

Diversity of Native and Exotic Fruit Genetic Resources in Nepal

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ABSTRACT

Diversity in fruit genetic resources in Nepal is contributed by wild, indigenous and exotic sources. This study was carried out to bring together the available fruit species and cultivars at various stations of Department of Agriculture (DoA), Nepal Agricultural Research Council (NARC), Agriculture and Forest University (AFU) and private farms until the Fiscal Year 2017/2018. Altogether there were 47 species of fruits from tropical zone of Terai (Tarahara, Janakpur, Sarlahi, Parwanipur and Khajura) to cold temperature zone of high hills (Marpha, Rajikot and Satbanj) across the country. Apple diversity was found at Horticulture Research Station, Rajikot, Jumla and has introduced 25 spur type cultivars. National Citrus Research Programme (NCRP), Dhankuta was citrus most diversity areas and has maintained 130 exotic and indigenous germplasms of citrus species followed by NCFD, Kirtipur. Mango diversity was noted at RARS, Tarahara (16 cultivars), RARS, Parwanipur (25 cultivars), Farm of DoA-Sarlahi (30 cultivars), Farms of DoA-Janakpur (18 cultivars), AFU-Rampur (17 cultivars). Some of the private nurseries like Everything Organic Nursery, Patlekheta, Kavre and international organization like Technology Demonstration Centre of ICIMOD, Godawari, Lalitpur were also found to be a diversity centre of many exotic and indigenous germplasms of fruit species. These indigenous fruit genetic resources were also used to develop varieties such as Sunkagati-1 and Sunkagati-2 and Tehrathum Local of acid lime, Khoku Local of mandarin orange, 'Malbhog' of banana which were notified by the National Seed Board, SQCC. The unique fruit genetic resources were 'Pharping Local' (Asian sand pear), 'Sindhuli Junar' (sweet orange), 'Dhankuta Local' and 'Manakamana Local' (mandarin), Local Malbhog (banana), Bhaktapure Lapsi (Nepalese hog plum) etc. which have superior traits than exotic fruits. Unique and wild fruit species were yellow, black and red raspberries (*Rubus ellipticus*), *R. foliolosus* and *R. acuminatus* respectively), bale (*Aegle marmelos*), pummelo (*Citrus grandis*), citron (*Citrus medica*), sweet lime (*Citrus limettoides*), butter tree or chiuri (*Basia buttyacea*), tamarind (*Tamarindus indica*), black plum (*Syzygium cumini*), wild apple (*Mallus baccata*), rough lemon (*Citrus jambhiri*), bayberry (*Myrica esculanta*), edimayal (*Pyrus pashia*), black and white ebony (*Diospyrus malbarica*), wild species of olive (*Olea ferruginea* and *O. glandulifera*), wild kiwifruit (*Actinidia callosa*) etc. Most of the diversity studies were based on phenotypic descriptions. We believe that the number of species and genotypes listed in this article would be increased if detail survey is further carried out. Way forward to utilize these valuable genetic resources has also been discussed in this manuscript.

Keywords: Nepalese fruits, Native fruits, Exotic fruits, fruit diversity

सारांश

नेपालको फलफूल वर्गको आनुवंशिक स्रोतमा विविधता यहाको जंगली, स्थानिय र विदेशी स्रोतहरूले योगदान पुर्याउँछन् । नेपाल सरकारको कृषि विभागका फार्म, नेपाल कृषि अनुसन्धान परिषदका फार्म (नार्क), कृषि तथा वन विश्वविद्यालय र निजी फार्महरूमा उपलब्ध फलफूलका प्रजातिहरूको विवरण अध्यावधिक गर्न आर्थिक वर्ष २०१४ देखि २०१७ मा यो अध्ययन गरिएको थियो । तराई (तराहरा, जनकपुर, सर्लाही, परवानीपुर र खजुरा) को उष्ण प्रदेशिय क्षेत्रदेखि चिसो तापक्रमको क्षेत्र (मार्फा, राजिकोट र सतवाभ्र) सम्म जम्मा ४७ प्रजातिका फलहरू पाइएका थिए । स्याउको विविधता बागवानी अनुसन्धान केन्द्र, राजिकोट, जुम्ला, मार्फा र सतवाभ्रको फार्म थिए भने राष्ट्रिय सुन्तला अनुसन्धान

कार्यक्रम (रा.सु.अ.का.), धनकुटा र एनसीएफडी, कीर्तिपुर अमिलो वर्गका फलफूलको सबैभन्दा बढि विविधता भएको फार्म थिए। यी दुवै फार्ममा १३० भन्दा बढि प्रजातीहरू संरक्षण गरिएका छन्। आँपको सबैभन्दा बढि विविधता नार्कको फार्महरू क्षेत्र.क.अ.के. तरहरा, क्षेत्र.क.अ.क परवानीपुर, सर्लाही फार्म, जनकपुर फार्म, कृषि र वन विश्वविद्यालय, रामपुर छन्। निजी नर्सरी जस्तै सबै जैविक नर्सरी, पात्लेखेत, काभ्रे र इसिमोड, गोदावरी, ललितपुरको टेक्नोलोजी प्रदर्शन केन्द्र जस्ता अन्तर्राष्ट्रिय संस्था पनि विदेशी र स्वदेशी फलफूलको प्रजातिहरूका विविधताका केन्द्र थिए। नेपालका स्वदेशी प्रजातिहरूमध्ये कागतीको सुनकागती १, सुनकागती २ र तेह्रथुम स्थानीय, सुन्तलाको खोकु स्थानीय, केराको मालभोग जस्ता जातहरू विकास गरि राष्ट्रिय वीउविजन बोर्डले सूचित गरेको छ। एशियाली नासपातीको फपिङ्ग स्थानीय, जुनारको सिन्धुली जुनार, सुन्तलाको धनकुटा स्थानीय र मनकामना स्थानीय, केराको स्थानीय मालभोग, भक्तपुरे लप्सी आदि अद्वितीय आनुवंशिक स्रोतहरू भएका फलफूल हुन जसमा विदेशी फलहरू भन्दा उच्च गुणहरू छन्। हामीलाई विश्वास छ कि यदि विस्तृत सर्वेक्षण गर्ने हो भने यस लेखमा सूचीबद्ध प्रजाति र जीनोटाइपहरूको संख्या बढि हुनेछ।

