyringone.

These results gave a positive indication that *Agrobac*-fcnwm-mediated transformation using leaf disks of C. *cajan* is possible. Four days of cocultivation using cocultivation medium supplemented with Acetosyringone produced a higher percentage of transformants. In the background of successful regeneration from leaf disks, this experiment supports the idea that genetic improvement of *C. cajan* is possible through the introduction of genes by *Agrobacterium-mediated* transfer.

Table 2. Number of leaf disks showing Kanamycin resistance and GUS-positive staining.

	Two-day cocultivation		Four-day cocultivation	
Experiment	AS+[1]	AS-[2]	AS +	AS-
I 20 days	3/8 (37.5)[3]	2/8 (25)	6/10 (60)	4/8 (50)
II 10 days	2/6 (33.3)	1/6 (16.7)	4/8 (50)	3/8 (37.5)
III 3 days	2/6 (33.3)	1/6 (16.7)	3/6 (50)	2/6 (33.3)

1. AS+ = Medium with Acetosyringone.
2. AS- = Medium without Acetosyringone.
3. Figures in parentheses are percentages.

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The Fourth Working Group Meeting on Botrytis Gray Mold of Chickpea reviewed research progress during the last two years in Bangladesh, India, and Nepal. This publication contains summaries of the findings and recommendations made for future research priorities. Field experiments conducted in Bangladesh, Nepal, and India suggested that an integrated disease management program if practised along with other improved agronomical practices, can substantially reduce disease severity in chickpea fields and increase chickpea production in disease-prone areas. High priority was given to participatory on-farm validation of the available components of BGM management such as moderate levels of host plant resistance, agronomic options (spaced planting and judicious use of fungicide), and their integration.

ICRISAT. 1998. From orphan crop to pacesetter: pigeonpea improvement at ICRISAT. (In En.) Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp. ISBN 92-9066-401-0. Order cide GA 034.

ICRISAT. 1998. Food from Thought no. 8. A series of narratives on the practical application of research conducted by ICRISAT and its collaborators. Ingredients of a successful project: donor's visiion, demand-driven research, and people's readiness. A story of collaboration between the African Development Bank, national stakeholders in eastern and southern Africa, and ICRISAT in improving pigeonpea. Order code: FTE 008. Single copies free.

Saxena, K.B. 1999. Pigeonpea in Sri Lanka (In En. Summaries in En, Fr.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 98 pp. ISBN 92-9066-399-5. Order code BOE 026.

Sri Lanka produces about 60 000 t of pulses per year in the dry and intermediate-rainfall zones. Domestic production is insufficient to meet demand, and annually about US$ 40 million is spent on pulse imports to make up the shortfall. Pigeopea (*Cajanus cajan),* commonly known as red gram, or *tur,* is an important protein-rich food for millions of vegetarians in the Indian subcontinent, Africa, and the Caribbean. The crop has the ability to survive and yield good economic returns in drought-prone environments and low-input production systems, enrich the soil through nitrogen fixation, and provide other benefits as well. Sri Lankan researchers believe pigeonpea has the potential for wider adoption by dryland farmers, and can contribute significantly to national pulse production and save foreign exchange. Adaptation of the crop to Sri Lankan conditions has been studied, and production constraints identified. This book summarizes the results of pigeonpea research and development in Sri Lanka. It discusses the identification of elite cultivars, production and processing technologies, marketing options, and the future prospects for pigeonpea in the country,

Nimal Jayantha, H.M., and Saxena, K.B. 1998. A new small-scale processor for pulses. (In En. Summaries in En, Fr.) Information Bulletin no. 54. Maha Illuppaliama, Sri Lanka: Farm Mechanization Research Centre, Department of Agriculture, Ministry of Agriculture and Lands; and Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 20 pp. ISBN 92-9066-394-4. Order code IBE 054.

