CPRI Potato Gene Bank – Management and Utilization

There are many serious threats including human settlements and modern agriculture which are resulting in extinction of plant diversity. An urgent need is to conserve the available diversity in gene banks for the present and future generations. One such gene bank where diversity in potato is conserved is at the ICAR-Central Potato Research Institute (CPRI), Shimla. This diversity is being used for developing improved cultivars for different regions of the country.

Objectives of Gene Bank

i) To conserve available germplasm through vegetative propagation, as true seeds and *in vitro*.

ii) To characterize and evaluate the genetic resources for better management and utilization.

iii) To make all kinds of data available to farmers, students and researchers.

iv) To make existing diversity available to future generation.

v) To distribute propagating material for research, study and productions to farmers, students and researchers

POTATO GERMPLASM IN INDIA

In India, work on potato germplasm was initiated soon after the start of the organized research on potato in the 1930's. After the establishment of the Central Potato Research Institute (CPRI) in 1949, collection, conservation, evaluation and documentation of potato germplasm and its utilization, has been an ongoing activity of the CPRI. The first attempt to collect variability of potato was made in 1940's, and about 400 indigenous samples were collected. In this mass of variability, 16 varieties were identified as known exotic cultivars, while the rest were grouped into 16 distinct morphotypes whose original identity could not be established. These cultivars represented some of the earliest introductions or their clonal variants and were termed as *desi* varieties. During 1983-1992, several explorations were conducted. A total of 621 samples were collected with the help of state agriculture departments. These samples were studied for various morphological characters and grouped into 125 distinct morphotypes. These were mostly susceptible to various diseases and pests and stocks were highly degenerated. Thus this material was not enough to have a robust breeding programme.

Acquisition of exotic germplasm from different countries has therefore, been a continuing activity of the CPRI. The CPRI now has a collection of over 4,300 accessions belonging to cultivated species (*S. tuberosums* sp *Tuberosum* and ssp *andigena*) and as well as wild or semi-wild species (Table 1). These germplasm accessions have been imported from 30 countries based on our requirements of resistance or tolerance to various biotic and abiotic stresses. The major source of this collection has been the International Potato Center (CIP), Lima, Peru and the USA Potato Gene bank, Sturgeon Bay, Wisconsin. Before the establishment of the CIP, maximum import of potato germplasm was made from the Common wealth Potato Collection, Dundee, Scotland.

Table 1. Potato germplasm holding at CPRI, Shimla

Material	No. of accessions				No. of donor countries
	Tuber	*In vitro*	True seed	**Total**	
a) Tuberosum (Cultivars / parental lines)					
Indian					
Cultivars bred at CPRI	56	56		**56**	
Advanced hybrids	86	50	-	**96**	
Indigenous varieties	51	107	-	**107**	
Indigenous samples	97	42		**97**	
Exotic	1837	2550	-	**2625**	30
b) Andigena	758	77	-	**762**	5
c) Wild/ semi-cultivated sps.	123 (40 species)	58 (15 species)	340 (71 species)	**482 (125 species)**	5
Total germplasm				**4322**	

CONSERVATION

Conservation refers to the protection of genetic diversity of crop plants from genetic erosion. Potato genetic resources can be conserved sexually as true seeds or asexually as clones through field propagation as tubers or through tissue culture.

At CPRI, the available germplasm is being maintained by three methods, 1) *in vivo* clonal propagation, 2) *in vitro* clonal propagation, and 3) true seeds.

1. **Field gene bank or *In vivo* clonal propagation:**It is being done as duplicate sets in field at Kufri and Jalandhar. It is the simplest method of maintenance, where the genetic integrity of the varieties can be verified directly. Potatoes are conserved as tubers, where the risk of loosing material through biotic and abiotic factors like diseases, pest, unfavourable weather conditions, is very high. This method of conservation is widely applied for varieties which are needed frequently. All *tuberosum* and a part of *andigena* accessions are being maintained and multiplied by this method to facilitate their evaluation for adaptability to different agro-climatic regions as well as for resistance/tolerance to various biotic and abiotic stresses.

Figure 1 *In vivo* clonal propagation

2. **True seeds:**A part of the 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 sibmating. Sibmating is often resorted to in the case of diploid species most of which are self-incompatible. Preservation of germplasm as true seed is less laborious and inexpensive as true seeds have low moisture content and can be kept at low temperature for many years. In addition it is easier to maintain the material free of pathogen as only few viruses are known to be seed transmitted.

3. ***In vitro* conservation:**Till date about 1700 *tuberosum* and some wild accessions have been conserved in this form. For this minimal growth conditions are used in which nodal cuttings are micropropagated on MS medium containing 20g/l sugar and 40g/l sorbitol under a 16-h photoperiod at 6°C. Under these conditions potato plantlets can be preserved up to 24 months without sub-culturing. This medium when used under normal propagation temperature reduces the plantlets life to only 9-12 months. Advantages of in vitro storage are that preserved material is sterile, there is no risk of infection by insects or damage throughinauspicious weather conditions and less laborious than field

maintenance.Also cultures canbe kept pathogen-free once virus or other pathogens have been eliminated.Another advantage is that the varieties are available throughout the year. Disadvantages are that growth retardants may alter plan morphology and can induce DNA methylation (Harding, 1994) and somaclonal variation (Kumar, 1994).

Figure 2 Slow-growth in-vitro conserved potato germplasm

4. **Cryopreservation:**Facilities and protocols are also being developed for cryopreservation of the meristem tips or axillary buds. This is the best method to date for long term conservation of vegetatively propagated plants, meaning storage of biological material in

liquid nitrogen at -196^{0}C without losing viability. In cryopreservation, cell division, metabolic and biochemical processes are arrested and thus the plant material can be stored without deterioration or modification for a long period of time. Advantages of cryopreservation are that material can be stored for theoretically indefinite time with low cost and little space. Work input is needed mainly at the beginning when samples are prepared and cooled. Once in storage, only refilling of liquid nitrogen is needed. Other advantages are prevention of infections and genetic changes. Further, the degree of cleanliness is highest for cryopreserved explants than *in vitro* and field cultures. Cryopreservation is only useful for long term storage, because the material is normally not ready for immediate utilization and rewarming and growth of plant material takes some time. Work on potato cryopreservation dates back to the late 1970s. Initially, the methods used to cryopreserve potato shoot tips or meristems were based on slow-freezing approaches. Subsequently, different freezing methods have been developed using ultra-rapid cooling or other modified cooling approaches. However, comparable results were not obtained in early potato cryopreservation work because of differential responses observed between and within groups and/or species. In addition, many of these techniques involve regeneration of cryopreserved shoot tips through an intermediary callus phase.

