Genetic Diversity of Pear (*Pyrus* spp.) in Uttarakhand Himalayas

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Survey of two pear growing districts of Uttarakhand (Champawat and Pithoragarh) was conducted during the fruiting season (July-August) of two consecutive years (2010 – 2011). A total of 38 accessions with distinct traits of horticultural importance were identified. Scion wood of the identified accessions was collected during following winter dormant period (January-February) and grafted on suitable rootstock for conservation in the field genebank. Prior to collection of scion wood of a plant, passport data and data pertaining to flowering and fruiting characters were recorded. Fruit length ranged from 3.6 – 8.2 cm, fruit width 2.6 – 6.7 cm, fruit weight 65 – 290 g, TSS 8.5 – 14.5 ^{0}Brix, vitamin 'C' 2.3 – 6.3 mg.100 ml^{-1}, organoleptic value 4 – 9 on 10 point scale and post harvest life of fruits ranged from 5 – 13 days. The accessions collected from different sites were found to have fairly rich diversity in parameters under study.

Key Words: *Pyrus* spp., Total soluble solids, Flowering, Fruit size, Genetic diversity

Introduction

The genus *Pyrus* has originated in Central Asia, the mountainous regions of western and southern China, from Asia Minor to India and further diversified and moved both in eastern and western directions from primary centre of origin (Watkins, 1976). The genus *Pyrus* is classified into more than 20 primary diploid species distributed over Europe and Asia (Zohary and Hopf, 1988) and six naturally occurring inter-specific hybrids (Bell *et al.*, 1996). On the basis of origin and commercial fruit production pear is classified into three main groups, viz., European pear (*Pyrus communis* L.), Japanese pear (*P. pyrifolia* Burm.) and Chinese pear (*P. bretschneideri* Rehd. and *P. ussuriensis* Maxim). Furthermore, the genus is also divided into two native groups, i.e. occidental and oriental pears. The occidental pears include over 20 species mostly found in Europe, Northern Africa, Asia Minor, Iran and Central Asia. The oriental pears include 12 to 15 species distributed from the Tian-Shan and Hindu Kush mountains eastward to Japan. Speciation has occurred mainly in eastern and central Asia in the Himalayas, Caucasus, Asia Minor and Eastern Europe. There are three centres diversity for cultivated pears *i.e.* Chinese centre, Central Asiatic centre and Near Eastern centre (Vavilov, 1951). Zeven and Zhukovsky (1975) have proposed the fourth centre of diversity as European Siberian centre.

Pyrus spp. grows in a wide range of climatic conditions and can tolerate temperature as low as -26°C in dormant stage and as high as 45°C in growing period. A large number of pear varieties require about 800 to 1200 h below 7°C during winter to complete their chilling requirements to flower and fruit satisfactorily. About 72% of all commercially cultivated species of genus *Pyrus* are native to Asia. People's Republic of China, United States, Italy, Argentina, Spain, India, Turkey, South Africa, South Korea and Belgium are top ten pear producing countries in the world with India producing 3,82,000 tonnes (FAO, 2010). Himalayan region in Asia is known for its biological richness and has always been a botanist's paradise. Its diversified landforms, relief and environmental conditions support a wide range of vegetations. Rich diversity of flora in general and temperate fruits in particular is available in Uttarakhand Himalayas which need to be collected and characterized for further utilization. Genetic diversity is the key component of any agricultural production system. The value of genetic diversity, in its various forms has been extensively discussed (Smale, 2006; Rausser and Small, 2011). Moreover, plant breeders require genetic variation (genotypes) for crop/ plant improvement. In spite of suitable climatic conditions for production of temperate fruits in general and pear in particular, production of pear in Uttarakhand is not keeping pace with the current

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demand. Pear is widely distributed in Champawat and Pithoragarh district of Uttarakhand. Pear germplasm have rich source of genetic variability as accumulated through hybridization, mutation and naturally seed based propagation. *Pyrus* species particularly wild populations are threatened worldwide with about more than 85% pear varieties lost in the 19th century, continuing even today (Sindelar, 2002). Furthermore, due to various insect-pests and pathogens, valuable and highly resistant to various abiotic stresses pear germplasm has been lost (Fowler and Mooney, 1990). Proper attention for exploration, collection, conservation and characterization of genetic resources of pear is an urgent need. Volk *et al.* (2006) reported that a high diversity exists in *P. communis* at the molecular level but that has not been exploited properly. Keeping this in view, the present investigation was undertaken to collect and evaluate the available genetic diversity of pear in two pear growing districts of Uttarakhand i.e., Champawat and Pithoragarh.