Pigeonpea *(Cajanus cajan* (L.) Millsp.) is an important protein-rich staple food in several parts of the semi-arid tropics. The development of new pigeonpea varieties has helped extend this crop into nontraditional production areas, but the commercial adoption of the crop depends largely on such factors as processing and consumption. The availability of an effective small-scale processing technology to dehull pigeonpea grain is critical to successful pigeonpea production and marketing. In Sri Lanka, the Department of Agriculture set up a promising pigeonpea production project supported by the Asian Development Bank and ICRISAT. Under the project, a small-scale processing machine was developed at the Farm Mechanization Research Centre (FMRC). The machine is capable of producing high-quality decorticated splits (*dhal*) of various pulse crops (black gram, green gram, cowpea, soybean, etc.), and can process about 40 kg of pigeonpea grain in 1 h with 70-74% recovery. Besides dehulling and splitting, the machine can clean and grade grain or splits. This document summarizes important research results and relevant technical information about this processing machine.

Sharma, H.C., Saxena, K.B., and Bhagwat, V.R. 1999. The legume pod borer, *Maruca vitrata:* bionomics and management. Information Bulletin no. 55 (In En. Summaries in En, Fr.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.42 pp. ISBN 92-9066-406-1. Order code IBE 055.

The legume pod borer, *Maruca (testulalis) vitrata* (Geyer) is one of the major limitations to increasing the production and productivity of grain legumes in the tropics. Bionomics, host-plant resistance, natural enemies, cultural practices, and chemical control of the legume pod borer have been discussed in this bulletin to identify gaps in present knowledge and to help plan future strategies for research on this pest on pigeonpea. While information is available on bionomics and host-plant resistance in cowpea, such information on pigeonpea and other legumes is limited. Several natural enemies have been recorded on *M, vitrata,* and pathogens such as *Bacillus thuringiensis, Nosema,* and *Aspergillus* play an important role in regulating its populations under field conditions. Cultural practices such as intercropping, time of sowing, density of sowing, and weeding reduce the pod borer damage. Several insecticides have been found to be effective for controlling this insect. There is a need to focus future research on standardizing the resistance screening techniques, identification and utilization of resistance, and integrated pest management strategies for sustainable agricultural production.

Allen, D.J., and Lenne, J.M. (eds.) 1998. The pathology of food and pasture legumes. Wallingford, Oxon, UK: CAB International, and Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 772 pp. *Copies can be ordered from CABI, Wallingford, Oxon OX10 8DE, UK.*

The plant family *Leguminosae* is second in economic importance only to *Gramineae,* which includes the world's cereals and pasture grasses. Indeed, about one quarter of the total output of crop protein in the world as a whole is derived from legumes, which are of great importance both in human diets and in the feeding of livestock. Production is nevertheless limited by major diseases, and therefore there is a great need for a reference book on the pathology of food and pasture legumes.

This book fills this need and provides substantial critical reviews of each crop type as well as a cross-commodity

perspective. It is written by leading research workers in the USA, UK, India, Nigeria, Malawi, New Zealand, Syria, Tanzania, and Uganda. The content is thus applicable to both the developed and the developing world, and to temperate and tropical zones. Well illustrated with both monochrome and colour plates, and thoroughly referenced to the research literature, it represents an indispensable volume for plant pathologists as well as plant breeders and agronomists.

Kumar Rao, J.V.D.K., Johansen, C., and Rego, T.J. (eds.). 1998. Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain; Patancheru, India, 26-28 Aug 1986. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 256 pp. ISBN 81-204-1297-4.

Among various agricultural production systems, the rice- and wheat-based cropping systems in the Indo-Gangetic Plain, covering Bangladesh, India, Nepal, and Pakistan, are both agroecologically and socioeconomically important. There have been expressions of concern for long-term sustainablility of rice- and wheat-based systems, as for other repetitive cropping systems. A closer examination of cropping sequences is needed if productivity of rice and wheat is to be maintained and further increased. In this context, the well-known ameliorative effects of legumes in crop rotations need close attention in relation to the sustainabiility of rice and wheat production systems.