Cryopreservation has been proved to be efficient method for long term preservation of the potato shoot tips. Several cryopreservation methods viz., vitrification, droplet vitrification, encapsulation-vitrification and encapsulation- dehydration have been employed for potato shoot tips. We have optimized the procedure for Droplet Vitrification in which expalnts were submitted to pre-culture in liquid medium containing various concentration of sorbitol and DMSO (1M sorbitol +0.1 M DMSO, 0.5 M sorbitol +0.01 M DMSO and 0.25 M sorbitol + 0.001 DMSO). The excised shoot tips were kept at 5^0 C in dark condition for two days and pretreated shoot tips were dehydrated with Loading Solution (LS) and PVS2 for different time intervals 0,10, 15, 20, 30, 40 50 minutes. Six different media were used for regeneration of cryo treated shoot tips with varying concentration of Pluronic F-68 (0.001% to 0.5%). The pretreatment with 0.5M sorbitol and 0.01M DMSO, LS treatment for 20 min, PVS2 for 15 minutes and regeneration media with 0.001% and 0.01% Pluronic F-68 gave 50-60% survival rate. But regeneration rate is 20-30% (Fig 1). The efforts are being made to improve regeneration rate to make cryopreservation technique more efficient and more economical to compliment *in vitro* conservation.

Fig 1. Stepwise regeneration of the potato shoot tips using improved Droplet Vitrification method

EVALUATION

Evaluation of the available germplasm is a continuous process at CPRI, Shimla and its regional station in different parts of the country. The germplasm accessions have been evaluated for economic characters like resistance to late blight (Barua*et al.*, 1976; Anon, 1991-92; Gopal and Singh, 1993; Gopal *et al.*, 2008, Kumar *et al.*, 2005), bacterial wilt (Shekhawat*et al.*, 1980; Chakrabarti*et al.*, 1992; Nagesh*et al.*, 1993), wart (Singh and Gopal, 1990; Singh and Gopal, 1994), nematodes (Nirula*et al.*, 1967, 1969; Anon, 1983), potato tuber moth (Anon, 1991-92; Chandla*et al.*, 2007), charcoal rot (Thirumalachar and Pushkarnath 1953, Pahariaet*. al.*, 1976; Somani, 2008), stem necrosis (Somani, 2009), hopper burn (Chaudhary *et al.*, 1983; Anon, 1995-96; Malik and Luthra, 2007) and viruses (Anon, 1991-92; Garg and Gopal, 1994; Garg *et al.*, 1999), besides maturity, tuber dormancy (Joseph and Gopal, 1994), storage quality (Kang and Gopal, 1993), tuber dry matter and protein content (Gaur and Gupta, 1981; Misra*et al.* 1991), etc. The accessions are also evaluated for adaptability under varying thermo-photoperiods. The results of evaluation have been compiled and presented in annual reports of the CPRI and the catalogues of potato germplasm collection have been published. (Gaur *etal.*, 1984; Gopal *et al.*, 1992; Birhman*et al.*, 1998; Kumar *et al.*, 2005; Kumar *et al.*, 2007). The electronic databases are also maintained and updated regularly so that breeders are able to use this information for selection of parental lines. A large number of accessions have been found suitable for use as parents in potato breeding programmes. Some of the most promising accessions for various characters are listed in Tables 2 .To identify good general combiners among the germplasm accessions found promising for various characters, combining ability studies have been conducted (Dayal*et al.*, 1985, Gaur *et al.*, 1983, 1985, 1993; Gopal, 1998a, 1998b, 1998c; Pandey and Gupta, 1997; Kaushik *et al.*, 2000; Kumar *et al.*, 2005,).

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 Bureau of Plant Genetic Resources (IBPGR) are used. The information on these characters for *tuberosum* (Kumar *et. al.*, 2005) and *andigena* (Kumar et. *al.*, 2007) accessions have been compiled.

Table: Some promising potato germplasm accessions for various characters

A	Resistance to late blight		Promising accessions
	I	**Foliage resistance**	**CP1350 (Monak), CP1361 (Albion), CP1382 (B 3401-15), CP1386 (Earlaine), CP1389 (B 3631-26), CP1395 (B 3627-18), CP1402 (Bea), CP1404 (Burmania), CP1422 (Patrones), CP1424 (Pionier), CP1425 (Prefect), CP1445 (Anita), CP1477 (Victor), CP1575 (B 5141-6), CP1613 (Erdkraft), CP1651 (Ulster Glade), CP1664 (Royal Kidney), CP1670 (Apis), CP1675 (Carpatin), CP1690 (Irish Cobbler), CP1696 (Sable), CP1715 (Perle Rose), CP1741 (Boone), CP1982 (Saphir), CP2011 (CIP 676082), CP2014 (CIP 720048), CP2018 (CIP 750847), CP2032 (G-5070), CP2067 (ASN 69-1), CP2068 (CFK-69-1), CP2076 [2070(4)], CP2098 (F-2), CP2110 (CFK.69.1), CP2113 (Mexiquense), CP2161 (Pentland Hawk), CP2173 (MS 82.60), CP2175 (LT-5), CP2178 (I-654), CP2179 (I-822), CP2182 (I-1035), CP2305 (PrimiciaInta), CP2333 (AL-624), CP2336 (Seseni), CP2370 (Muziranzara), CP2379 (CEW-69-1), CP2384 (AGG 69.1), CP2385 (AND-69-1), CP2407 (Montsama), CP2415 (MEX 750821), CP2416 (MEX 750826), CP3087 (Iiertha), CP3098 (27/15), CP3129 (G-6), CP3147 ((Muruta), CP3171 (Bzura), CP3190 (Kinigi), CP3191 (25/40), CP3198 (Ischcopuro), CP3208 (MF-1),CP3250 (CIP381379.15) ,CP3276 (CIP 384321.3), CP3290 (Hope Hely), CP3364 (TPS-7), CP3369 (LBR-2), CP3390 (Agria), CP3609 (Cruza 118), CP 3610 (AKK-69-1), CP3564 (Amarilis Inia), JEX/A nos. 198, 877, 1244, 1245, 1269, &1270**
	II	**Tuber Resistance**	**CP1385 (B 929-23), CP1396 (Chippewa), CP1436 (Ultimus), CP1420 (Meerster), CP1435 (Tedria), CP1444 (5050/23/1), CP1451 (Lori), CP1470 (Jiiueca), CP1606 (B 5052-7), CP1648 (Shoshoni), CP1665 (Arran Banner), CP1675 (Carpatin), CP1696 (Sable), CP1706 (Farfadette), CP1724 (OberarnbacherFruhe), CP1741 (Boone), (CP1924 (B 6705-12), CP1937 (BR 6614-1), CP1984 (61.303/34), CP2068 (CFK-69-1), CP2113 (Mexiquense), CP3100 (Nishiyutaka), CP3102 (Linlesh), CP3171 (Bzura), CP3250 (CIP381379.15), CP3252 (CIP 381382.34), CP3255 (CIP 381403.5), CP3384 (LBR-15), CP3597 (LBR-20)**