Materials and Methods

Four exploration tours (two survey and identification tours during the fruiting season in July-August and two scion wood collection tours during winter dormant stage in January – February were conducted during 2010 – 2012 in pear growing areas of district Champawat and Pithoragarh (Uttarakhand) (Fig. 1) to collect available genetic diversity of *Pyrus* spp. Champawat district is situated between 29°5' - 29°30' N latitude and 79°59' - 80°3' E longitude. Pithoragarh district lies between 29°4' - 30°3' N latitude and 80^0 - 81°E longitude. Formal and informal conversation with local farmers was adopted as a strategy to collect the information about the pear germplasm available in the area. In each village three four farmers were consulted before identification of a genotype for collection. Accessions were selected randomly at fruit maturity stage from 38 sites of these districts and earmarked with durable label (aluminium sheet) during survey. The available diversity of primitive cultivars frequently found in the cultivated habitats of the area was collected from population through selective sampling technique along with passport information. Only disease-free plants bearing fruits with unique traits of horticultural importance were identified for collection. Precocity of flowering, fruit shape, fruit colour, ripening time, fruit size, fruit weight, total soluble solids (TSS) (by refractometer) in the fruit pulp were the main parameters for identifying a genotype for collection. Fruits of identified accessions were collected and vitamin C content was estimated in the laboratory following the method of Davies and Masten (1991). Observations were recorded for growth habit of plants (upright, pyramidal

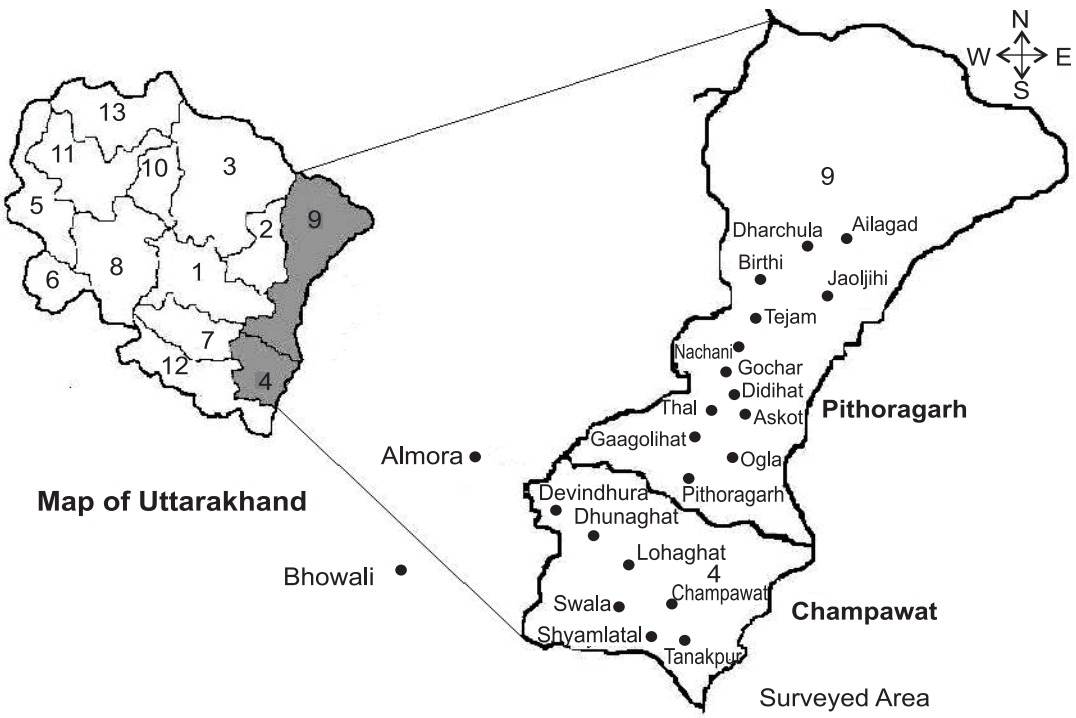

Fig. 1. Sites of *Pyrus* species germplasm collection in Uttarakhand Himalayas

and broad spreading tree) and time of ripening (early to medium, medium and medium to late) in *in situ*. Post-harvest life of ready to eat fruits was calculated by storing them at ambient room temperature. The quantitative data collected were subjected to statistical analysis following two ways analysis of variance considering year and accession as two independent variables. The difference between the two groups was assessed by computation of least significant difference taking 't' values for error at the 5% level of significance.