INTRODUCTION

Nepal is bestowed with diversified climatic conditions with many micro-climatic niches to cultivate diverse biotypes of fruit species. The complex maze of mountains and ridges, interspersed by deep valleys and low lands are rich in fruit genetic resources (Kaini 1994, Kaini 1999). Among 6,500 species of flowering plants reported by Chalise et al (1993) Nepal is rich in wild edible, exotic and cultivated fruit genetic resources (Joshi et al 2017, Upadhyay and Joshi 2003). The total number of agro-horticultural crops found in Nepal is roughly estimated to be 400 species and subspecies (Regmi 1990). It is believed that Nepal is original home of many fruit species. About 107 indigenous fruit species have been reported in Nepal (Joshi et al 2007). There are 45 species belonging to 37 genera and are reported as wild edible fruits (Kaini 1994). Southern Terai region is suitable for cultivation of true tropical fruits while northern mid-hills and high-hills are suitable for sub-tropical to warm and cold temperate fruit and nut species. In addition, few species of fruits are found growing across agro-ecological regions. For example, some true tropical fruits such as banana, litchi, pineapple, papaya and mango can be grown in Terai, inner-Terai, foot hills and mid-hills. Similarly, some species of citrus species particularly acid lime can be grown from tropical Terai to mid-hill conditions. From the reviews of the past research initiatives on fruit and nut species, it shows that many exotic fruit germplasm has been introduced in many public farms (Thapa et al 2017, Shrestha et al 2017) but comprehensive documentation of these germplasm is still lacking. In the context of not having explicit database of fruit diversity introduced and maintained in Nepal, this study was carried out to bring together the available indigenous and exotic fruit and nut species in the country so that further research can be streamlined in varietal research and initiate the selection, notification and or release process of promising genotypes. It was also aimed to get insight of the existing and imported fruit germplasm available at the farms of DoA and NARC all over the county.

METHODOLOGY

This study was carried out by using a standard format of inventory collection of the fruit and nut species available at different farms belonging to DoA, stations of NARC and AFU, Rampur, Chitwan. Information were collected from ARS Pakhribas; NCRP, Dhankuta; RARS, Tarahara, Parwanipur; Lumle and Nepalgunj; HRS, Malepatan and Jumla respectively. Most of the germplasm available and maintained at DoA farms were listed from the web sites of former Fruit Division Directorate (<http://fdd.gov.np/index.php/dwndsection>). In addition to public farms and stations, field visit and detailed survey was carried out to collect information from Technology Demonstration Centre of ICIMOD and Everything Organic Nursery (EVON), Kavre. Secondary data from previous publications, for example, HRD (2014, 2015) and NCRP (2013, 2016, 2017) were also used to update and cross validate the inventory lists. Literature on Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal (CUAPGR) has also been reviewed and updated the findings of Thapa et al (2017), Shrestha et al (2017) and Karki et al (2017).

RESULTS AND DISCUSSION

Fruit diversity at species and varietal levels

Citrus fruit diversity: It has been found that National Citrus Research Program, Paripatle (NCRP), Dhankuta and its command areas were the most diversity centre of citrus species (130 species) in

Nepal (Table 1). NCRP has continued varietal evaluation of sweet orange including 23 exotic and local landraces since establishment. More than 45 different genotypes of citrus (22 mandarin, 14 sweet orange, 5 grapefruit, 3 tangor and 3 tangelo) were introduced from the French National Institute for Agriculture Research (INRA)-CIRAD, France; Japan; Pakistan; and other countries in 2005 and have been preserved and were being evaluated in field gene bank of NCRP, Dhankuta (NCRP 2013).

Table 1. Collection and conservation of citrus germplasm in field gene bank at NCRP, Dhankuta

Species	No. of germplasms	Source
Mandarin Oranges	32	France, Japan and Local
Sweet Orange	34	India and France
Tangelo	3	France and Japan
Tan gore	4	France and Japan
Acid Lime	21	Local
Lime	6	Local
Grape fruit	8	France and Vietnam
Muntala	3	India
Rootstocks	19	Local and France
Total	130	

Source: NCRP 2017

Among them cv. Washington Navel and Valencia Late of sweet orange has been tested and are pipeline cultivars. Based on the preliminary research finding Washington Navel is recommended for low altitude, seedless, matures in Kartik-Mangsir (Oct.–Nov.) while Valencia Late is recommended for late season, matures in Chaitra (Mar.–Apr.). National Centre for Fruit Development, Kirtipur is second most diversity centre of citrus species followed by HRS, Malepatan and HRS, Dailekh of NARC (Table 2).

