Role of Plant Introductions in Varietal Development of Pulses in India

Masood Ali*, Sanjeev Gupta, BB Singh and Shiv Kumar
Indian Institute of Pulses Research, Kanpur-208024, Uttar Pradesh, India

Plant introduction is the oldest and simplest method of crop improvement, as well as an effective means to overcome the narrow genetic diversity observed in certain parts of the world. Genetic base of pulse varieties is narrow and needs immediate corrective measures by involving unadapted germplasm accessions, exotics and wild relatives in breeding programme. Over a period of time, several promising exotics of pulses were introduced in India from different countries. A total of 8 exotics of chickpea, two of pigeonpea, eleven of mungbean, one of lentil, five of fieldpea and four of Rajmash have contributed in the development of 52 cultivars of different pulse crops released in India. Rate of infusion of new exotics in pulse breeding programme has been slow. Several exotic accessions with useful traits are yet to be exploited in breeding programmes. Access to unique and potential valuable germplasm is key to sustained pulse improvement programme. The present paper describes the analysis of genetic base of the released cultivars, status of utilization of exotics, target traits for introduction, availability of useful exotic germplasm and possible approaches and strategies for their utilization in pulse improvement programme.

Key words: Pulses, Introduction, Varietal development, Genetic base, Released cultivars

In India more than a dozen pulse crops are grown on 22-24 million ha area with an annual production of 13-15 million tonnes. The major pulse crops grown in the country are chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* Millsp.), lentil (*Lens culinaris* L.), mungbean (*Vigna radiata* L. Wilczek) and urdbean (*Vigna mungo* L. Hepper). India holds the first position in area as well as production of these crops. As compared to cereals, most of these pulses still await significant breakthrough in terms of production and productivity. Productivity of pulses is still regarded as below the acceptable levels. In resource rich regions, these are not able to compete with cereals and cash crops as most of the pulses are not responsive to higher inputs. The reasons for low productivity are attributable to narrow genetic base, poor plant type, vulnerability to abiotic and biotic stresses and their cultivation in marginal and harsh environments. Over a period of time, a large number of improved cultivars have been developed in pulse crops. Notwithstanding the number of cultivars released, there has been limited improvement in productivity of pulses in almost all the environments. For example, yield of lentil, urdbean and mungbean have remained on plateau for the last ten years, while chickpea and pigeonpea observed marginal increase in yield during the period. Genetic diversity is limited both within production system and breeding programmes.This indicates that immediate steps should be taken up for broadening the genetic base of pulse crops either through exploitation of exotics or wild relatives, as most of the present day cultivars of different pulse crops are very closely related.

Genetic Base of Released Cultivars

Due to concerted breeding efforts, a total of 442 varieties of different pulse crops were released for cultivation in India. Of them, 126 varieties in chickpea, 100 in pigeonpea, 72 in urdbean, 100 in mungbean, and 37 in lentil were developed through different breeding methods. About 230 varieties were developed through hybridization following pedigree selection. Pedigree analysis of these varieties revealed narrow genetic base in most of the pulse crops (Table 1).

Pedigrees of 86 chickpea cultivars that have been released through hybridization were traced back to 95 ancestors. The top ten ancestors contributed more than 35 % to the genetic base of the released varieties. Most frequently used ancestors were Pb 7,IP 58, F8, Rabat and S 26 (Kumar *et al.*, 2004).

Coefficient of parentage were worked out by Gupta *et al.* (2004) to quantify the ancestral contributions to 99 cultivars of mungbean and identify the ancestor genotypes which contributed the most to cultivated germplasm. From the analyses it is evident that these varieties could be traced back to 74 ancestors. The ancestor genotypes T1, T49, T2, BR2, G65 and Madhira were those which contributed the most to the current mungbean germplasm. T1 alone contributed as high as 17 % of the genetic base of the released cultivars (Gupta *et al.*, 2004).