B.	**Resistance to virus**		
	I	**Resistance to PVX**	**CP1426 (Prof. Broekema), CP1439 (Craigs Royal), CP1474 (Duquesa), CP2366 (7XY.1), CP2371 (LT-8), 2372 (LT-9), 2390 (BL1.5), CP2391 (BL 1.10), CP2427 (Pirola), CP2428 (Granola), CP2936 (G-7), C3029 (Clavela), CP3247 (LB-III), CP3251 (LB-III), CP3257 (LB-III)**
	II	**Resistance to PVY**	**CP1447 (Cunchita), CP3209 (Clavela), CP3068 (Ica Nevada), CP3093 (MPI-106), CP3316 (YY.6), CP3317 (YY.3), CP3331 (YY.5), CP3332 (YY.12), CP3333 (YY.12), CP3335 (YY.4), CP3336 (YY.3)**
	III	**Resistance to PVX + PVY**	**CP1358 (Idaho), CP1441 [BD-2424a(1)], CP1457 (Fink), CP1496 [2812c(2)], CP1548 [2787e(22)], CP1567 (B 5000-18), CP1573 (B 5089-17), CP1578 (PI 222952), CP1595 (B 4808-8), CP1596 (B 4808-19), CP1597 (B 4830-19), CP1605 (B 5052-14), 1613 (Erdkraft), CP1664 (Royal Kidney), CP1670 (Apis), CP1683 (Cherokee), CP1718 (Solanum), CP1754 (Monona), CP1832 (Ica Cuantiva), CP1958 [2070(50)], CP1970 (Amaryl), CP1971 (Saturna), CP1990 [H-345VD(F)8749B], CP1996 (H-497VD72.54/4), CP2246 (U 593/7), CP2286 (Leven), CP2289 (MagayarRozsa), CP2303 (Baronesa), CP2362 (Timate), CP2366 (7 XY.1), CP3029 (Clavela), CP3068 (Ice Nevada), CP3093 (NPI-106), CP3247 (CIP 381396.16), CP3251 (CIP 381381.20), CP3254 (CIP 381403.1), CP3534 (SL 85-482), CP3617 (Pampeana-Inta)**
C	**Tolerance to heat**		**CP1402 (BEA), CP1588 (Cosima), CP1604 (205052-7), CP1748 (IrshCobler), CP1765 (Saranac), CP1907 (B6532-3), CP1960 (Plymouth), CP1765 (Saranac), CP2058 (CIP379386), CP2070 (DTO-33), CP2100 (DTO-28, CP2108 (LT-1), CP2109 (LT-2), CP2118 (Desiree), CP2150 (KufriLauvkar), CP2175 (LT-5), CP2176 (LT-7), CP2186 (Norcip), CP2371 (LT-8), CP2372 (LT-9), CP3868 (HT/92-621)**
D	**Resistance to Cyst Nematodes**		**CP1492 (VD-2-21), CP1495 [2805(2)], CP1663 (Pentland Ace), CP1664 (Royal Kidney), CP1729 (Ia 1106-5), CP1843 (Pontiac), CP2059 (CIP 379389), CP2077 [3681 AD(1)], CP2134 (PI- 1230502), CP2290 (G-1), CP2329 (KTT 60.21.19), CP2417 (MEX 750838), CP3128 (G-5), CP3129 (G-6), CP3181 (G-2), CP3206 (KufriNeela), CP3750 (GarhuashHuayro), JEX/A nos. 121, 131, 171, 216, 217, 225, 240, 252, 267, 281, 300, 310, 314, 322, 350, 422 & 708**
E	**Tolerance to hopper bunn**		**CP1523 (Roslin Riviera), CP1588 (Cosima), CP1611 (Deodara), CP1677 (Magura), CP1680 (Craigs Defiance), CP1685 (Fundy), CP1691 (Keswick), CP1722 (Falke),**