Table 2. Diversity of citrus species at different horticulture farms of Nepal, 2017

SN	English name	Nepali name	Scientific name	Diversity stations (No. of cultivars/genotypes)
1.	Mandarin orange	Suntala	Citrus reticulata L.	DoA, Kirtipur (7), NCRP, Dhankuta (32), ICIMOD, Godawari (3), HRS, Dailekh (5)
2.	Unshu mandarin	Unshu Mandarin	Citrus unshui	NCRP, Dhankuta (5), DoA, Kirtipur (6)
3.	Sweet orange	Mausambi / Junar	Citrus sinensis	NCRP, Paripatle (25), DoA, Kirtipur (11), ICIMOD, Godawari (7), DoA, Godwari (2)
4.	Acid lime	Kagati	Citrus aurantifolia	NCRP, Dhankuta (22), HRS, Malepatan (3), RARS, Nepalgunj (7), DoA, Kirtipur (2), EVON (2), ICIMOD, Godawari (2), RARS, Parwaipur (1)
5.	Pummelo	Bhogate	Citrus maxima or grandis	DoA, Kirtipur (6), NCRP, Dhankuta (3)
6.	Tangelo			NCRP, Dhankuta (6),
7.	Trifoliate orange	Tinpate	Poncirus trifoliata	DoA, Kirtipur (3), NCRP, Dhankuta (1)
8.	Hill lemon	Nibuwa	Citrus limon	EVON (1), NCRP, Dhankuta (6), DoA, Kirtipur (2), HRS, Malepatan (1), ICIMOD, Godavari (2)
9.	Grapefruit	Sankhatro	Citrus paradisi	NCRP, Dhankuta (5), DoA, Kirtipur (1), ICIMOD, Godawari (1)
10.	Kumquat	Muntala	Fortunella japonica	DoA, Kirtipur (2), NCRP, Dhankuta (2), DoA, Godawari (2),
11.	Citrangle		C. sinensis x P. trifoliata	DoA, Kirtipur (2), NCRP, Dhankuta (2),
12.	Citron		Citrus medica	NCRP, Dhankuta (15),
13.	Tangor			NCRP, Dhankuta (3), DoA, Kirtipur (1)

Figure in paranthesis indicates number of fruit germplasm maintained at different farms. DoA, Department of Agriculture; ARS, Agriculture Research Station; Hort., Horticulture; EVON, Everything Organic Nursery; NCRP, National Citrus Research Program; HRD, Horticulture Research Division; ICIMOD, International Center for Integrated Mountain Development,

Temperate fruit diversity

About 10 spur type apple germplasms were collected from RHRS, Mashobra, Simla and HTS, Kandaghat Solon and 15 germplasms were imported from Canada and planted in 2011 at HRS, Rajikot, Jumla (ARS 2012). The recent result showed that three spur cultivars collected from India, Oregon spur II, Starkrimson Delicious and Red Spur were found to be promising for good fruit quality, storability and disease pest resistant up to now and therefore proposals are being developed for registration by the fiscal year 2019/20. Similarly, some promising fruit germplasm of temperate fruits were imported by Horticulture Research Division, Khumaltar with support of *Association Du Bessin Au Nepal*, France and *Kam For Sud*, Switzerland (HRD 2018) (Table 3).

Table 3. Recent introduction of temperate fruit germplasms

Species	Varieties/lines	Year of introduction	Farm/Stations/location
Apple <i>Malus pumilla</i> var. <i>domestica</i>	10 cultivars collected from India Oregon Spur II, Red Chief, Bright N Early, Red Gold, Vance Delicious, Top Red, Starkrimson Delicious, Well Spur, Red Spur, Stark Spur Gold	2011	HRS, Jumla
	15 cultivars introduced from Canada Ambrosia, Blushing Susan, Honey Crisp, Gala, Red Gravenstein, Jonagold (P), Jubile Fuji, Pristine, Redfree, Robinete, Sinta, Sunrise, Tsagaru, Zestar, Jim		
	Canada Gris, Baskoop, Malrose, Idared, Cox Orange, Belchard, Akane, Judaine, Reine des, Reinettes, Boskoop, Florina, Mutterapfel, Prime Red Schneider Apfel, Sparton, Beauty of Kent, King of Pippin,	2017	HRS, Jumla and DoA, Marpha
Apple rootstocks/	MM111, MM106	2017	HRS, Jumla
Walnut	Franquette	2017	HRS
Hazelnut	Coutard	2017	HRS
Black Currant	Neva, Andega	2017	HRS
Himalayan Goji	GT8, 100/130 3L	2017	HRS
Raspberry	Zeva	2017	HRS
Peach	Benedite, Surprise	2017	HRS
Plum	Mirabelle	2017	HRS
Nectarin	Big Van, Burlat	2017	HRS
Apricot	Hargrand, Bergeron	2017	HRS, Jumla