* E-mail: mali@iipr.ernet.in

Table 1. Genetic base of varieties of pulse crops released in India

Crop	Number of varieties developed	Number of varieties developed through hybridization	Number of ancestors used	Relative contribution of top 10 ancestors (%)	Name of top five ancestors
Chickpea	126	86	95	35	Pb 7*, IP 58, F 8, Rabat, S 26
Pigeonpea	100	47	57	48	T1*, T 190, P 4768, Sangareddy selection, Brazil 1-1
Lentil	35	14	22	30	L 9-12*, T 8, LG 171, JLS 2, JLS 1
Mungbean	99	50	74	79	T1*, T 49, BR2, G 65, Madhira
Urdbean	72	33	26	69	T 9*, D-6-7, G 31, Netiminumu

* Appearance of most frequent ancestor

The pedigrees of 35 lentil varieties released in the country were traced back to 22 ancestors. Out of these, the top ten ancestors contributed 30 % to the genetic base of the released varieties. L 9-12 is the most frequently used parent followed by K 8, LG 171, JLS 2 and JLS 1.

In pigeonpea, 57 ancestors were used to develop 47 varieties through hybridization. The top ten ancestors contributed 48 % to the genetic base of the released varieties. Ancestors T 1 and T 190 appeared in 34% varieties. Other ancestors used very frequently were P 4768, Sangareddy selection and Brazil 1-1.

Pedigree analyses were performed by Gupta *et al.*, 2003 to quantify the ancestral contributions to 72 urdbean cultivars released in India so far. From the analyses it was evident that these varieties could be traced back to 26 ancestors. Five ancestors, T9, D-6-7, G31, Netiminumu and AB-1-33 together contributed 50% to the total genetic base. T9 alone contributed as high as 31 % of the genetic base of the released cultivars (Gupta *et al.,* 2003).

Extensive and repetitive use of superior genotypes with common ancestry explained why the genetic base of the released varieties is narrow and the integration of unadapted germplasm, exotics and wild relatives is of paramount importance for broadening the genetic base of pulse crops.

Successful Introductions and their Utilization

Plant Introductions have been important to meet the varietal needs for a growing situation and overcoming the narrow genetic diversity observed in a region. A total of 31 exotics have contributed in the development of 45 cultivars of different pulse crops released in India. Of them, 8 of chickpea, two of pigeonpea, five of fieldpea, 11 of mungbean, one of lentil and four of *Rajmash* have contributed significantly in pulse improvement programme (Table 2).

Table 2. Utilization of exotic germplasm in varietal development of pulses in India

Crop/Accession	Country of origin	Varieties
Munbean		
China Moong	China	Shining Moong 1, Sunaina, RMG 62, Jalgaon 781
NM 9473	Pakistan/ AVRDC	Pusa 9531
NM 92	Pakistan/ AVRDC	Pusa Vishal
NM 94	Pakistan/ AVRDC	SML 668
V 2164	AVRDC,Taiwan	SML 134
V 3484	AVRDC,Taiwan	Pusa 101, WGG 2
VC 1137-213	AVRDC,Taiwan	Pusa 105
CES 44	Phillipines	AAU 34
MG 50-10	Phillipines	Co 5, Co 6
VC 6368	AVRDC,Taiwan	Pant Mung 2
Rajmash		
EC 94453	Bulgaria	Uday
ET 8447	Columbia	Amber
EC 400431	Columbia	Utkarsh
EC 400418	Columbia	Arun
Fieldpea		
L 116	Sweden	Hans
EC 33866	Russia	Harbhajan
EC 109196	–	Aparna (HFP 4)
EC 109185	–	Uttara, Sapna
Afilaknund	–	HUP 2
Lentil		
Precoz	Argentina	NDL 1, DPL 58
Pigeonpea		
PI 2817-2	Zimbawe	Hy 3C
Brazil 1-1	Brazil	Mukta, Sharad, Pusa Ageti
Chickpea		
Cyprus Local	Cyprus	Pragati
Rabat	Jordon	L 550, L 144
Ceylon 2	Sri Lanka	Phule G 12
ICC 3935	Egypt	BG 391
E 100Y	Greece	Gaurav, Dharwad Pragati
FLIP 88-120	Syria	BG 1053
P 9847	Russia	BG 261, BG 244
P 9263	Russia	BG 267