			CP1754 (Monona), CP1767 (Snow Flake), CP1818 (B 6039-1), CP1851 (Reliance), CP1867 (Hassia), CP1868 (Hilla), CP1907 (B 6532-3), CP1938 (K 83-13), CP1970 (Amaryl), CP1971 (Staurna), CP1985 (62.47/20), CP2001 (CIP 575012), CP2007 (CIP 676006), CP2021 (Blank)), CP2070 (DTO-33), CP2085 (Caxamarca), CP2089 (CIP 279099), CP2159 (Pentland Ivory), CP2161 (Pentland Hawk), CP2167 (MS 42.3), CP2173 (MS 82.60), CP2174 (BR 63.15), CP2184 (I-1062), CP2287 (Tasman), CP2298 (P-7), CP2374 (TM-1), CP2376 (Cruza-27) CP2420 (Mineira), CP3072 (Flor-Blanca), CP3152 (TM-3), CP3189 (Sissay), CP3210 (BW-9), CP3359 (MF-1)
F	**Keeping quality**		CP1457 (Fink), CP1460 (Schwalbe), CP1647 (Blanca), CP1649 (Arran Bann), CP1652 (Ulster Ran), CP1673 (Dr. Mclntosh), CP1710(Kerpondy), CP1746 (Delus), CP1779 (Format), CP1818 (B6039-1), CP1827 (Icapurpce), CP1933 (BR 6317-25), CP1964 (Alaska-114V.F.), CP1974 [(VTN)2.62.33.3], CP1982 (Saphir), CP2014 (CIP 720048), CP2040 (Stor Mont Dawn), CP2041 (Majestic), CP2042 (Red Skin), CP2044 (Maris Piper), CP3153 (TM-4), CP3156 (Monserrate), CP3160 (Janka), CP3162 (Sowa), CP3194 (BW-5), CP3195 (Andinita), CP3204 (MF-II), CP3275 (CIP 38439.1), CP3355 (88108),CP3372 (LBR-5), CP3387 (FL-1533)
G	**Chipping quality**		CP658 (Unknown), CP1187 (Unknown), CP1197 (Unknown), CP1231 (Unknown), CP1344 (Kotnov), CP1363 [AG-16(X143)], CP1390 (B3620-1), CP1410 (Gineka), CP1413 (Ijesselster) CP1780 (Tombola), CP1798 (316.1), CP1806 (Tunika), CP1880 (RoslinEbur), CP1940 (K-85-6), CP1945 (K194-3), CP2330 (Atlantic)
H	**Adaptability**		
	I	**Hills**	CP1351 (Walanga),CP1364 (AG 29), CP1366 (B 721-35), CP1379 (96-56), CP1221 (Pandora), CP1429 (Regina), CP1435 (Tedria), CP1449 (Capella),CP1486 (B 3692-4), CP1490 (Dorita), CP1519 (Red Craigs Royal), CP1523 (Roslin Riviera), CP1578 (PI 222952), CP1613 (Erdkraft), CP1690 (Irish Cobbler), CP1691 (Keswick), CP1917 (B 6581-4), CP1922 (B 6603-12), CP1982 (Saphir), CP2004 (CIP 575022), CP2008 (CIP 676013), CP2015 (Tollocan), CP2038 (Arran Victory), CP2053 (CIP 379376),CP2063 (B 71-240.2), CP2070 (DTO-33), CP2110 (CFK.69.1), CP2159 (Pentland Ivory), CP2253 (U 596/11), CP2333 (AL 624), CP2370 (Muziranzara), CP2378 (POOS.16), CP2380 (CFQ-69-1) , CP2415 (MEX 750821), CP3098 (27/15), CP3127 (CIP

			378711.2), CP3157 (Dalia), CP3171 (Bzura), CP3250 (CIP 384321.9), CP3290 (Hope Hely), CP 3364 (TPS-7), CP3393(Anosta)
	II	Plains	CP1351 (Walanga), CP1353 (Croissement), CP1367 (B 922-6) , CP1403 (Bevelander), CP1414 (Irene), CP1458 (Meise), CP1462 (Spatz), CP1515 (3392-1), CP1523 (Roslin Riviera), CP1547 (Pentland Envoy), CP1564 (B 4829-7), CP1588 (Cosima), CP1596 (B 4808-19), CP1644 (MP 150.247/2), CP1659 (Eclipse), CP1671 (Cobra), CP1695 (Red Pontiac), CP1697 (Sebago), CP1711 (Madoz), CP1736 (PI 161695-1), CP1787 (Mira), CP1812 (Hyb.No. 20078), CP 1817 (B 6038-1), CP1835 (F 5208), CP1860 (62.55/11), CP1905 (B 6518-8), CP1912 (B 6562-14), CP 1927(B 6739-2), CP1932 (BR 6293-12), CP2058 (CIP 379386), CP2123 (Sequoia), CP2183 (I-1039), CP2297 (P-6), CP2298 (P-7), CP2369 (V3), CP2384 (AGG 69.1), CP2392 (BL 2.9), CP2411(ARX 69.1), CP2413 (Piratini), CP2422 (Ballenera), CP3088 (Obelix), CP3165 (Tarpan), CP3172 (Frezja), CP3185 (BW-1), CP3195 (Andinita), CP3275 (CIP 384390.1), CP3276 (CIP 384321.3), CP3281 (CIP 381403.22), CP 3290 (Hope Hely), CP 3356 (CIP 387466.6), CP 3357 (Jopung), CP 3359 (MF-1), CP 3372 (LBR-5), JEX/A nos. 187, 194, 283, 444, 456, 461, 552, 592, 715, 736, 804, 805, 901, 947, 1036, 1037, 1083 & 1098
I	Good combiners		
	I	Tuber yield and components	CP1673 (Dr. Mclntosh), CP2000 (I-1062), CP2110 (CFK69-1), CP2333 (AL-624), CP2334 (AL-575), CP2346 (F-6), CP2370 (Muziranzara), CP2378 (Toss-16), CP1377 (Katahdin), CP3402 (KufriPukhraj), CP2144 (KufriJyoti), CP2138 (KufriBadshah), CP2139 (KufriBahar), EX/A680-16, EX/B6-87, JX-115, MS/82-797, MS/90-518, MS/91-1325, CP3874 (QB/A9-120), JEX/A-15, JEX/A-30, JEX/A-805
	II	Tuber Dry Matter	CP2346 (F-6), CP2370 (Muziranzara), CP2378 (POOS.16), CP2416 (MEX750826), CP2417 (MEX750838), EB/C-899, JY-712
	III	Late Blight	Among males, CP2110 (CFK-69-1), CP2132 (Tollocan), CP2346 (F-6), CP2351 (Tobique), CP2407 (Montsama) and among females CP1441 [BD-2424a(1)], CP1673 (Dr. Mclntosh), CP1998 (Michoacan), CP2030 (G 6246), CP2298 (P-7), CP2376 (Cruza-27), CP2378 (POOS.16)CP2380 (CFQ-69-1), CP2384 (AGG-69-1), CP2411 (ARX 69.1), CP3072 (Flor-Blanca) , CP3333 (AL-624), CP3874 (QB/A9-120)
	IV	Early Blight	EX/A680-16