P= pollinizer

Source: ARS 2012 and HRD 2018

It has been found that about 15 exotic apple cultivars were introduced at Satbanj and 39 cultivars at Marpha under DoA and 25 cultivars at ARS, Rajikot, Jumla since its establishment. The highest diversity in peach and pear fruits were found at National Central Fruit Development (NCFD), Kirtipur under DoA. More than 40 apple (*Malus pumila* L.) genotypes were introduced to Nepal, and evaluated for many years at NCFD, Kirtipur before 1985. Clonal rootstocks M9, M26, M27 of Malling series and MM101, MM106, MM111 of Malling Merton series were introduced to a few horticultural stations and were used for propagation in a very limited scale. About 13 exotic cultivars of peach and pear have been maintained at NCFD, Kirtipur. During Horticulture Development Project Phase I and Phase II, Japanese pear (*P. pyrifolia*) cvs. Shinsui, Shinko, Kosui, Hosui, Chojuro and Okusankichi were introduced. Later, over 40 cultivars of peach (*Prunus persica*) were introduced in Nepal and grafted on a wild species of peach (*Prunus* species). At present, National Centre for Fruit Development (NCFD), Kirtipur has maintained 13 European plum cultivars such as Green Gage, Early Transparent Gage, Stanley, Ruth Gestetner and Japanese plum cultivars Santa Rosa, Methley,

Satsuma, Formosa, Mariposa, Burbank, Kelsey, Oishi Wase and Shiro were also introduced during this period. Similarly, about 13 cultivars of apricot and some popular nectarine cultivars such as Independent, Panamint, Arm King, Ruby Gold, Fantasy, Nectaret-2 and Neyorkert were introduced. Popular persimmon cultivars Fuyu, Jiro, Zenjmoru, Hiratanonashi, Hachiya were introduced from Japan and evaluated since the HDP II. The astringent cv. Hiratanenashi and Aizumisirazu, and non-astringent cv. Matsumoto Wase and Maekawajiro of persimmon were also introduced. Similarly, six exotic chestnut cultivars were introduced to LARC. Sweet cherry is mostly available in private nurseries such as EVON, Kavre and international organization ICIMOD, Godawari.

Clonal rootstocks M9, M26, M27 of Malling series and MM101, MM106, MM111 of Malling Merton series were introduced to a few horticultural stations and were used for propagation of apple in a very limited scale (Devkota 1999). Over 40 cultivars of peach (*Prunus persica*) were introduced to Nepal, grafted on a wild cultivar of peach (*Prunus* spp) which is also a rootstock for nectarine (*Prunus persica* var. *nectarina*) and almond (*Prunus amygdalus*) (Schnell 2012).

European pear varieties (*P. communis*) (Bartlett, Quince, Anjou and Conference) were also introduced at Central Horticulture Centre (CHC), Kirtipur farm and evaluated for cool temperate regions of Nepal. Similarly 44 improved varieties of peach have also been introduced and evaluated and found that Peregrine, Triumph, Elberta, Baby Gold, Sun Crest, Rhodes, Red Haven and Florida Red were high chilling varieties while Orion, Spring Time, French Early, Cardinal, Arm Gold, Florida, Kuratake Wase, Texas, Spring Time, Early Red were low chilling varieties. European plum varieties (Green Gage, Early Transparent Gage, Stanley, Ruth Gestetner) and Japanese plum varieties (Santa Rosa, Methley, Satsuma, Formosa, Mariposa, Burbank, Kelsey, Oishi Wase and Shiro) were also introduced during the period. About 13 varieties of apricot were introduced into Nepal at different times but unfortunately only a few of them have been successful for commercial cultivation under Nepalese conditions (Devkota 1999). Among those introduced varieties (Blenheim, Titon, Bulida, Rcale Dimola, Prete, Canino, Kaisha, Charmagz, Shakarpara), Shakarpara was found to be the most successful variety in Nepal. Popular nectarine varieties such as Independent, Panamint, Arm King, Ruby Gold, Fantasy, Nectaret-2 and Neyorkert were introduced. Popular persimmon varieties Fuyu, Jiro, Zenjmoru, Hiratanonashi, Hachiya were introduced (Devkota 1999).

Similarly, different deciduous fruit varieties were introduced and evaluated at Pakhribas Agriculture Center, Dhankuta (Gautam et al 1995) and Lumle Agricultural Research Center, Lumle (Subedi et al 1995). They further reported the suitability of Anna and Vered, low chilling varieties of apple for the eastern hills.

Table 4. Diversity of exotic and native temperate fruits germplasm in Nepal, 2017

SN	English name	Nepali name	Scientific name	Diversity stations (No. of cultivars/genotypes)
1.	Apple	Shyau	Malus pumila var. domestica	HRS, Jumla (38), EVON (5), DoA, Daman (17), DoA, Marpha (39), DoA, Satabanj (18), ICIMOD, Godawari (9), DoA Godawari (3), ARS, Pakhribas (2)
2.	Apple rootstock	Edi Mayal/Local	Pyrus pashia	DoA, Godawari (8), DoA, Marpha (4), DoA, Damana (3)
3.	Almond	Kagazi Badam	Prunus amygdalus	HRS, Jumla (1), DoA, Marpha (1), DoA, Satabanjh (4), EVON (6),
4.	Apricot	Khurpani,	Prunus armeniaca	ICIMOD, Godawari (7), DoA Daman (1), HRS, Jumla (3), DoA, Marpha (4), DoA Bonch (3)
5.	Blackberry	Kalo Ainselu	Rubus sp.	EVON (5)
6.	Blackcurrent		Ribes nigrum	EVON (1)
7.	Blueberry	Nilo Ainselu	Vaccinium sp.	EVON (1)
8.	Gooseberry		Ribes grossularia	EVON (2)