Chickpea variety, Pragati, was the outcome of the direct introduction of Cyprus local. Besides, 16 cultivars of chickpea released in India have been developed through utilization of exotic germplasm as an immediate parent in their pedigrees. Some of these varieties are Pusa 261, Pusa 244, Pusa 267, C 104, L 550, L 144, BG 1003, BG

1053, Phule G12, BG 391, Gaurav and BGD 72. Rabat, an exotic *Kabuli* variety, in combination with S 26 and Pb 7 led to the development of *kabuli* varieties L 144 and L 550, respectively. In two different cross combinations, the *Ascochyta* blight resistant line from Greece, E 100Y led to the development of Gaurav and Dharwad Pragati. The Russian accession, P 9847 in different combinations led to the development of tall *desi* variety BG 261. This exotic was also involved in a three way cross to develop a variety BG 244. Another Russian accession P 9263 was also involved in a three way cross and led to the development of a *kabuli* variety BG 267.

Pigeonpea cultivar, Hy 3C was a secondary selection from exotic line PI 2817-2. Another exotic line Brazil 1-1 has been used as a source of earliness in pigeonpea, which, in combination with NPWR 15, NP 41 and NP 69, has led to the development of early maturing varieties Mukta, Sharad and Pusa Ageti.

Promising exotics were extensively utilized in the development of at least seventeen popular cultivars in mungbean. Pusa Vishal, a selection from AVRDC accession NM 92, released for NWPZ has become most popular because of its large seed (6 g/100 seed weight). SML 668, a promising cultivar of mungbean for summer/spring cultivation is also a direct selection of exotic line NM 94. Selections made from exotic material introduced from China and Iran have led to the development of Shining Moong 1 and PS 16, respectively. These selections were widely used in crossing programme and subsequently few superior cultivars such as KM 1, Sunaina and RMG 62 were released. An accession from AVRDC, V3484 contributed shining coat character in development of Pusa 101 and WGG 2.

Introduction of an early, rust resistant *macrosperma* line, Precoz, from Argentina has accelerated *microsperma* x *macrosperma* crosses in lentil resulting in the development of NDL 1 and DPL 58.

In fieldpea, an exotic accession EC109196 in a cross combination led to the develoment of a dwarf, leafless and powdery mildew resistant cultivar, HFP 4. HUP 2, a tall cultivar is the product of three way cross involving an exotic Afiakund. An old pea variety, Hans was a mutant of L116, an exotic accession from Sweden, and Harbhajan was a selection from exotic line, EC33866. Exotic pea accessions for useful traits viz., resistant to *Pea mosaic virus* (EC271572), resistant to powdery mildew (EC322745 and EC381853), tolerant to drought (EC389374) are yet to be exploited in pea improvement programme.

Rajmash (*Phaseolus vulgaris* L.) is relatively a recent introduction in the country. It was believed to have originated in the America and domesticated in Mexico, Peru and Columbia. The primary gene pool is well represented in collections of CIAT and Columbia. *Rajmash* cultivar, Uday was selected from exotic germplasm, EC 94453 introduced from Bulgaria, while Amber, Utkarsh and Arun were selected from Columbian accessions, ET8447, EC400431 and EC400418, respectively.

Traits for Introduction

In pulses, traits other than high yield had little importance. With the development of production systems in which the pulses are grown, other traits are now becoming more important. For introduction, normally those traits are considered for which sufficient variability is not present in the indigenous material. However, for rapid breeding advancements, the exotics with useful traits like disease and insect-pest resistance, drought and cold tolerance, low neurotoxins and high protein content are important and these should be introduced for further utilization. In different pulse crops, the preferred traits for introduction are mentioned in Table 3.