Table: Some Promising Potato Accessions Having Multiple- Resistance

CP Numbers	Variety	Characters
CP1363	AG-16(X143) (USA)	**Early maturity, resistance to late blight (tuber), good keeper, medium dry matter, good chipping quality, resistance to common scab.**
CP1402	Bea (Netherlands)	**Early maturity, adapted to plains, moderately resistant to late blight (foliage to tuber), immune to wart, resistance to PVX, resistance to stem necrosis, resistance to PVA, tolerance to heat.**
CP1410	Gineke (Netherlands)	**Immune to wart, highly resistance to stem necrosis, good chipping quality, medium dry matter, resistance to common scab, resistance to PVA, tolerance to drought.**
CP1447	Conchita (United Kingdom)	**Highly resistant to late blight, resistance to PVX & PVY, resistance to *G. pallida.***
CP1461	Sieglinde (Germany)	**Moderately resistant to PVX & PVY, resistance to *G. pallida.* Moderately resistant to late blight, highly resistant to stem necrosis, good keeper.**
CP1474	Duquesa (Spain)	**Medium maturity, resistance to late blight (foliage& tuber), resistance to PVX & PVY, immune to wart, good keeper.**
CP1588	Cosima (Germany)	**Adapted to normal & early planting to plains, resistance to late blight (foliage), moderately resistant to hopper burn & mites, good keeper.**
CP1604	B5052-7 (USA)	**Adapted to plains, resistance to late blight (foliage & tuber), immune to wart, moderately resistant to charcoal rot, resistance to PVX & PVY, resistance to ring rot, moderately resistant to common scab, resistance to stem necrosis.**
CP1664	Royal Kidney (United Kingdom)	**Adapted to plains, resistance to late blight (foliage & tuber), immune to wart, resistance to PVX & PVY, resistance to both spp of cyst nematodes**
CP1673	Dr. Mclntosh (Irelands)	**Early maturity, adapted to hills and plains, resistance to late blight (foliage & tuber), moderately resistant to stem necrosis, immune to PVA, good keeper.**
CP1690	Irish Cobbler (Canada)	**Adapted to hills & plains, resistance to late blight (foliage & tubers), moderately resistant to stem necrosis, good keeper.**

CP1729	La 1106-5 (USA)	**Adapted to plains, resistance to late blight (foliage & tuber), resistance to cyst nematodes (both Spp.), good keeper.**
CP1798	316.1 (USA)	**Resistance to late blight (foliage to tuber), immune to wart, resistance to PVX, good chipping quality, medium dry matter.**
CP1818	B 6039-1 (USA)	**Immune to wart, tolerance to bacterial wilt, resistance to hopper burn, high dry matter, good keeper.**
CP1927	B 6739-2 (USA)	**Medium maturity, adapted to plains, resistance to late blight (foliage & tuber), resistance to stem necrosis, moderately resistant to hopper burn.**
CP1971	Saturna (Netherlands)	**Adapted to hills, immune to wart, resistance to scab, resistance to stem necrosis, resistance to hopper burn & mites, resistance to PVX & PVY, immune to PVA, resistance to common scab, high dry matter.**
CP2011	CIP 676082 (Peru)	**Adapted to hills & plains, resistance to late blight (foliage & tubers), moderately resistance to stem necrosis.**
CP2018	CIP 750847 (Peru)	**Adapted to hills & plains, resistance to late blight (foliage & tubers), immune to wart, resistance to hopper burn.**
CP2058	CIP 379386 (Peru)	**Adapted to hills & plains, tolerance to heat, highly resistant to late blight (foliage), immune to wart, moderately resistant to charcoal rot, resistance to hopper burn.**
CP2118	Desiree (Netherlands)	**Medium maturity, adapted to plains, resistance to PVX, tolerance to heat & drought, immune to wart, resistance to powdery scab.**
CP2173	MS 82.80	**Adapted to hills & plains, resistance to late blight (foliage & tubers), moderately resistant to termite, resistance to hopper burn.**
CP2175	LT-5 (Peru)	**Early maturity, adapted to hills & plains, resistance to late blight (foliage), immune to wart, resistance to stem necrosis, resistance to hopper burn, tolerance to heat.**
CP2369	V-3 (Peru)	**Medium maturity, adapted to plains, resistance to late blight (tuber), resistance to PVX, PVY & PLRV, moderately resistance to hopper burn & mites.**
CP2371	LT-8 (Peru)	**Early maturity, adapted to hills & plains, moderately resistant to late blight (tuber), immune to wart,**

		resistance to PVX, high dry matter, tolerance to heat.
CP2384	AGG 69.1 (Peru)	**Medium maturity, adapted to hills and plains, resistance to late blight (foliage), resistance to cyst nematodes (both spp.), moderately resistant to PVA.**
CP2385	AND 69.1 (Peru)	**Medium maturity, adapted to hills & plains, resistance to late blight (foliage & tuber), resistance to PVY, high drymatter.**
CP3088	Oblix (Netherlands)	**Adapted to hills & plains, tolerance drought, resistance to PLRV, immune to wart, resistance to common scab, resistance to *G. rostochinesis.***
CP3091	Nicola (Netherlands)	**Adapted to hills, resistance to late blight (tuber), immune to wart, tolerance to bacterial wilt, resistance to PVX & PVY, resistance to both spp of cyst nematodes, moderatelry resistance to common scab & drought.**
CP3098	27/15 (Peru)	**Early maturity, adapted to hills & plains, resistance to late blight (foliage & tuber), immune to wart.**
CP3171	Bzura (Poland)	**Early maturity, adapted to hills & plains, resistance to late blight (foliage & tuber), immune to wart, resistance to PLRV.**
CP3187	BW-8 (Peru)	**Adapted to hills & plains, resistance to late blight (tuber), resistance to PVX & PVY, resistance to cyst nematodes (both spp.)**
CP3191	24/40 (Peru)	**Early maturity, adapted to hills & plains, resistance to late blight (foliage & tuber).**
CP3247	LB-2 (Peru)	**Adapted to hills, resistance to late blight (foliage & tuber), resistance to PVX & PVY, resistance to cyst nematodes (*G. pallida*)**
CP3251	LB-3 (Peru)	**Adapted to hills, resistance to late blight (foliage & tuber), resistance to PVX & PVY.**
CP3290	Hope Helly	**Adapted to hills & plains, resistance to late blight (foliage & tuber).**