The book is a product of a regional workshop entitled ''Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain" held at the International Crops Research Institute for the Semi-Arid Tropics (1CRISAT), Patancheru, India during 26-28 Aug 1996. The objectives of the workshop were: (1) to collate and interpret existing information on legume residual effects on subsequent crops for the region, and (2) to formulate future research needs. About forty participants representing Rice-Wheat Consortium member countries (Bangladesh, India, Nepal, and Pakistan), Cornell University (USA), Vietnam, and 1CRISAT participated in the workshop. The group discussed existing information on legume residual effects on subsequent crops for the region and then deliberated on research needs on grain legumes, forage legumes and green manure legumes in relation to constraints to adoption of technologies for including legumes, knowledge gaps and researchable issues, target regions and important cropping systems. This book is based on the papers presented and the deliberations of the workshop.

Bantilan, M.C.S., and Joshi, P.K. (eds.) 1998. Assessing joint research impacts. Proceedings of an International Workshop on Joint Impact Assessment of NARS/ICRISAT Technologies for the Semi-Arid Tropics, Patancheru, India, 2-4 Dec 1996. Patancheru 502 324, Andhra Pradesh, India: ICRISAT, 288 pp. ISBN 92-9066-396-0. Order code CPE 119. LDC $27.50. HDC $74.50. India Rs. 1025.00.

Pursuit of a joint approach to the assessment of research impact is critical for the continuing viability of national and international research within the global agricultural R&D system. This workshop on "Joint Impact Assessment of NARS / ICRISAT Technologies for the Semi-Arid Tropics" was organized to achieve three objectives: a) to report results of case studies on adoption and impact undertaken jointly by teams from ICRISAT and the national programs; b) to provide a forum for peer review; and c) identify through working group sessions key issues and priority areas for the ICRISAT / NARS research agenda on impact assessment.

The workshop was attended by ICRISAT scientists from all disciplines, by representatives from private and public sector research institutions, the seed sector, and other international research organizations. These proceedings include the presentation of case studies featuring research impact in four areas—genetic enhancement research; resource management options; intermediate products of research; and impact of networks. That adoption is a condition of impact was noted. The efficiency dimension of impact served as a starting point in most analyses. Other dimensions of impact include food security, gender equity, sustainability, human nutrition, employment, and spillover effects. The integration of these dimensions in the research evaluation process was discussed. Peer review was an important feature of this workshop; it served as a basis for the discussions on priorities for the future research agenda on impact assessment.

Chung, K.R. 1998. The contribution of ICRISAT's mandate crops to household food security: a case study of four rural villages in the Indian semi-arid tropics. Information Bulletin no. 52. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 40 pp. ISBN 92-9066-390-1. Order code 1BE 052. LDC $19.50. HDC $55.50. India Rs.775.00.

The conceptual linkage between increased food production and improved nutritional status appears straightforward; yet, devising research strategies that lead to real change has proved difficult. Although intra-household resource allocations are a strong determinant of individual nutritional status, this bulletin focuses on the possibilities for

technical change to improve consumption at the household level. The reported study therefore seeks to update knowledge of the role that ICRISAT mandate crops play in the diets of the rural poor. Specifically, it examines the state of undernutrition in the study area, the dependence of the rural poor on ICRISAT's mandate crops, the actions available for improving the diets of the rural poor, and the role agricultural research should play in the fight to reduce undernutrition. These topics are addressed through a household-level analysis of dietary patterns in four rural villages in the semi-arid tropics (SAT). The ultimate purpose is to discuss the menu of options available to researchers interested in strengthening the link between agricultural technology and nutritional well-being. The analysis focuses on identifying current dietary and expenditure patterns in two regions within the Indian SAT.

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About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of Southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research that can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is cosponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).

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