Results and Discussion

The list of 38 genetypes of pear collected from cultivated habitats of surveyed area are shown in Table 1. Genotypes collected show upright or pyramidal growth habit with more vertical branching which helps in proper light interception and growth of plants. Diversity in precocity of flowering ranged from early to late and intensity in flowering ranged medium to high in most of the accessions collected. Variability in morphological characters is considered as an important prerequisite for

Table 1. Passport data of pear germplasm collected during exploration

S. No.	Collector No.	Botanical name	Vernacular name	District	Altitude (m)	Latitude	Longitude
1.	AKT/VC-01 (2011)	*Pyrus communis*	Jagnel	Champawat	1930	29^0 23' 34.3"N	80^0 08' 43.6"E
2.	AKT/VC-02 (2011)	*Pyrus communis*	Babboogosa	Champawat	2040	29^0 24' 34.0" N	79^0 52' 19.9" E
3.	AKT/VC-03 (2011)	*Pyrus communis*	Garmehel	Champawat	2040	29^0 24' 34.0" N	79^0 52' 19.9" E
4.	AKT/VC-04 (2011)	*Pyrus communis*	Garmehel	Champawat	2035	29^0 24' 48.5" N	79^0 52' 49.8" E
5.	AKT/VC-05 (2011)	*Pyrus communis*	Garmehel	Champawat	2060	29^0 22' 56.2" N	80^0 00' 43.8" E
6.	AKT/VC-06 (2011)	*Pyrus communis*	Garmehel	Champawat	1950	29^0 23' 54.0" N	80^0 09' 46.7" E
7.	AKT/VC-07 (2011)	*Pyrus communis*	Chusnee	Champawat	1935	29^0 21' 55.4" N	80^0 10' 40.1" E
8.	AKT/VC-08 (2011)	*Pyrus communis*	Kakariya	Champawat	1950	29^0 23' 14.3" N	80^0 04' 28.0" E
9.	AKT/VC-09 (2011)	*Pyrus communis*	Kakariya	Champawat	1720	29^0 23' 14.9" N	80^0 04' 30.0" E
10.	AKT/VC-10 (2011)	*Pyrus communis*	Jagnel	Champawat	1720	29^0 23' 14.9" N	80^0 04' 30.0" E
11.	AKT/VC-11 (2011)	*Pyrus communis*	Garhmehel	Champawat	1720	29^0 23' 14.9" N	80^0 04' 30.0" E
12.	AKT/VC-12 (2011)	*Pyrus communis*	Garhmehel	Champawat	1720	29^0 23' 14.9" N	80^0 04' 30.0" E
13.	AKT/VC-13 (2011)	*Pyrus communis*	Garhmehel	Champawat	1845	29^0 23' 15.6" N	80^0 04' 36.0" E
14.	AKT/VC-14 (2011)	*Pyrus communis*	Garhmehel	Champawat	2060	29^0 23' 14.1" N	80^0 04' 18.0" E
15.	AKT/VC-15 (2011)	*Pyrus communis*	Kakariya	Champawat	2060	29^0 23' 14.1" N	80^0 04' 18.0" E
16.	AKT/VC-16 (2011)	*Pyrus communis*	Jagnel	Champawat	2060	29^0 23' 14.1" N	80^0 04' 18.0" E