SN	English name	Nepali name	Scientific name	Diversity stations (No. of cultivars/genotypes)
9.	Chestnut	Katus	Castanea mollissima/Castanea sp	ICIMOD (2), ARS, Pakhribas (1), HRS, Malepatan (2), EVON (1), DoA, Kritipur (7), DoA, Bonch (6), DoA Daman (1), DoA, Godavari (1)
10.	Raspberry	Ainselu	Rubus ideaus	EVON (5)
11.	Hazelnut/ Filbert nut	Khathe Badam	Corylus avellana	DoA, Bonch (2)
12.	Pear	Naspati	Pyrus communis (European) and P. pyrifolia (Japanese)	ARS, Pakhribas (3), HRS, Jumla (2), EVON (6), DoA, Bonch (5), DoA, Daman (6), DoA, Marpha (3), DoA, Kirtipur (14), ICIMOD, Godawari (11), HRD, Khumaltar (4), DoA, Godawari (5), RARS, Lumle, (2)
13.	Peach	Aaru	Prunus persica	ARS, Pakhribas (2), HRS, Jumla (1), EVON (4), DoA, Bonch (4), DoA, Daman (2), DoA, Marpha (8), DoA, Kirtipur (14), ICIMOD, Godawari (7), HRD, Khumaltar (2), DoA, Godawari (9), RARS, Lumle, (7)
14.	Plum	Aarupokhada	Prunus domestica	ARS, Pakhribas (6), HRS, Jumla (2), EVON (1), DoA, Bonch (6), DoA, Daman (4), DoA, Marpha (3), DoA, Kirtipur (5), ICIMOD, Godawari (5), HRD, Khumaltar (4), DoA, Godawari (5), RARS, Lumle, (2), DoA, Satbanjh (4)
15.	Pecan Nut	Chuche Okhar	Carya illinoensis	ARS, Pakhribas (1), EVON (1), DoA, Kirtipur (4), ICIMOD, Godawari (1), DoA, Godawari(2)
16.	Persimmon	Haluwabed	Diospyros kaki	EVON (1), DoA, Kirtipur (12), ICIMOD, Godawari (6), DoA, Godawari (2), DoA, Daman (3), DoA, Satbanjh (4), HRD, Khumaltar (5)
17.	Sweet cherry	Guliyu Paiyun	Prunus avium	ICIMOD, Godawari (6), EVON (2), DoA, Bonch (2)
18.	Sour cherry	Amilo Paiyun	Prunus cerasus	EVON (1)
19.	Strawberry	Bhui Kaphal	Fragaria x ananassa	EVON (5), ARS, Pakhribas (1)
20.	Walnut	Okhar	Juglan regia	ICIMOD, Godawari (2), EVON (4), DoA, Godawari (1), ICIMOD, Godawari (4), DoA, Bonch (2), DoA, Marpha (2), DoA, Daman (1)

Note: figure in paranthesis indicates number of fruit germplasm maintained or available at survey date. DoA, Department of Agriculture; RARS, Regional Agriculture Research Station; ARS, Agriculture Research Station; Hort., Horticulture; EVON, Everything Organic Nursery; HRD, Horticulture Research Division; ICIMOD, International Center for Integrated Mountain Development

Diversities in subtropical and tropical fruits species

Pomegranate: The most diversity area at cultivar level for pomegranate was HRD, Khumaltar. There were 12 germplasms collected from various parts of the country and maintained at the mother stock block of HRD, Khumaltar, Lalitpur. Eight germplasms with accessions, HRDPOM001, HRDPOM002, HRDPOM003, HRDPOM004, HRDPOM005, HRDPOM006, HRDPOM007 and HRDPOM008 were collected in the FY 2013/14 and planted at HRD mother stock block. Two germplasms with accession HRDPOM009 and HRDPOM010 were collected from Manakamana Nursery, Gantaghar, Birgunj, Parsa. Additional two genotypes with accession HRDPOM011 and HRDPOM012 were collected from farmer's field, Milanchowk, Pidhuwa, Tandhi, Chitwan in the FY 2014/15 (HRD 2015). These genotypes were multiplied by cuttings and are under multi-location evaluation at four different agro-ecological conditions, RARS, Nepalgunj, ARS, Surkhet, HRS, Dailekh and GRP, Salyan including HRD, Khumaltar. Collected genotypes are maintained at the mother stock block of HRD, Khumaltar, Lalitpur. At the species level, the most diversity area of pomegranate is Dolakha, Nuwakot, Kavre, Sindhuli, Tanahun, Lamjung, Kaski and Palpa.

Kiwifruit: The first specimens of *Actinidia callosa* on which the genus is based were collected by Nathaniel Wallich, in Nepal in 1821 (Kaini 1994). Another wild type of kiwifruit is known as thekiphal (*A. Callosa* var. *callosa*) primarily available in forest of Solukhumbu district from about 1500 to 2200 m. Other species available in Nepal is *A. strigosa*, very localized only in Nepal and Sikkim at altitudes of 2500 to 3000 m.