Chickpea

The chickpea has two main types, the *Desi* type with small, brown and angular seeds, and the *Kabuli* type with large, beige seeds with ram-head shape. Wilt is a serious problem wherever chickpea is grown. Different pathogenic races of *Fusarium oxysporum* f.sp. *ciceri* were recognized by Dolar (1995) and Singh and Jimenez-Diaz (1996). Ascochyta blight is a serious problem in

Table 3. Preferred traits for introductions in pulse crop

Crop	Preferred traits
Chickpea	Short duration, Bold seed, High temperature tolerance at maturity (> 25°C), Cold tolerance (< 5°C), Salinity tolerance, Resistance against Wilt and Ascochyta blight
Pigeonpea	Short duration, Cytoplasmic Male Sterility (CMS) source, Resistance against Wilt and Phytophthora Stem Blight
Mungbean	Short duration, Bold seed (> 6g), Photo-thermo insensitivity, Bruchids resistance, Pre-harvest sprouting tolerance, Resistance against Powdery mildew and *Cercospora* Leaf Spot
Lentil	Bold seed, Resistance against Rust and Vascular Wilt
Fieldpea	Dwarfness, Afila types, Short duration (<100 days), Resistance against Powdery mildew
Rajmash	Cold tolerance (< 5°C), *Bean common mosaic virus* (BCMV) resistance

comparatively cooler environments. Race specific resistant sources are needed for pyramiding the genes and thereby insulating the crop against the particular disease. Drought is one of the major abiotic stresses as the crop is mostly grown on residual moisture in *rabi* seasons. The crop experiences low temperature of 0-5°C for about 15-20 days in North Plain Zone of the country. Prevalence of such a low temperature at early flowering stage causes flower abortion, leading to 15-30% yield loss. Accessions which can retain flowers and set pods under these conditions are needed for their utilization in breeding programme. Introductions from Russia (e.g. K1189) have shown cold tolerance. Similarly, prevalence of temperature above 30°C especially during the reproductive stage can also cause severe stress in Southern region. Efforts are needed to identify tolerant sources for high temperature. Tolerant sources for salinity/ alkalinity are also needed as the crop also suffers from these stresses. Bold seeded types are becoming popular among farmers. The proportion of bold seeded varieties have gone upto 41% during last decade showing the promise that the genetic manipulation for seed size can be made successfully. Therefore, infusions of new sources for seed size both for *desi* and *kabuli* types are urgently needed. Availability of short duration varieties has made it possible to shift the sowing of chickpea from October to November and December making rice–chickpea rotation a reality in northern zone. Similarly, the early maturing varieties have been the main catalyst behind the expansion of the crop in southern and central zones. Since the trait is occupying importance in production systems, the new sources for short duration types (maturing < 120 days) should be made available for their utilization in breeding programmes.

Pigeonpea

Pigeonpea is the second most important pulse crop of the country. Among biotic stresses, wilt, stem blight and sterility mosaic are major challenges to its production. Sources of durable resistance to these diseases are needed for improvement programmes. Short duration maturity allows great flexibility in its planting. Development of early maturing cultivars has made pigeonpea–wheat rotation a great success in northern states. New sources of short duration types hold promise in further advancement of breeding efforts. Sources of cytoplasmic male sterility (CMS) are important for exploitation of heterosis in pigeonpea. So far, the CMS sources could be available from wild species only. However, promising CMS sources, wherever available, need to be introduced to accelerate hybrid pigeonpea programme in the country.

Fieldpea

Some minor characters seemed to be of interest and were used in breeding but the main targets were, naturally, yield and stiffness. Analysis of crosses with exotic material was not very informative. The only approach was for phenotypic selection and the first character addressed was stem length. Unfortunately a lot of germplasm are very tall and selecting shorter types gave no major step forward in desired characters. Afila, a natural mutant observed in early 50's has been found responsible for transformation of leaflet into tendrils. This type has some obvious advantages and therefore regarded as a major breakthrough in changing plant type of fieldpea. Aparna (HFP 4), Uttara (HFP 8909) and Sapna are such successful cultivars developed using Afila mutant gene *'af'*. These cultivars were developed using exotic accessions. Several germplasm carrying 'ramosus' gene has been identified having branching ability at several levels of plant (Beveridge *et al.*, 1990) and these need to be utilized in breeding programme identified a flowering gene *'lfa'* which determines the level of first flowering node. This trait is useful for modulation of earliness. Short duration pea cultivars maturing in less than 100 days may be important as these can ensure intercropping of mungbean and urdbean in spring planted sugarcane. Sources of powdery mildew and rust resistance are important to sustain fieldpea breeding programme. Resistance to *Erysiphe pisi* was first observed in an accession carrying *'er1'* and *'er2'* genes in Peru.Since than several sources have been reported in the literature. It is necessary to exploit exotic germplasm, carrying such useful traits. To make a major step forward in yield, stiffness, plant type, earliness etc., it is necessary to continue exploiting exotic germplasm.