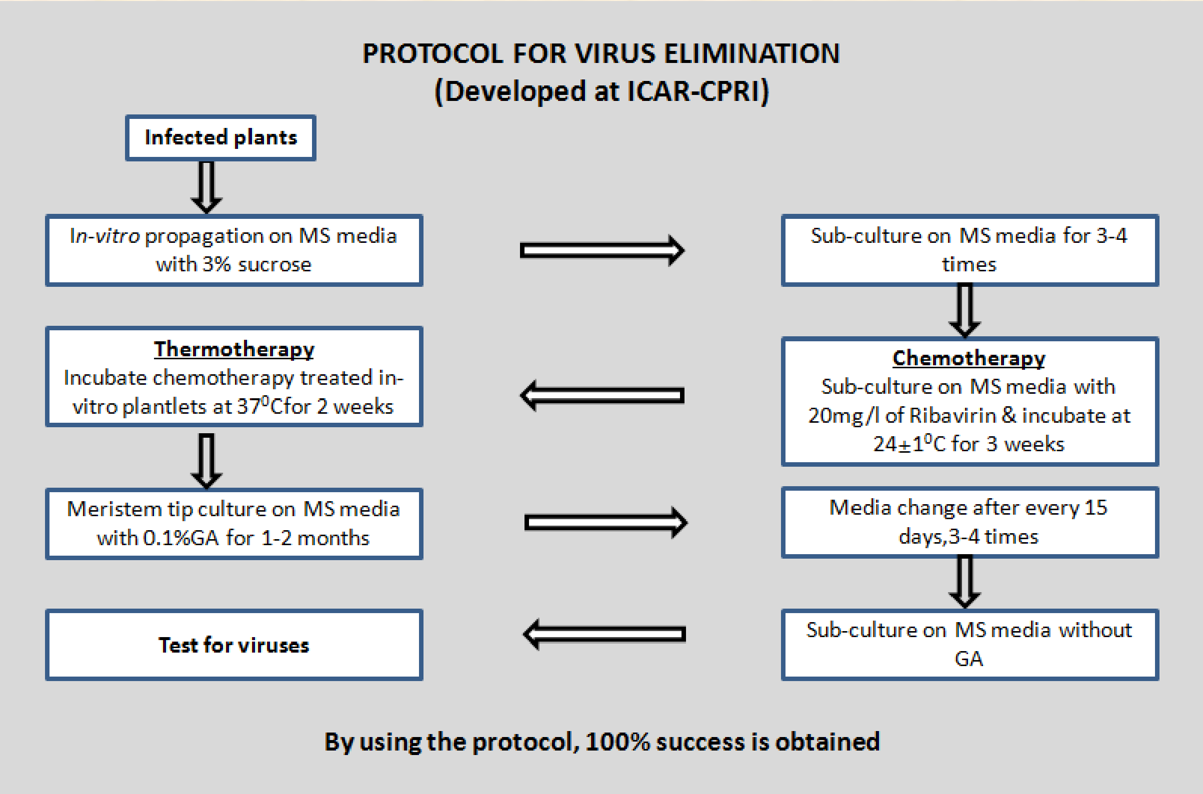
DOCUMENTATION

Documentation is an integral part of germplasm conservation for its effective utilization. Since 1951, the information on potato germplasm has been published on regular basis. The information on passport data, morphological characteristics and reaction to various biotic and abiotic stresses of *tuberosum* germplasm has been published in the form of germplasm catalogues. Besides the documentation of the *Tuberosum* collections, an inventory has also been prepared for the *andigena* collections as available in the country. The entire data available has been computerised in readily retrievable form. Seven catalogues listed below have been published.

1. Pal, B.P. and Pushkarnath. 1951. Indian Potato Varieties. Indian Council of Agricultural Research, New Delhi. Misc. Bull. 62, 63 p.
2. Pushkarnath, 1964. Potato in India- Varieties. Indian Council of Agricultural Research, New Delhi. 466 p.
3. Gaur, P. C., P. C. Misra and N. M. Nayar. 1984. Catalogues of Potato Germplasm Collection Group Tuberosum. Central Potato Research Institute, Shimla. 38 p.
4. Gopal, J., R. K. Birhman and C. L. Khushu. 1992. Inventory of Potato Germplasm (Group Tuberosum) Collection. Central Potato Research Institute, Shimla. 47p.
5. Birhman, R. K., J. Gopal, S. K. Kaushik, G. S. Kang, Raj Kumar, T. A. Joseph and S. K. Luthra. 1998. Inventory of Potato Germplasm (Group Andigena) Collection. Central Potato Research Institute, Shimla 51 p.
6. Kumar, V., J. Gopal, Raj Kumar, S.K. Luthra, S.K. Kaushik and S.K. Pandey. 2005. Inventory of cultivated potato germplasm. CPRI Shimla Tech Bull 70, CPRI, Shimla, 162p.
7. Kumar, R., V. Kumar, J. Gopal, S.K. Luthra and SK. Pandey. 2007. Inventory of potato germplasm (Group Andigena) collection. Tech. Bull. N.. 86, CPRI, Shimla 100 p.

ELIMINATION OF VIRUSES USING MERISTEM TIP CULTURE

Meristem tip culture has become a powerful and successful tool for virus elimination from infected plants and has been successfully applied in potato. A protocol has been standardised for the elimination of viruses. A total of 158 genotypes including many commercial varieties have been freed from all viruses during last ten years.