At varietal level, the most diversity area of kiwifruit is a Surya Organic Kiwi Farm located at Phaskot of Patleket, Kavre district followed by International Centre for Integrated Mountain Development (ICIMOD), Godawari, Lalitpur. ICIMOD introduced kiwifruit cultivars from India and established a demonstration/production plot at Godawari during 1990s. Some kiwi cultivars namely; Hayward, Bruno, Monte, Allison and Tomori were cultivated in Horticulture farms of Kirtipur and Daman since the year 2000. Red Kiwi, Hayward (both round and oblong), Bruno, Monte, Abbolt, Allisan and ICIMOD Oblong were planted at Surya Kiwifarm, Patleket, Kavre in 2005. Similarly, six cultivars Hayward, Monte, Abott, Bruno, Allison and Red Kiwi were planted in 2012 at ARS, Pakhribas, Dhankuta for characterization and evaluation. Horticulture Research Division has planted six kiwifruit germplasms and was under evaluation.

Table 5. Tropical and sub-tropical fruit diversity in in Nepal, 2017

SN	English name	Nepali name	Scientific name	No. of cultivars/genotypes
1.	Acid lime	Kagati	Citrus aurantifolia (Christm.) Swing	11
2.	Areca nut	Supari	Areca catechu Linn.	7
3.	Avocado	Ghewphal	Persea americana Mill.	5
4.	Banana	Kera	Musa paradisiaca Linn.	20
5.	Coconut	Nariwal	Cocos nucifera Linn.	3
6.	Indian Gooseberry	Amala	Emblca officinalis Gaerth. Syn. Phyllanthus emblica Linn.	4
7.	Grapes	Angoor	Vitis venifera Linn.	7
8.	Guava	Amba, Belauti	Psidium guajava Linn.	11
9.	Jackfruit	Katahar	Artocarpus heterophyllus Lamk.	7
10.	Jujube	Baer	Ziziphus mauritiana Lamk.	4
11.	Kumquat	Muntala	Fortunela japonica (Thunb) Swing.	2
12.	Lemon	Nibuwa	Citrus limon (Linn.) Burm. f.	6
13.	Litchi	Litchi	Litchi chinensis (Gaertn.) Sonn.	12
14.	Macadamia nut	Macadamia nut	Mecademia integrifolia F. Muell.	4
15.	Mandarin orange	Suntala	Citrus reticulata Blanco.	11
16.	Mango	Aanp	Mangifera indica Linn.	30
17.	Mangosteen	Mangosteen	Garcinia mangostana Linn.	21
18.	Papaya	Mewa	Carica papaya Linn.	19
19.	Pineapple	Bhuinkatahar	Ananas comosus (Linn.) Merr.	5
20.	Sapota	Sapatu	Achras sapota Linn.	2
21.	Sweet orange	Junar	Citrus sinensis (Linn.) Osbeck.	8
22.	Wood Apple	Bale	Aegle marmelos (Linn.) Corr.	5
23.	Trifoliate orange	Tin Pate Suntala	Poncirus trifoliate Raf.	5
24.	Pomegranate	Anar	Punica granatum Linn.	7
25.	Kiwifruit	Thekiphal	Actinidia deliciosa C.F. Liang & A.R. Ferguson	8

Source: Gautam and Tiwari 2007; NCRP, 2016; Gotame et al 2014; Kaini 1994

Thirteen accessions of avocado (ARS P A-01, ARS P A-02, ARS P A-03, ARS P A-04, ARSP A-05, ARSP A-06, ARSP A-07, ARSP A-08, ARSP A-09, ARSP A-10, ARSP A-11, ARSP A-12, ARSP A-13) were collected from different locations of Dhankuta district and evaluation process is ongoing at ARS, Pakhribas (ARS 2018). The shape and size of fruits have high variations and can be used in new

variety development. AFU has also maintained Arica nut, mangosteen, guava, avocado, jackfruit, kathe jyamir, chuche okar, and drumstick.

Unique fruit genetic resources in Nepal

Nepal is rich in wild and indigenous fruit germplasms. Many of the indigenous fruit species are performing as good as or better than exotic varieties. For example, cultivars ‘Pharping’ (Asian sand pear), ‘Junar’ (sweet orange), ‘Dhankuta Local’ (mandarin), ‘Kagaji and Sunkagati, Lime’ (acid lime) are superior to exotic varieties due to many desirable economic characters. Besides the traditional and exotic varietal crops, there are some fruits which are traditionally or wildly grown in Nepal. For example, Indian gooseberry (*Emlica officinalis*), yellow, black and red raspberries (*Rubus ellipticus*, *R. foliolosus* and *R. acuminatus* respectively), pomegranate (*Punica granatum*), bale (*Aegle marmelos*), pummelo (*Citrus grandis*), citron (*Citrus medica*), sweet lime (*Citrus limettoides*), butter tree or chiuri (*Basia buttyacea*), tamarind (*Tamarindus indica*), black plum (*Syzygium cumini*), wild apple (*Mallus baccata*), rough lemon (*Citrus jambhiri*), bayberry (*Myrica esculanta*), edimayal (*Pyrus pashia*), gaub tree (malabar ebony/pale moon ebony (tindu) (*Diospyrus malbarica*), wild species of olive (*Olea ferruginea* and *O. glandulifera*), wild kiwifruit (*Actinidia callosa*) etc. mulberry (*Morus indica*), Nepalese hog plum (*Choerospondias axillaris*), edimayal (*Pyrus pashia*), common fig (*Ficus carica*), jackfruits etc. There is ample scope for selection of promising clones from these existing wild relatives through evaluation and selection breeding procedure. Upreti et al (2012) made an inventory of wild edible fruit crops of Nepal from Makawanpur, Tanahun, Dang, Bardia and Kailali districts and recorded 44 wild fruit species. Some of these fruits include Jambol (black jamun), bay berry (kafal), wild gooseberries and figs. Wild relatives of kiwifruit species and its diversity is found in Sankhuwasaba district of Nepal (Kaini 1994, Kaini 1999) and are used as rootstock. Most probably these rootstocks have high abiotic and biotic stress tolerance but have yet to be studied. There are many landraces that associated with certain geography and have potential of geographical indication right (Table 9) (Joshi et al 2017)

