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POTATO GENETIC RESOURCES IN INDIA

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Potato (*Solanum tuberosum*) originated in Peru-Bolivian region, was introduced in India long back towards the beginning of 17th century from Europe. After the establishment of CPRI, Shimla in 1949, potato germplasm collection, conservation, evaluation, documentation and utilization received greater impetus. This paper reveals systematic efforts made by the CPRI in collecting, evaluation and development of potato varieties for consumption etc. Conservation efforts were also highlighted.

Key words: Potato, genetic resources, collection, evaluation, conservation documentation, utilization

Potato belongs to the family *Solanaceae* and the large genus *Solanum*, which contains about 2000 species, out of which nearly 235 are tuber bearing (Hawkes, 1990). These are confined mainly to the Andean region of south America. The ploidy level of potato species varies from 2X to 6X with 73 per cent of these being diploids, 4 per cent triploids, 15 per cent tetraploids, 2 per cent pentaploids and 6 per cent hexaploids (Hawkes, 1990). The commonly cultivated potato belongs to the species *S. tuberosum* L. (2n = 4x = 48) which has two subspecies viz. ssp *tuberosum* adapted to long days and ssp. *andigena* adapted to short days. Besides these, six primitive species *viz., S. ajanhuiri* (diploid), *S. phureja* (diploid), *S. stenotomum* (diploid), *S. chaucha* (triploid), *S. juzepckjukii* (triploid) and *S. curtilobum* (pentaploid) are also under cultivation, but are restricted to the high Andes from central Peru to central Bolivia.

The cultivated potato is believed to have originated near lake Titicaca basin in Peru-Bolivian region (Simmonds, 1976; Ross, 1986). It was introduced in India from Europe towards the beginning of 17th century, about 40 years after its introduction in Europe. By the end of nineteenth century, potato cultivation spread throughout the country (Pushkarnath, 1976). After establishment of the Central Potato Research Institute (CPRI) in 1949 at Shimla, the potato germplasm collection, conservation, evaluation, documentation and utilization, became regular activities of the CPRI.

COLLECTION EFFORTS

The work on collecting variability in potato was initiated in 1940s with the help of the State Departments of Agriculture and about 400 indigenous lines were collected. Of these 16 varieties were identified as known exotic cultivars, while the rest were grouped into 16 distinct morphotypes whose original identity could not be established (Table 1). These cultivars represented some of the earliest introductions or their clonal variants and were termed as *desi* varieties (Pal and Pushkarnath, 1951; Pushkarnath, 1964). Morphologically, these varieties resemble ssp *andigena* (Swaminathan, 1958; Sinha and Pushkarnath, 1964). With the introduction of high yielding potato varieties, much of the earlier variability was lost over the

Table 1. Old indigenous (desi) and exotic potato varieties in India

Indigenous Varieties	Exotic Varieties
Agra Red	Ally
Chamba Red	Arran counsal
Coonoor White	Ben Cruachan
Coonoor Red	Craig's Defiance
Darjeeling Red Round	Runbar Cavalier
Desi	Great Scot
Dhantauri	Italian White Round
Gola type A	Late Carman
Gola Type B	Magnum Bonum
Gola type C	Majestic
Phulwa	Northen Star
Phulwa Purple Splashed	President
Red long Kidney	Raeburn's Gregor Cups
Sathoo	Red Rock
Shan	Royal Kidney
Silbilati	Up-to-Date

Source : Pushkarnath (1964).

period of time, some genetic variability, however, still exists in remote and difficult areas of the country. Attempts were, therefore, made during 1983-92 to collect this variability through surveys. A total of 621 samples were collected (Table 2). These were studied for various morphological characters and grouped into 125 distinct morphotypes (CPRI, 1992-93). These are now being fingerprinted by protein electrophoresis to eliminate duplicates, if any.

Since potato is not native to India, one cannot expect much genetic variability in the material available within the country. Acquisition of exotic germplasm from different countries has, therefore, been a continuing activity of the CPRI. This activity has been accelerated after establishment of the

International Potato Centre (CIP) at Lima, Peru in 1972, which has a large collection of potato germplasm. The collection at CPRI now has over 2,500 accessions, consisting mostly of cultivated species (*tuberosum* and *andigena*) and some of the wild or semi-wild species (Table 3). These germplasm accessions have been imported from 30 countries based on requirements of various potato improvement programmes in India.