POST ENTRY QUARANTINE TESTING

During last eight years, a total of 322 cultures were imported from 13 countries. All these cultures were micro propagated and sent to Division of Plant Protection for quarantine testing. After quarantine clearance,308 cultures have been added to germplasm repository of CPRI, Shimla.

SUPPLY OF GERMPLASM MATERIAL

Supply of germplasm material to researcher as per their indent and other end user is a regular activity of various units of CPRI Gene Bank.Every year nearly 900 Accessions are being supplied to various testing sites for evaluation to various biotic and abiotic stresses for identification of potential trait specific accessions. During last 10 years 500 *in vitro* plantlet tubes of 222 accessions were supplied to agencies attracting revenue of Rs. 25.00 Lacs. Details of *in vitro* material supplied during last 10 years is given below.

Year	No. of cultures supplied	No. of *invitro* tubes supplied	Name of Organisation
2008-2009	5	10	Directorate of Horticulture and Soil Science, Govt. of Tripura
	1	100	Pepsico India Holding Pvt Ltd. Hoshiarpur.
2010-2011	7	14	Directorate of Horticulture and Soil Science, Govt. of Tripura
	8	16	TechnicoAgri Sciences. Chandigarh
	5	10	McCain Foods India Pvt. Ltd., New Delhi
	1	6	Pepsico India Holding Pvt Ltd. Hoshiarpur.
2011-2012	10	10	TechnicoAgri Sciences. Chandigarh
	20	20	Mahindra & Mahindra, Mohali, Punjab
2012-2013	20	40	TechnicoAgri Sciences. Chandigarh
2013-2014	9	18	TechnicoAgri Sciences. Chandigarh
2014-2015	12	24	TechnicoAgri Sciences. Chandigarh
	11	24	Pepsico India Holding Pvt Ltd. Hoshiarpur
	8	16	Mahindra & Mahindra, Mohali, Punjab
	4	8	McCain Foods India Pvt. Ltd.
	2	4	Sidhivinayak, Pune
2015-2016	32	64	TechnicoAgri Sciences. Chandigarh
	5	10	Merino Industries , Hapur
	4	8	SidhivinayakAgri Processing Pvt. Ltd., Pune
	2	4	McCain Foods India Pvt. Ltd., New Delhi
2016-2017	19	19	Mahindra & Mahindra, Mohali, Punjab
	7	11	SidhivinayakAgri Processing Pvt. Ltd., Pune
	4	8	TechnicoAgri Sciences. Chandigarh
	2	4	Mc Cains Foods India Pvt. Ltd., New Delhi
2017-2018	22	50	Pepsico India Holding Pvt Ltd. Hoshiarpur
	2	2	SidhivinayakAgri Processing Pvt. Ltd., Pune
Total	**222**	**500**	

ROLE IN VARIETAL DEVELOPMENT

In the early stages of potato research in India, evaluation of a large number of European varieties was undertaken to identify cultivars adapted to Indian conditions. These efforts were, however, largely unsuccessful because the exotic cultivars being adapted to temperate long-day growing conditions in the west were unsuitable under the sub-tropical short day conditions prevailing in nearly ninety per cent of the potato growing area in India. Requirements of short duration varieties that could be stored at high temperatures prevailing after the harvest of crop in plains further necessitated the initiation of indigenous potato breeding programmes. Attention was, therefore, focused to identify suitable parental lines for Indian potato breeding programmes. The available germplasm is being utilised in

Table 3. Cultivars developed using both parents from indigenous germplasm

Sr. No.	Cultivar	Year	Parentage
1.	KufriSindhuri	1967	Kufri Red x KufriKundan
2.	KufriNeelamani	1968	KufriKundan x 134-D
3.	KufriChandramukhi	1968	Seedling 4485 x KufriKuber
4.	KufriBadshah	1979	Kufri Jyoti x Kufri Alankar
5.	KufriMegha	1989	SLB/K 37 x SLB/Z-73
6.	KufriJawahar	1996	KufriNeelamani x KufriJyoti
7.	Kufri Sutlej	1996	KufriBahar x KufriAlankar
8.	KufriGiriraj	1998	SLB/J 132 x EX/A 680-16
9.	KufriAnand	1999	Kufri Ashoka x PH/F 1430
10.	KufriArun	2005	Kufri Lalima x MS/82-797
11.	KufriShailja	2005	KufriJyoti x EX/A 680-16
12.	Kufri Chipsona-3	2006	MP/91-86 x Kufri Chipsona-2
13.	KufriHimsona	2008	MP/92-35 x Kufri Chipsona-2
14.	KufriSadabahar	2008	MS/81-145 x PH/F 1545
15.	KufriKhyati	2008	MS/82-639 x KufriPukhraj
16.	KufriFrysona	2009	MP/92-30 x MP/90 – 94
17.	KufriNeelima	2010	E/79-15 x E/79-42
18.	Kufri Gaurav	2012	JE 812 x K. Jyoti
19.	KufriGarima	2012	PH/F-1045 x MS/82-638
20.	KufriSukhyati	2016	MS/82-639 x KufriPukhraj
21.	Kufri Ganga	2017	MS/82-638 x Kufri Gaurav
22.	TPS Population (92-PT-27)	2007	83-P-47 x TPS/D-150

various breeding programmes at CPRI. This has resulted in release of 59 improved varieties of potato. Kufri Safed and Kufri Red represent clonal selections from indigenous cultivars Phulwa and Darjeeling Red Round, respectively and the other 57 varieties are hybrids. Pedigree of these varieties show that in 22 varieties, both of the two immediate parents were of Indian origin (Table 3), 26 varieties have one parent of Indian origin and one of exotic origin (Table 4) and 9 varieties have both parents of exotic origin (Table 5).