17.	AKT/VC-17 (2011)	*Pyrus communis*	Garhmehel	Pithoragarh	1850	29^0 37' 11.0" N	80^0 15' 38.4" E
18.	AKT/VC-18 (2011)	*Pyrus communis*	Kakariya	Pithoragarh	1970	29^0 37' 31.9" N	80^0 16' 26.4" E
19.	AKT/VC-19 (2011)	*Pyrus communis*	Jagnel	Pithoragarh	1935	29^0 38' 25.4" N	80^0 18' 32.6" E
20.	AKT/VC-20 (2011)	*Pyrus communis*	Jagnel	Pithoragarh	1740	29^0 36' 55.8" N	80^0 11.4' 52" E
21.	AKT/VC-21 (2011)	*Pyrus communis*	Garhmehel	Pithoragarh	1740	29^0 36' 55.8" N	80^0 11.4' 52" E
22.	AKT/VC-22 (2011)	*Pyrus communis*	Garhmehel	Pithoragarh	1740	29^0 36' 55.8" N	80^0 11.4' 52" E
23.	AKT/VC-23 (2011)	*Pyrus communis*	Garhmehel	Pithoragarh	1740	29^0 36' 55.8" N	80^0 11.4' 52" E
24.	AKT/VC-24 (2011)	*Pyrus communis*	Kakariya	Pithoragarh	1640	30^0 00' 00.0" N	80^0 54' 22.5" E
25.	AKT/VC-05 (2012)	*Pyrus communis*	Gola	Champawat	1350	29^0 03' 38.9" N	80^0 07' 8.2" E
26.	AKT/VC-06 (2012)	*Pyrus communis*	Garmehal	Champawat	887	29^{0}13' 32.5" N	80^0 02' 53.0" E
27.	AKT/VC-07 (2012)	*Pyrus communis*	Garmehal	Champawat	820	29^0 21' 55.4" N	80^0 10' 40.1" E
28.	AKT/VC-16 (2012)	*Pyrus communis*	Garmehal	Pithoragarh	1787	29^0 42' 52.1" N	80^0 02' 34.1" E
29.	AKT/VC-17 (2012)	*Pyrus communis*	Jagnel	Pithoragarh	1781	29^0 43' 32.1" N	80^0 02' 12.9" E
30.	AKT/VC-18 (2012)	*Pyrus communis*	Jagnel	Pithoragarh	1781	29^0 43' 32.1" N	80^0 02' 12.9" E
31.	AKT/VC-19 (2012)	*Pyrus communis*	Garmehal	Pithoragarh	1722	29^0 47' 46.3" N	80^0 02' 19.9" E
32.	AKT/VC-20 (2012)	*Pyrus communis*	Garmehal	Pithoragarh	1292	29^0 50' 11.4" N	80^0 10' 58" E
33.	AKT/VC-21 (2012)	*Pyrus communis*	Jagnel	Pithoragarh	1360	29^0 46.06' 3" N	80^0 19.44' 9" E
34.	AKT/VC-22 (2012)	*Pyrus communis*	Gola	Pithoragarh	1360	29^0 46.06' 3" N	80^0 19.44' 9" E
35.	AKT/VC-23 (2012)	*Pyrus communis*	Gola	Pithoragarh	793	29^0 47' 48.2" N	80^0 24' 18.3" E
36.	AKT/VC-16 (2012)	*Pyrus communis*	Gola	Pithoragarh	809	29^0 47' 51.5" N	80^0 24' 27.9" E
37.	AKT/VC-24 (2012)	*Pyrus communis*	Garmehal	Pithoragarh	818	29^0 52' 37.3" N	80^0 33.44' 7" E
38.	AKT/VC-25 (2012)	*Pyrus communis*	Gola	Pithoragarh	820	29^0 52' 37.3" N	80^0 33.44' 7" E

characterization and evaluation of pear genotypes for breeding and research. Therefore, variability available with respect to these traits was collected up to maximum possible extent.