GERMPLASM CONSERVATION

At CPRI, the available germplasm is being maintained by three methods, (i) *in vivo* clonal propagation, (ii) *in vitro* clonal propagation, and (iii) as true seeds. *In vivo* clonal propagation is done in glasshouses at Shimla and as duplicate sets in fields at Kufri and Jalandhar. All *tuberosum* and a part of *andigena* accessions are being maintained and multiplied by this method to facilitate their evaluation for adaptability in different agro-climatic regions as well as for resistance/tolerance to various biotic and abiotic stresses. A part of accessions belonging to *andigena* and wild species are being maintained in true seed form. True seeds for short term storage are maintained at CPRI at 10-15°C and for long term storage in cold modules at the National Bureau of Plant Genetic Resources, New Delhi. True seeds are produced by selfing and/or sib-mating. Sib-mating is often resorted to in the case of diploid species most of which are self-incompatible. Only a part of the germplasm is being maintained *in vitro*. Till date about 700 *tuberosum* accessions have been conserved in this form. It is proposed to conserve all the material *in vitro* as facilities and protocols are developed for cryopreservation of the meristem tips or axillary buds.

GERMPLASM EVALUATION

Evaluation of the available germplasm is a continuous process at CPRI, Shimla and its regional station located in different parts of the country. In the early stages of potato research in India, evaluation of a large number of European varieties was undertaken to identify cultivars adapted to temperate long day growing conditions in the hills and sub-tropical short day conditions in the plains. Simultaneously, attention was paid to identify suitable parental lines for Indian potato breeding programmes. The germplasm accessions were thus evaluated for economic characters like resistance to late blight (CPRI 1991-92; Gopal and Singh, 1993), bacterial wilt (Chakrabarti *et al.*, 1992; Nagesh *et al.*, 1993), wart (Singh and Gopal, 1990; Singh and Gopal, 1994), nematodes (CPRI, 1983), potato tuber moth (CPRI, 1992-92), powdery scab (Dutt and Pushkarnath, 1960), charcoal rot (Paharia *et al.*, 1976), hopper burn (CPRI, 1995-96) and viruses (CPRI, 1991-92; Garg and Gopal 1994), besides maturity, tuber dormancy (Joseph and Gopal, 1994), tuber drymatter and protein content (Gaur and Gupta, 1981), etc. The results of evaluation have been compiled

and presented in the catalogues of potato germplasm (ssp. *tuberosum*) collection (Gaur *et al.*, 1984; Gopal *et al.*, 1992).

Table 2. Indigenous potato variability collected during explorations in India (1983-92)

Year	Months	Duration of survey (days)	State	Districts surveyed	No. of samples collected
1983-84	November-March	130	UP	Farukhabad	20
1985	November	5	UP	Uttarkashi	18
1986	March	18	UP	Azamgarh, Barabanki, Ballia, Basti, Deoria, Faizabad, Gonda, Gorakhpur, Jaunpur, Lucknow, Raibareli, Sultanpur, Varanasi	160
1986	August-September	10	HP	High hills of Shimla	41
1986	November	11	Assam	Kokrajhar and Nawgaon	10
			Meghalaya	Jawai and Khasi Hills	16
1986	December	5	Assam	Karbi, Anglong, Nawgaon	11
			Meghalaya	East Khasi hills and jaintia hills	9
1987	February	20	Bihar	Begusarai, Bhojpur, Darbhanga, Gopalaganj, East Champaran, Gaya, Khagaria, Madhubani; Muzaffarpur, Nalanda, Patna, Purnea, Ranchi, Rohtash, Saharsa, Samastipur, Saran, Sitamarhi, Siwan	125
1988	February-March	22	Bihar	Bhagalpur, Devgarh, Dumka, Gonda, Kishanganj, Munger, Sahibganj	23
			W. Bengal	Barrackpore, Birbhum, Cooch Behar, Hooghly, Jalpaiguri, Midnapore, Siliguri	30
1988	October-November	22	HP,UP	Kinnaur, Shimla, Uttarkashi	55
1991	September	18	HP	Rampur, Kinnaur	55
1992	November	7	HP	Chamba	38
Others*			HP	Kullu	2
			HP	Kinnaur	11