Table 4. Cultivars developed using one parent from indigenous germplasm and one from exotic germplasm

Sr. No.	Cultivar	Year	Parentage
1.	Kufri Kumar	1958	Lumbri x Katahdin
2.	KufriJeevan	1968	M 109-3 x Seedling 698-D
3.	KufriKhasigaro	1968	Taborky x Seedling 698-D
4.	Kufri Naveen	1968	3070d (4) x Seedling 692-D
5.	KufriAlankar	1968	Kennebec x ON 2090
6.	KufriChamatkar	1968	Ekishirazu x Phulwa
7.	KufriSheetman	1968	Craig's Defiance x Phulwa
8.	Kufri Dewa	1973	Craig's Defiance x Phulwa
9.	KufriBahar	1980	Kufri Red x Gineke
10.	KufriLalima	1982	Kufri Red x AG 14 (Wis. x 37)
11.	Kufri Swarna	1985	Kufri Jyoti x $(VTn)^2$ 62.33.3
12.	K. Ashoka	1996	EM/C 1021x Allerfrüheste Gelbe
13.	Kufri Pukhraj	1998	Craig's Defiance x JEX/B 687
14.	KufriChipsona -1	1998	MEX.750826 x MS/78-79
15.	KufriChipsona - 2	1998	F-6 x QB/B 92-4
16.	KufriKanchan	1999	SLB/Z 405 (a) x Pimpernel
17.	Kufri Puskar	2005	QB/A 9-120 x Spatz
18.	Kufri Surya	2006	KufriLauvkar x LT-1
19.	KufriHimalini	2006	I-1062 x Tollocan
20.	KufriGirdhari	2008	Kufri Megha x Bulk Pollen (10 genotypes)
21.	KufriChipsona – 4	2010	Atlantic x MP/92-35
22.	KufriLalit	2014	85-P-670 x CP 3192
23.	Kufri Mohan	2015	MS/92-1090 x CP 1704
24.	KufriKesar	2016	CP 2376 x JP 100
25.	KufriNeelkhanth	2017	MS/90-1095 x CP 3290
26.	KufriSahyadri	2018	D/79-56 x CP 1974

In total, 91 parents were involved in the development of 59 potato varieties. The exotic cultivars that have figured more frequently as parents in the release of Indian varieties are Craig's Defiance, Kathadin, Adina, Ekishiraju and parental lines obtained from late Dr. William Black of UK. Among Indian varieties/cultures, old indigenous cultivar Phulwa was used repeatedly resulting in the development of 4 varieties whereas KufriJyoti was present in the parentage of five varieties. Cultivar Kufri Red was the parent of three varieties. Parents resulting in the release of 2 varieties each were KufriKundan, Kufri Chipsona-2, MP/92-35 and EX/A 680-16. As many as 39 varieties have either both or one parent from Indian origin reflecting the predominance of parental lines of Indian origin in breeding programmes in India.

Table 5. Cultivars developed using both parents from exotic germplasm

Sr. No.	Cultivar	Year	Parentage
1.	KufriKisan	1958	Up-to-date x Sd.16
2.	KufriKuber	1958	(*S. curtilobum x S. tuberosum) x S. andigenum*
3.	KufriKundan	1958	Ekishirazu x Katahdin
4.	KufriNeela	1963	Katahdin x Shamrock
5.	KufriJyoti	1968	[3069d (4) x 2814a (1)]
6.	KufriMuthu	1971	3046(1) x M 109-3
7.	KufriLauvkar	1972	Serkov x Adina
8.	Kufri Sherpa	1983	Ultimus x Adina
9.	Kufri Lima	2018	CIP 391180.6 x CIP 392820.1

Among the 38 unreleased indigenous selections used a parents, 28 (viz. EM/C 1021, MS 78-79, ON 2090, PH/F 1430, QB/B 92-4, SLB/J-132, SLB/K-37, SLB/K-73, SLB/Z 405a, EX/A 680-16, MS/82-797, MP/91-86, MP/92-35, MS/81-145, PHF/1045, PH/F 1545, MS/82-638, MS/82-639, MS/90-1095, MS/92-1090, MP/90-94, MP/92-30, JE 812, 83-P-47, TPS/D-150, QB/A 9-120, D/79-56, 85-P-670) were advanced improved hybrids. Some of these had reached to the stage of multi-locational trials but could not be released as varieties.

The use of Indian potato varieties and advanced hybrids developed during the recent past as parents of other Indian varieties released during the same period indicates that the genetic base of the various Indian varieties is quite narrow. Main reason for the poor use of germplasm in potato breeding programmes apparently reflects the intention of the potato breeders to confine to parents known to result in families with acceptable tuber and yield characters.

The utilization of wild and semi-cultivated tuber bearing *Solanum* species in Indian potato breeding programmes has been poor. Only four species from the collection available at CPRI have been used for developing parental lines. Wild species *S. verrucosum* and *S. microdontum* with durable resistance (horizontal) to late blight have been used for transferring this resistance to *tuberosum* background (Sharma *et al.*, 1982; Birhman*et al.*, 1991). Resistance to charcoal rot from *S. chacoense* has been transferred to *tuberosum* background (Upadhya*et al.*, 1977). Resistance to cyst nematodes in variety KufriSwarna has been derived from *S. vernei*. In most of these programmes, dihaploids of ssp. *tuberosum* have been utilized because the species involved are diploids (2n =24). Attempts are being made to combine durable resistance to late blight with immunity to viruses.

Though vast amount of genetic variability exists in potato, very little has been actually used in the improvement of cultivated potato. This is true for India as well as other countries. In the "Index of European Potato Varieties (1985)", one can find that only 10 primitive cultivars or species had been used in the pedigrees of 62 per cent of the 627 cultivars listed there. Remaining varieties involved only ssp. *tuberosum.* Ross (1986) has estimated that only 13 species have been used so far in the variety improvement programmes of the world. Clark (1925) reported that the parentage of as many as 171 American varieties could be traced to a single variety Rough Purple Chili introduced from Chiloe region of southern Chile. Though tetraploid and diploid crosses are not very difficult to make, in one direction at least, the viability of the species hybrids is not very high (Hawkes and Hjerting, 1969). Undesirable tuber traits of the wild species and cross ability problem of certain species also act as deterrents for their use by the breeders. Pre-breeding of the wild species at diploid level for combining disease resistance to various diseases and pests with agronomic characters thus need to be paid special attention.