On the basis of flowering time, genotypes of pear are classified into three main groups, viz., early, medium and late flowering types (Table 2). Although, flowering time is under phylogenetic control (Jung and Muller, 2009), variability exists in flowering period (Jung and Muller, 2009). Flowering time is also affected by environmental factors like mean temperature, differences in chilling requirement for breaking bud dormancy, age and vigour of tree as well as natural factors/ calamities like heavy rainfall and hail storms. Variation in other quantitative

Table 2. Growth habit, flowering and fruiting characters of pear germplasm collected during exploration

S. No.	Vernacular name	Growth habit	Precocity of flowering*	Fruit shape	Fruit colour	Ripening time **
1.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
2.	Babboogosa	Pyramidal	Late	Pear shaped	Green to light yellow	Late
3.	Garmehel	Upright	Early	Round	Yellow with brown russet	Late
4.	Garmehel	Upright	Early	Round	Yellow with brown russet	Late
5.	Garmehel	Upright	Early	Round	Yellow with brown russet	Late
6.	Garmehel	Upright	Early	Round	Yellow with brown russet	Late
7.	Chusnee	Upright	Early	Pear shaped	Smooth green to yellow	Early
8.	Kakariya	Pyramidal	Late	Oblong	Green to light yellow	Late
9.	Kakariya	Pyramidal	Late	Oblong	Green to light yellow	Late
10.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
11.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
12.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
13.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
14.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
15.	Kakariya	Pyramidal	Late	Oblong	Green to light yellow	Late
16.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
17.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
18.	Kakariya	Pyramidal	Late	Oblong	Green to light yellow	Late
19.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
20.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
21.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
22.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
23.	Garhmehel	Upright	Early	Round	Yellow with brown russet	Late
24.	Kakariya	Pyramidal	Late	Oblong	Green to light yellow	Late
25.	Gola	Upright	Early	Round	Dark brown	Early
26.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
27.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
28.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
29.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
30.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
31.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
32.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
33.	Jagnel	Pyramidal	Medium	Pear shaped	Green to light yellow	Medium
34.	Gola	Upright	Early	Round	Dark brown	Early
35.	Gola	Upright	Early	Round	Dark brown	Early
36.	Gola	Upright	Early	Round	Dark brown	Early
37.	Garmehal	Upright	Early	Round	Yellow with brown russet	Late
38.	Gola	Upright	Early	Round	Dark brown	Early

* Precocity of flowering: early- flowering in April second fortnight, medium-flowering in May first fortnight, late-flowering in May second fortnight.
** Ripening time: early-June second fortnight, medium-July first fortnight, late-August first fortnight.

and qualitative characteristics of fruit like nutritional quality traits viz., TSS, total sugars, vitamins C and texture/ post-harvest life also exist among genotypes (Table 3). Post-harvest life is a crucial trait for collection of genetic variability of fruits which are to be grown in remote areas (Sharma *et al*., 2012). In conformity with the present findings Muratovic *et al.* (1990) have also emphasized that high yielding cultivars of pear should be selected and conserved in field in mountainous areas for crop improvement. Exploration and collection of germplasm and morphological characterization provides a base and raw picture of germplasm of specific plant species about variability and genetic diversity. These characters can be used as a base for further study at molecular level.

The green revolution has resulted in farmers planting fewer varieties of a plant that they grow so that they can focus on use of high yielding varieties. In addition,

Table 3. Fruit size, fruit weight and fruit quality traits of *Pyrus* spp. germplasm collected during exploration