Lentil

In lentil, an exotic Precoz has been used in breeding programme to develop bold seeded cultivars in the country. Extra bold types are preferred in cultivation mainly for export purposes. New exotics need to be introduced to achieve this objective. Among biotic stresses, rust and vascular wilt are major fungal diseases. Several other important traits such as biomass yield, pod shedding etc., could not be addressed in breeding programmes because of non-availability of appropriate sources.

Mungbean

Development of short duration varieties of mungbean brought the era of short duration pulses in different cropping systems. Since the crop has occupied a place in different cropping systems, it often faces major challenges from biotic and abiotic stresses. Reliable and durable sources of powdery mildew and cercospora leaf spot are not available to the breeding programmes. Bold seed size (>5 g) is the most preferred trait for introductions. Besides, bruchid resistance and pre-harvest tolerance are two major traits, for which new sources need to be introduced.

Rajmash

Rajmash is a successful example where exotics played an important role with useful traits. An exotic from Bulgaria, EC 94453, led to the development of cultivar 'Uday' (PDR 14) which has made cultivation of *rajmash* possible in plains during *rabi* season. Since the crop has been introduced in new nitches, it is becomming prone to many biotic and abiotic stresses. *Bean common mosaic virus* resistance and cold tolerance are two major traits, for which the potential sources are needed. However, for attractive seed colour and size, sufficient variability is available in existing collections from CIAT, Columbia.

Future Needs

Breeding efforts with introduced germplasm tend to increase genetic diversity. Germplasm introgression in virtually all areas has increased, and selection programmes with increased levels of exotic germplasm are expected to continue in the future. This exchange of germplasm and breeding efforts has generated different germplasm sources available to breeders for development of cultivars. Introduction of exotic germplasm will increase the genetic base of pulse crops, but lower productivity will not be acceptable in any breeding programme. The increased genetic variability will have to contribute positively to breeding programmes. Hence, careful introgression and selection will be necessary to develop germplasm sources to meet desired standards for productivity, maturity, quality and resistance to biotic and abiotic stresses. The need for plant introduction is continuous, since new diseases and new niches are continually appearing. This makes it imperative that breeders be constantly supplied with useful germplasm and that reservoirs of basic plant material be maintained in gene banks.

Germplasm Enhancement

Integrating some exotics into adapted germplasm has advantages over selecting with in the exotic material for adapted types. This requires patience and long- term selection and breeding. Most of the exotics sometimes are difficult to use in conventional breeding programmes. Thus, except as a last resort, breeders tend to avoid using this germplasm. The major reasons for limited use of exotics may include: adverse photoperiod response masks desirable traits, linkages between favourable and unfavourable genes in exotic adapted populations cannot readily be broken and no current basis exists for choosing the best exotics. Germplasm enhacement is referred as the act of transferring useful genes from exotic or wild types into more adapted backgrounds. Rick (1984) used the terms " prebreeding" or " developmental breeding" to describe the same activity, but enhancement has become more commonly used term among breeders. Enhancement implies the use of any tool available to plant breeders. The precise technique used will depend upon the mating system of the material and intended results. The progress made in the past few years in molecular biology makes biotechnology a promising way to integrate specific genes from related as well as nonrelated species into adapted material.

Introgression Library

For advanced backcross QTL methodology, it is necessary to have an introgression library of useful traits in different pulse crops. Efforts are also needed to find new interesting alleles. With the haplotype breeding, it is necessary to investigate new tools to introduce valuable alleles from exotic germplasm.