*Samples received from NBPGR Regional Station, Shimla (HP)

Table 3. Potato germplasm collection maintained at CPRI (1997)

Material	No. of accession				No. of donar countries
	Tuber	*In vitro*	True seed	Total	
Tuberosum					
Cultivars/parental lines					
Indian					
Cultivars bred at CPRI	24	19	-	24	
Old indigenous cultivars	16	8	-	16	
Parental lines	11	1	-	11	
Indigenous samples	86	67	-	86	
Exotic	1156	638	-	1156	30
Andigena	1028	-	200	1028	2
Wild semi-cultivated sps.	50	-	175	187 (32 species)	2

The germplasm accessions found promising for various characters have also been studied for their combining ability (Gaur *et al.*, 1983, 1985, 1993; Gopal, 1996a, 1996b; Kaushik *et al.*, 1996; Pandey and Gupta, 1997). A list of good general combiners for various characters is given in Table 4. Poor combiners, which may not be used in the breeding programmes, are also listed.

Flowering and fruiting behaviour of potato is important both in variety improvement as well as in raising crop from true potato seed. Germplasm accessions have been studied for these characters also (Gopal, 1994). Out of 676 accessions of cultivated ssp. *tuberosum* from 25 countries studied under natural long days (12-14 h) at Kufri, the majority (58.3%) bloomed profusely, whereas, 20.4% did not bloom at all. The time taken for flowering ranged from 6 to 15 weeks with majority (66.5%) of accessions blooming within 8 to 9 weeks of planting. The duration of flowering ranged from 1 to 10 weeks with the majority of accessions blooming for 1 to 4 weeks only. Twenty three per cent of the flowering accessions were completely male sterile. No berry setting was observed in 31.8% of the flowering accessions. Premature bud abscission was the major cause of sterility.

Table 4. General combining ability of some germplasm accessions

Character	General combining ability		
	Good	Average	Poor
Tuber Yield	CP 2000(1-1062), CP 2110 (CFK 69.1), CP 2334, (F-6) (AL-575), CP 2346 (F-6), CP 2370 (Muziranzara), CP 2378, (Poos. 16), Katahdin, K. Jyoti, K. Badshah, K. Bahar, EX/A 680-16, EX/B 687	CP 2407 (Montsama), CP 2417 (MEX 750838), K. Jeevan, K. Kundan, K. Khasigaro, K. Dewa, Up-to-date, EX/A 679-10	CP1710 (Kerr Pondy), CP 2132 (Tollocan), CP 2351 (Tobique), CP 2401 (CIP 702867)
Tuber Number	CP 2378 (Poos. 16), CP 2413 (Piratini), K. Kuber, K. Khasigaro, K. Dewa, EX/A680-16, EX/A 723, EX/A-687	CP 2346 (F-6), CP 2351 (Tobique), CP 2401 (CIP 702867), CP 2417 (MEX 750838), Dekama, Up-to-date, K. Jeevan, K. Sheetman, K. Kundan	CP 1710 (Kerr Pondy) CP 2334 (AL-575), CP 2370 (Muziranzara), CP 2407 (Montsama), CP 2132 (Tollocan), CP 2416 (MEX 750826), Katahadin, K. Jyoti, K. Badshah, K. Bahar
Average tuber weight	CP 2334 (AL-575), Katahbin, K. Jyoti, K. Badshah, K. Bahar, EX/A 680-16	CP 2407 (Montsama), CP 2416 (MEX 750826), CP 2417 (MEX 750838)CP 2346 (F-6), CP 2370 (Muziranzara), CP 24378 (Poos. 16), Dekama, Up-to-date, K. Jeevan, K. Kundan, EX/B 687	CP 2401 (CIP 702867), CP 2413 (Piratini), CP 2132 (Tollocan), CP 2351 (Tobiqu), K. Sheetman, K. Kuber, K. Khasigaro, EX/A 679-10, EX/A 723
Tuber dry matter	CP 2346 (F-6), CP 2370 (Muziranzara), CP 2378 (poos 16), CP 2416 (MEX 750826), CP 2417 (MEX 750383)	CP 2334 (AL-575), CP 2407 (Montsama), CP 2413 (Piratini)	CP 2351 (Tobique), CP 2401 (CIP 702867)
Resistance to late blight	CP 1673 (Dr. McIntosh), CP 2030 (G. 6246), CP 2333 (AL624), CP 2378 (Poos.16)	CP 2011 (CIP 676082), CP 2370 (Muzranzara), CP 2381 (CFI 69.1), Desiree	CP 2013 (Atzimba), CP 2110 (CFK 69.1), Dekama, K. Badshah
Resistance to early blight	EX/A 680-16	CP 2132 (Tollocan)	CP 1710 (Kerr Pondy), EX/A 723