S. No.	Vernacular Name	Fruit size		Fruit weight (g)	Total soluble solids (^{0}Brix)	Total sugars (%)	Vitamin 'C' (mg/ 100 ml juice)	Organoleptic evaluation (1-10 Scale)	Post harvest Life (days)
		Length (cm)	Width (cm)						
1.	Jagnel	6.2	4.1	225	13.5	8.5	3.2	8.5	8
2.	Babboogosa	5.8	5.3	265	12.2	8.8	4.2	7.5	13
3.	Garmehel	4.8	4.1	210	8.5	9.6	4.1	5	7
4.	Garmehel	4.7	3.8	200	9.0	9.3	4.6	5	5
5.	Garmehel	5.0	4.2	195	9.6	10.0	4.5	5	5
6.	Garmehel	5.1	4.3	205	9.5	10.2	4.8	5	6
7.	Chusnee	3.6	2.6	65	14.5	12.2	2.3	9	5
8.	Kakariya	7.6	5.3	270	12.5	9.6	2.4	7.5	11
9.	Kakariya	8.2	5.6	255	12.8	10.0	2.7	7.5	13
10.	Jagnel	6.0	4.6	185	11.8	8.4	3.4	8.5	9
11.	Garhmehel	4.6	4.1	180	9.6	8.6	4.8	5	6
12.	Garmehel	4.9	4.3	195	10.0	8.9	5.1	5	8
13.	Garhmehel	5.3	4.5	210	10.3	9.0	5.0	5	8
14.	Garhmehel	5.2	4.4	220	10.8	9.0	5.3	5	9
15.	Kakariya	8.0	6.1	280	12.6	10.0	2.9	7.5	12
16.	Jagnel	6.2	4.6	210	11.4	8.7	3.0	8.5	10
17.	Garhmehel	5.3	5.0	180	8.8	10.2	5.6	5	8
18.	Kakariya	7.6	5.8	290	12.2	11.0	3.1	7.5	10
19.	Jagnel	5.9	4.3	240	10.6	8.3	2.8	8.5	9
20.	Jagnel	6.1	4.6	200	10.2	8.8	2.6	8.5	10
21.	Garhmehel	5.2	5.0	180	8.5	9.8	4.3	5	7
22.	Garhmehel	5.1	4.6	190	8.8	9.7	4.8	5	7
23.	Garhmehel	5.0	4.9	210	9.4	9.6	4.6	5	8
24.	Kakariya	8.2	6.7	285	11.6	10.6	3.0	7.5	12
25.	Gola	4.3	3.6	85	10.2	7.2	4.9	4	10
26.	Garmehal	5.4	3.8	170	10.6	10.5	4.9	5	8
27.	Garmehal	5.4	4.1	190	10.8	10.8	4.9	5	9
28.	Garmehal	5.0	4.0	175	11.0	9.8	5.0	5	7
29.	Jagnel	6.6	4.6	160	13.2	8.6	3.1	8.5	9
30.	Jagnel	6.4	4.5	180	12.8	9.2	2.5	8.5	10
31.	Garmehal	4.7	3.9	210	9.6	11.1	5.2	5	7
32.	Garmehal	5.2	4.3	200	10.2	11.4	4.7	5	7
33.	Jagnel	6.0	4.6	160	11.0	9.7	3.4	8.5	9
34.	Gola	4.3	4.2	90	10.2	7.8	5.8	4	10
35.	Gola	4.0	4.5	100	10.8	8.6	6.3	4	11
36.	Gola	4.4	3.3	75	11.4	8.2	5.2	4	12
37.	Garmehal	5.0	4.1	160	8.8	10.3	4.8	5	8
38.	Gola	4.5	3.9	110	11.6	8.5	5.9	4	11
Mean±S.E.		5.54 ±0.47	4.47 ±0.31	189.73 ±13.73	10.81 ±0.97	9.48 ±0.88	4.20 ±0.37	6.10 ±0.59	8.78 ±0.77
Range		3.6-8.2	2.6-6.7	65-290	8.5-14.5	7.2-12.2	2.3-6.3	4.0-9.0	5-13
LSD ≤ 0.05		2.4	1.3	21	2.6	3.1	0.90	1.2	1.8

the varieties that are planted have been bred to a high degree of genetic uniformity within each variety. Both of these approaches are a change from past practices, in which farmers planted a large number of different, often locally-adapted, varieties, each of which generally contained a large number of different genotypes. Moreover, valuable genetic resources of plants especially fruits are eroding rapidly which results in large scale depletion of variability. There are many reasons for such depletion including deforestation, road laying, urbanization and land slides in mountainous terrain. Genetically uniform modern varieties are replacing the highly diverse primitive cultivars/ landraces in traditional agro-ecosystem even in far and remote areas. Breeders are much interested in germplasm having early ripening time, big fruit size, more weight per fruit, attractive shape, appealing colour and high organoleptic ranking. These traits were taken into consideration during the survey and collection of *Pyrus* spp. germplasm (Table 3). Conservation of indigenous fruit species serves as a stock and source gene bank for fruit breeding. Low level of variability in cultivated pear genotypes is alarming the need to widen the genetic base to conserve an adequate level of genetic diversity for breeding programmes (Wunsch and Hormaza, 2007). Cultivation of primitive cultivars having resistance to abiotic and biotic stresses as well as desirable fruit quality traits is in decreasing trend. Therefore, there is an urgent need to collect the available genetic diversity and conserve in the field genebank for use in crop improvement programme and other research purposes.

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