Trait Specific Introductions

Over 60,000 accessions of pulse crops were introduced by National Bureau of Plant Genetic Resources, New Delhi from more than 56 countries under strict quarantine measures. However, most of the introduced materials were in the form of international screening nurseries and yield trials. Such introductions have little impact in breeding programmes as the efforts were directed only for screening and evaluation. For effective utilization, an emphasis has to be given on the introductions with useful gene(s). Different accessions with useful traits are available in literature and these should be introduced for utilization and gene introgression (Table 4).

Informal Introductions

There is a legitimate need to introduce new germplasm

Table 4. Source of germplasm with useful traits

Crop/Trait	Accessions	Source	Reference
Chickpea			
Fusarium wilt (race 0,1,5)	ILC 9784	ICARDA	Singh and Jimenez-Diaz, 1996
Fusarium wilt (race 0,1)	ILC 9785, -9786, FLIP 86-93C, FLIP 87-38C	ICARDA	Singh and Jimenez-Diaz, 1996
Resistance to Ascochyta Blight	ILC 72, ILC 191, ILC 3279, ILC 3856	ICARDA	
Resistance to Dry root rot	ICC 2867, ICC 9023, ICC 1003	ICRISAT	
Cold tolerance	FLIP 87-38C, FLIP 86-93C	ICARDA	Singh and Jimenez-Diaz, 1996
	ILC 8262, ILC 8617, FLIP 8-82C	ICARDA	
Combined resistance to Ascochyta Blight and wilt and Cold Tolerance	FLIP 91-178C, FLIP 93-53C, FLIP- 93-98C	ICARDA	Singh *et al.*, 1997
Resistance to Ascochyta blight and cold tolerance	ILC 72, ILC 3279, ILC 482, ILC 2956	ICARDA	Singh *et al.*, 1989
Drought tolerance	FLIP 87-59C	ICARDA	Singh *et al.*, 1996
	ICC 4958, ICC 5680, IC 10448	ICRISAT	
Pod borer resistance	ICCV 7	ICRISAT	Singh *et al.*, 1997
Bruchids resistance	(*Cicer echinospermum*) ILWC 39, ILWC 181	ICARDA	Singh *et al.*, 1997
Pigeonpea			
Resistance to Fusarium wilt	ICP 9145	ICRISAT	Reddy *et al.*,1995
	ICP 8959, ICP 8863, ICP 9120	ICRISAT	
High Protein	ICPL 87162	ICRISAT	Reddy *et al.*, 1997
Waterlogging tolerance	ICPL 227	ICRISAT	Chauhan, 1987
Resistance to sterility mosaic	ICP 7035, ICP 886	ICRISAT	Reddy *et al.*, 1995
Resistance to Phytophthora Stem Blight	ICPL 84023	ICRISAT	Reddy, *et al.*, 1991
Fieldpea			
Resistant to pea mosaic virus	EC 271572	France	NBPGR, 2000
Resistant to Powdery Mildew	EC 322745, EC 381853	Canada	NBPGR, 2000
Tolerance to drought	EC 389374	Syria	NBPGR, 2000
Lentil			
Cold Tolerance	ILL 323, ILL 465, ILL 857, ILL 975	ICARDA	ICARDA, 2000
Resistant to Bean Leaf Roll Virus	ILL 74, ILL 85, ILL 213	ICARDA	ICARDA, 2002
Resistant to Necrotic Yellow virus	ILL 6816, ILL 213	ICARDA	ICARDA, 2003
Resistant to wilt	ILL 6994, ILL 7201	ICARDA	ICARDA, 1999
Mungbean			
Photo-thermo Insensitivity	V 1400, V 1944, V 3726	AVRDC	AVRDC, 2003
Bruchids resistance	VM 2011, VM 2164, V 2802, TC 1966	AVRDC	AVRDC, 2004
Flood Tolerance	V 1968, V 2984, V 3092	AVRDC	AVRDC, 2000
Maruca resistance	V 2109, V 4270, V 2106	AVRDC	
Resistance to Cercospora Leaf Spot	V 2773, V 4718, V 5000, V 1137A, V 1560D, VC 2720A	AVRDC	AVRDC, 2003

into plant breeding programmes for specific traits preferred by the consumers or to reduce the vulnerability of the crop to diseases. There are certain cases of informal introductions for specific traits and subsequently brought into a large scale cultivation. For example, Mahrashtra farmers are growing extra bold seeded Kabuli type 'Mexican Gold' brought from other countries. These materials might have found place either through informal trade or bulk import for grain purposes. Such movement of material is at risk because of quarantine reasons. To avoid pathogen transfer, germplasm movement must be based on a safe strategy. Therefore, any such introductions should only be permitted with the concurrence of official plant quarantine service.