For characterisation of various accessions, observations have been recorded for morphological characters like tuber skin colour, tuber shape, eye depth, tuber flesh colour, flower colour etc. For this purpose, descriptors of the

International Board for Plant Genetic Resources (now IPGRI), are used. The information on these characters for ssp. *tuberosum* (Gopal *et al.*, 1992) and ssp. *andigena* (Unpublished) accessions has been compiled.

DOCUMENTATION

The information on passport data, morphological characteristics and reaction to various biotic and abiotic stresses of *tuberosum* germplasm has been published from time to time in the form of germplasm catalogues. The list of catalogues published is given below:

1. Pal, B.P. and Pushkarnath, 1951. Indian potato varieties. ICAR, New Delhi. Misc. Bull. 62, 63 p.
2. Pushkarnath, 1964, Potato in India-Varieties. ICAR, New Delhi. 466p.
3. Gaur, P.C., P.C. Misra and N.M. Nayar, 1984. Catalogues of Potato Germplasm Collection group Tuberosum, CPRI, Shimla, 38 p.
4. Gopal, J., R.K. Birhman and C.L. Khushu, 1992. Inventory of potato germplasm (group Tuberosum) collection, CPRI, Shimla. 47p.

The institute is presently in the process of publishing a similar catalogue on group Andigena. The entire data available is being computerised in readily retrievable form.

UTILISATION OF GERMPLASM

The available germplasm is being utilised in various breeding programmes at the CPRI. This has resulted in release of 29 improved varieties of potato. The parentage of these varieties show that in 9 varieties both the parents are of Indian origin (Table 5), 12 varieties have one parent of Indian origin and

Table 5. Cultivars developed using both parents from indigenous germplasm

S. No.	Cultivar	Year	Parentage
1.	Kufri Safed	1958	Phulwa (clonal selection)
2.	Kufri Red	1958	Darjeeling Red Round (clonal selection)
3.	Kufri Sindhuri	1967	Kufri Red × Kufri Kundan
4.	Kufri Neelamani	1968	Kufri Kundan × 134-D
5.	Kufri Chandramukhi	1968	Seedling 4485 × Kufri Kuber
6.	Kufri Badshah	1979	Kufri Jyoti × Kufri Alankar
7.	Kufri Megha	1988	SLB/K 31 × SLB/273
8.	Kufri Jawahar	1996	Kufri Neelamani × Kufri Jyoti
9.	Kufri Sutlej	1996	Kufri Bahar × Kufri Alankar

one of exotic origin (Table 6) and 8 varieties have both the parents of exotic origin (Table 7). The exotic cultivars that have figured more frequently as parents in the release of Indian varieties are Adina, Craigs Defiance, Ekishiraju, Katahdin and Up-to-Date, and parental lines obtained from late Dr. William Black of UK.