Table 9. Nepali geographical indicator (GI) of fruit species in Nepal

Commodity/ Product	Land races	Location	Nepali geographical indicator	Unique traits
Apple	Local apple	Trans-Himalayan apple of Marpha/Jumla/Dolpa	Marpha/Jumla/Dolpa ko Shyau	Very attractive, delicious and red, high in anthocyanin content
Apple	Local apple	Helambu, Sindhupalchock	Helambu ko Shyau	Red colour, high anthocyanin content
Mayal	Local Mayal			
Apricot	Local Khurpani	Humla/Jumla	Humla ko Chuli (local apricot)	Oil from seed has medicinal value
Banana	Jhapali Malbhog	Kawashoti, Nawalparasi	Kawashoti ko Kera	Scented, tasty, large size, thin skin and high in flavor content
Banana	Ghiu Kera	Lamjung, Tanahun	Local Malbhog Kera	Scented, small size, thin skin, testy, high flavor
Banana	Mungre Kera	Gorkha, Lamjung, Tanahun	Mungre Kera	Extra large size, long finger, yellow color, thick skin, cold tolerant
Guava	Local Aamba	Dhunibeshi, Dhading	Dhunibeshi ko Aamba	Delicious, soft
Acid lime	Local Sun Kagati	Fakchmara, Terhthum	Sthaniya Kagati	Juicy, yellow and thin skin colour, small, round size
Lapsi	Sthaniya Lapsi	Bhagara, Parbat	Bhagara Sthaniya	More pulp, tasty, long storability
Lapsi	Lapsi	Lele, /Lalitpur/Bhaktapur	Bhaktapur ko Lapsi, Godawari ko Lapsi	Sweet and tasty
Mandarin	Manakaman	Manakamana,	Manakamana ko	Juicy and tasty

Commodity/ Product	Land races	Location	Nepali geographical indicator	Unique traits
	a Local	Gorkha	Suntala	
Mandarin	Khoku Local	Khoku, Dhankuta	Dhankuta ko Suntala	Juicy and tasty
Mandarin	Ramjattaar Local	Ramjattaar, Okhaldunga	Ramjattar ko Suntala	Sweet
Mango	Local Maldah Aap	Kalyanpur of Siraha and Mulghat of Dhankuta	Kalyanpur. Mugaat ko maaldah	Sweet and attractive flavour
Pear	Pharping Local	Pharping, Kathmandu	Pharping ko Naspati	Juicy and delicious, high fruiting habit, large plant canopy, large fruits, higher storability, drought tolerant plants
Sweet orange	Junar	Sindhuli	Sindhuli ko Junar	Sweet, tasty, juicy, fetch high price
Sweet orange	Mausam	Dadeldhura	Dadeldhura ko Mausam	Juicy, late maturity, can be harvest until February, large size, fetch high price

There were some cultivars of popular fruits selected and commercially cultivated using Nepali gene pool. For example, many types of mandarin grown at present such as Banskark Local, Parbat Local, Khoku Local; sweet orange cultivar as Junar which is Nepali landraces, have high pomological characters.

Diversity in wild fruit relatives in Nepal

There are indefinite numbers of wild fruits in Nepal which remain as not studied scientifically thus underutilized fruit germplasm of the country. Ainselu (*Rubus ellipticus* Sm.), commonly known as the golden Himalayan raspberry or yellow Himalayan raspberry grows in Nepal as well as in China, India, Indo-China region and the Philippines. No research or molecular verification has been carried out to study the origin and distribution of this Asian thorny shrub species. There are unverified reports that roots of Aiselu contain nodules, which fix nitrogen. If this could be confirmed by further study and research, such trait could be widely used to reclaim the marginalized and degraded lands. Similarly, bayberry (*Myrica esculanta*), Indian gooseberry (*Emlica officinalis*), butter tree or chiuri (*Basia buttyacea*), chinkapin (*Castanopsis indica*), tamarind (*Tamarindus indica*), black plum (*Syzygium cumini*), gaub tree (malabar ebony/pale moon ebony (tindu)) (*Diospyrus malbarica*), mulberry (*Morus indica*), Nepalese hog plum (*Choerospondias axillaris*), common fig (*Ficus carica*), chestnut (Katus) (*Castanea indica* Roxb.ex Lindl.), and Kyamuna (*Cleistocalyx operculatus* Roxb.Merr. & LM Perry) which grow in jungles play a significant role in supplying nutrition, particularly to poor and marginalized people in mid-hills and high-hills. In addition to the ripened fruits, these plants are chief sources of fodder, fire wood, timber and Aurvidic medicine for the local community. Nepalese hog plum (*Choerospondias axillaris*) and bale (*Aeglemarmelos* (L.) Correa) are unique to Nepal. Local people of Kathmandu, Bhaktapur and Kavre make candies using Nepalese hog plum fruit which are very popular. Candies and pickles made from tamarind, Nepalese hog plum and Indian gooseberries are popular among the Nepalese people. Commercially grown but in small scale, the bale fruit juice is bottled and marketed as *marmelous* (the name derived from bale's Latin name, *Aegle marmelos*) by private companies in Bardia district. People drink bale fruit juice for health benefits (Thapa et al 2018).