References

Baranger A, G Aubert, Arnau, AL Laine, G Deniot, J Potier, C Weinachtet, J Lallamad and J Bustin (2004) Genetic diversity in *Pisum sativum* using protein and PCR used markers. *Theor. Appl. Genet.* **108:** 1309-1321.

Beveridge CA, JJ Ross and IC Murfet (1990) Branching in pea: action of genes Rms 3 and Rms 4. *Plant Physiol.* **110:** 859-865.

Dolar FS (1995) Evaluation of some chickpea cultivars for resistance to *Ascochyta rabie* (Pass.) Labr. *Fusarium oxysporum* and *F. solani* in Turkey. *J. Turkish Phytopathol.* **24:**15-22.

Gupta Sanjeev, Shiv Kumar and BB Singh (2004) Relative genetic contribution of Indian mungbean (*Vigna radiata* (L.) Wilczek) cultivars based on coefficient of parentage analysis. *Indian J. Genet.* **64(4):** 299-302.

Gupta Sanjeev and Shiv Kumar (2003) Pedigree analysis of urdbean varieties released in India. *Indian J. Pulses Res.* **18(2):** 153-155.

Kumar Shiv, Sanjeev Gupta, Suresh Chandra and BB Singh (2004) How wide is the genetic base of Pulse crops? In: *Pulses in new perspective* (eds. Masood Ali, BB Singh, Shiv Kumar and Vishwa Dhar). Indian Society of Pulses Research and Development, IIPR, Kanpur, India. pp. 211-221.

Reddy MV, VK Sheila, AK Murthy and N Padma (1995) Mechanism of resistant to *Aceria cajani* in pigeonpea. *Intern. J. Tropical Diseases* **13:** 51-57.

Reddy MV, YL Nene, TN Raju, VK Shiela, N Sarkar and P Ramanadan (1991) Pigeonpea lines with field resistance to Phytophthora blight. *Intern. Pigeonpea News Letter* **13:** 20-22.

Reddy LJ, KB Saxena, KC Jain, Umaid Singh, JM Green, D Sharma, DG Faris, AN Rao, RV Kumar and YL Nene (1997) Registration of high protein pigeonpea elite germplasm, ICPL 87162. *Crop Sci.* **37:** 294.

Reddy MV, YL Nene, TN Raju, J LKannaiyan, P Remanandan, MH Mangesha and KS Amin (1995) Registration of pigeonpea germplasm line resistant to Fusarium wilt. *Crop Sci.* **35:** 1231.

Singh Onkar, SC Sethi, SS Lateef and CLL Gowda (1997) Registration of Pod borer resistant ICCV 7 chickpea germplasm line. *Crop Sci.* **37:** 295.

Singh KB, S Weigand and MC Saxena (1997) Registration of ILWC 39 and ILWC 181 *Cicer echinospermum*, resiatant to *Callosobruchus chinensis*. *Crop Sci.* **37:** 634.

Singh KB and MV Reddy (1989) Ascochyta blight and cold toerant chickpea. *Crop Sci.* **29:** 657-659.

Singh KB, M Omar, MC Saxena and C Johansen (1996) Registration of FLIP 87-59C, a drought tolerant chickpea germplasm line. *Crop Sci.* **36:** 472.

Singh KB and RM Jimenez-Diaz (1996) Registration of six *Fusarium* wilt resistant chickpea germplasm lines. *Crop Sci.* **36:** 817.

Singh KB, RS Malhotra and MC Saxena (1997) Chickpea germplasm lines resistant to Ascochyta blight, Fusarium wilt and cold tolerance. *Crop Sci.* **39:** 1817.