Table 6. Cultivars developed using one parent from indigenous germplasm and one from exotic germplasm

S. No.	Cultivar	Year	Parentage
1.	Kufri Kisan	1958	Up-to-Date *timex* Sd.16
2.	Kufri Jeevan	1968	M 109-3 × Seedling-698-D
3.	Kufri Khasigaro	1968	Taborky × Seedling-698-D
4.	Kufri Naveen	1968	3070d (4) × Seedling 392-D
5.	Kufri Alankar	1968	Kennebec × ON-2090
6.	Kufri Chamatkar	1968	Ekizhirazu × Phulwa
7.	Kufri Sheetman	1968	Craigs Defiance × Phulwa
8.	Kufri Deqa	1973	Craigs Defiance × Phulwa
9.	Kufri Bahar	1980	Kufri Red × Gineke
10.	Kufri Lalima	1982	Kufri Red × Ag-14 (Wis × 37)
11.	Kufri Swarna	1985	Kufri Jyoti × $(VTn)^2$ 62.33.3
12.	K. Ashoka	1996	EM/C 1021 × CP 1468

Table 7. Cultivars using both parents from exotic germplasm

S. No.	Cultivar	Year	Parentage
1.	Kufri Kuber	1958	(S. curtilobum × S. tuberosum) × S. andigenum
2.	Kufri Kumar	1958	Up-to-date × Katahdin
3.	Kufri Kundan	1958	Ekishirazu × Katahdin
4.	Kufri Neela	1963	Katahdin × Shamrock
5.	Kufri Jyoti	1968	3069 (4) × 1814a (1)
6.	Kufri Muthu	1971	3046(1) × M 109-3
7.	Kufri Lauvkar	1072	Serkov × Adina
8.	Kufri Shera	1983	Ultimus × Adina

In recent years, there has been a shift in the choice of parents in favour of Indian cultivars and parental lines. Whereas, the first batch of cultivars released during 1950-59 and mainly exotic varieties in their parentage, those released during 1960- 69 often involved one indigenous variety as one of the parents. At present, the choice of parents falls more often on newly bred

Indian cultivars and Indian *parental lines. Thus, the cultivars* **Kufri Badshah, Kufri Swarna, Kufri Jawahar** and **Kufri Sutlej,** have improved Indian cultivars in their parentage.

Wild species *S. verrucosum* and *S. microdontum* have been used as donors of durable resistance (horizontal) to late blight (Sharma *et al.*, 1982; Birhman *et al.*, 1991). Similarly, *S. chacoense* has been used to provide resistance to charcoal rot (Upadhyay *et al.*, 1977). Resistance to cyst nematodes in variety **Kufri Swarna** has been derived from *S. vernei.* In most of these programmes, dihaploids of ssp. *tuberosum* have been used as a bridge to transfer resistance to cultivated potato. Another programme worth mentioning is the development of parental lines possessing immunity of PVY and PVX at triples or quadriplex levels. Attempts are also being made to combine durable resistance to late blight with immunity to viruses.

FUTURE THURST

The CPRI is already recognised as the National repository for potato germplasm collection. The present collection is modest but is the best in South East Asia. This collection is proposed to be augmented to serve entire South Asian region. Efforts are being made to improve quarantine facilities to handle large import of germplasm. Infra-structural facilities are also being strengthened to maintain large collection in *in vitro.* Greater attention needs to be paid to *Solanum tuberosum* ssp. *andigena* which is adapted to short days and is thus more suitable for sub-tropical plains. Development of improved parental lines of *andigena* for various agronomic characters like tuber colour, tuber shape, eye depth, tuber size etc. is important if *andigena* is to be exploited extensively in the breeding programmes. Such lines also need to be evaluated for their general combining ability. In Indo-Gangetic plains which is the major potato growing region in India, potato is one of the crops in a multiple cropping system. This, and the economic considerations often require early planting of the crop when the ambient temperatures during germination and growth phase are high. Hopperburn and mites also pose serious problem to this crop. Need is, therefore, being felt to evaluate germplasm accessions for adaptability to these conditions. There is also need to extensively evaluate the germplasm for resistance to bacterial wilt and potato tuber moth which are major problems of the crop in mid hills and the plateau region. Characterisation of accessions for specific genes in terms of their allelic constitution is also required to be done. Work on DNA fingerprinting needs to be accelerated to have a catalogue for monitoring genetic integrity of germplasm collection from time to time, in the light of WTO and TRIPS.

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