Rough lemon (*Citrus jambhiri* Lush.) is a citrus hybrid from a cross between citron and lemon. Its traits are similar to mandarin orange. Rough lemon is a cold-hardy citrus and can grow into a large tree. There are several cultivars of rough lemon in farmers' fields. Shrubs are often grown as biological fences. They can be grown around national parks and botanical gardens as eco-friendly fences. They are also effective to reclaim erosion prone hills to prevent soil erosion. Butter tree (*Madhuca butyracea*), a native to Nepal and grows mainly in the sub-Himalayan tracts on steep

slopes, ravines and cliffs at an altitude of 400 to 1400 masl. Chepang (an ethnic community of Nepal) communities process plant fat from butter tree fruit seeds. These trees are mostly grown for production of honey in some districts like Dadeldhura. Another important wild fruit with high potential is chutro (*Berberis asiatica*), a shrub with many historical uses in Nepal (Komal et al 2011). It has a potential to be promoted internationally due to high quality wine making fruits.

Utilization of fruit genetic resources in variety development

With long efforts of research in fruits, two varieties of acid lime Sunkagati-1 and Sunkagati-2 have been released while Khoku Local of mandarin and Tehrathum Local of acid lime have been registered so far. Banana germplasms particularly 'Malbhog', 'William Hybrid' and 'G9' were registered by Horticulture Research Division, Khumaltar in the National Seed Board in 2019.

Similarly, collection, characterization and evaluation of new emerging commercial fruits (dragon fruit, avocado, cherry and blueberry) in Nepal have been started since 2018.

Table 10. Released fruit varieties with yield potential and recommendation domain

Name of Fruit	Name of variety	Year of release	Registered/ released	Yield potential (t/ha)	Recommendation domain
Acid lime	Sun Kagati 1	2014	Released	34.5	Terai, inner Terai and Mid hills
	Sun Kagati 2	2014	Released	26.9	Terai, inner Terai and Mid hills
	Tehrathul Local	2018	Registered		Terai, inner Terai and Mid hills
Mandarin orange	Khoku Local	2018	Registered	16-24	Terai, inner Terai and Mid hills
Banana	Malbhog	2019	Registered	25-30	Terai, inner Terai and Mid hills
	William Hybrid	2019	Registered	50-60	Terai, inner Terai and Mid hills
	G 9	2019	Registered	50-60	Terai, inner Terai and Mid hills

Source: Gotame et al 2020

Utilization of indigenous fruit genetic resource in Nepali culture

Indigenous and minor fruits are utilized in several ways in the rural households. Lapsi, Amala, Tamarind are popularly used to prepare pickles and candies. They are preserved for long term storage and used throughout the year. Small quantities of candy and pickles are imported by Nepalese communities abroad. Kafal, Aiselu, Bale, Jamun are eaten or sold fresh as they ripen. Such fruits contribute substantially to the people's diet. Bale fruit is used widely by the Newar community to perform "Bale Bibah" of young girls before menstruation, when they are five to nine years old. Leaves of bale tree are offered to Shiva temples as his favorite leaves. Due to medicinal properties of bale, its juice is becoming popular. People drink bale leaf to cure diabetes. Chiuri fruit is consumed fresh and its seeds are processed to produce ghee, the latter is popular among the Chepang community. Citron and pummelo are used during "Tihar and Chhat" festivals and are also consumed fresh. Apart from them, Newar communities use chestnut (katus), Hade bayer, Satibayer, persimmon, walnuts during the Tihar festival. While, in Brahman-Chetri communities, walnut is crushed at the door during "Bhaitika" by sisters to symbolically smash the enemies of their brothers. Due to nutritional value and beneficial health effects, the demands for different types of nuts are increasing (Thapa et al 2018).

WAY FORWARD

Fruit germplasms are scattered across the country. All the fruit germplasms are being maintained in field. Therefore, a National Genetic Resource Centre including fruit germplasm repository should be established to utilize these introduced and existing species in fruit development. Along with

germplasm repository, there should be a provision of freeze preservation and cryopreservation, in-vitro as well as a field gene banks. These fruit germplasms available in public organization and private farms should be characterized, evaluated, multiplied and selected for wider geographical recommendation based on yield performance, export quality and market niche from the single door.

CONCLUSION

The fruit diversity showed that Nepal is rich in both exotic and native fruit genetic resources, but research in fruit varietal evaluation has not been streamlined. Hence streamlining of fruit research in public sector is a pressing need of time. There are a number of remote and hard-to access areas within Nepal that have yet to be explored for potentially valuable indigenous fruit species for commercial purposes.

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