Chapter 7
Erosion and Prevention of Crop Genetic Diversity Landraces of Georgia (South Caucasus)

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Abstract Georgia (South Caucasus) has many ancient crop varieties used with very old farming traditions and owns linguistics of old civilization coinciding with early Neolithic epoch. The traditional landraces used by local people for thousands of years affected the health and human longevity of individuals in the Georgian population predicting adaptation to healthy food. Crop domestication is associated to existence of crop wild relatives (CWRs) on the territory of Georgia. Molecular studies confirmed domestication of grapevine (*Vitis vinifera*) from wild species (*V. vinifera* subsp. *sylvestris*) and pear varieties from wild Caucasian pear (*Pyrus caucasica*). Many fruits are associated to wild tree species distributed in the refugium territory of the western Georgia. Some crops: wheat, barley, ray, oats, lentil, pea, chickpea, etc., are genetically related with wild species. Therefore, the most important challenges in the near future are certainly the molecular characterization of germplasm collections for preserving them from genetic erosion and the identification of phenotypic variants potentially useful for breeding new varieties. Georgian ancient crop varieties reveal a high level of adaptation to local climatic conditions, and often have high resistance to diseases. The loss of landraces and ancient crop varieties should be considered as main threat to agrobiodiversity in Georgia. Besides the diminishing of the amount of agricultural products, the main threat to agrobiodiversity is the loss of the territory of Georgia. Additionally, there are several reasons for the genetic erosion of the ancient cultivars and the wide distribution of new varieties of introduced crops. Germplasm of the landraces extinct in the local farms are stored only in the gene banks and in the living collections of Georgia and foreign countries. One of the problems is the deficit of information about the current state of ancient crops and recommendations for their conservation are inadequate. Therefore, it is necessary to assess research needs and implications for protection of genetic resources and to formulate recommendations for the conservation and on-farm maintenance of Georgian landraces.

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7.1 Introduction

Georgia is located in the South Caucasus and owns very old agricultural traditions that have preserved to our time. Georgia officially covers a territory of 69,700 km^2, and its population is almost 4.6 million. The name of the country is “Sakartvelo” in the Georgian language but it is common name “Georgia” is semantically linked to Greek (γεωργία, transliterated geōrgía) and Latin (georgicus) roots meaning “agriculture” (Javakhishvili 1930). Archeological data clearly show that Georgian nation was settled in the Caucasus and Asia Minor areas from prehistoric time and the origin of ancient crop varieties and landraces in Georgia coincides with early Neolithic epoch. According to Vavilov (1992), the primary domestication in the fourth center of crop origin and diversity named as the Near East included the South Caucasus, Asia Minor, Iran, and the Fertile Crescent. Many local varieties and endemic species of Georgian ancient crops are known in this domesticated center. Especially, they are characterized by the introduction of the varieties of wheat, rye, oats, seed and forage legumes, herbs, fruits, and grapes for winemaking; 83 species all tolled (Zhukovskij 1962). The ownership of the local cultivars for Georgians living on this territory is confirmed by concrete names of prehistorically Georgian language, fonts, and traditions (Ketskhoveli 1957). The language of the Georgian people is not part of the Indo-European language and belong to the proto-Georgian language group known as Kartveluri (Melikishvili 1970). Moreover, the traditional landraces used by local people for thousands of years affected the health and human longevity of individuals in the Georgian population predicting adaptation to healthy food (Fox 2004). Georgian centenarians were reputed to have been over age 120 in 1959 and the percentage of males over age 70 was 0.9 % in 1959 and 1.07 % of women were over 70 (Garson 1991). This percentage of human longevity is diminished last time, when local population replaced landraces and agriculture is generally oriented on introduced cultivars from different countries.

The loss of landraces and ancient crop varieties should be considered to be the main threat to agrobiodiversity in Georgia. These varieties reveal a high level of adaptation to local climatic conditions, and often have high resistance to diseases. Colchis forest is refugium in the Western Georgia of Tertiary geologic period from 66 to 2.588 million years ago (Nakhutsrishvili 2013). The relict trees of the Colchis forest are remained from Tertiary period till recently and represent the ancestral species. According to palaeontological and palynological data, European territory contained a mixed forest of Colchis type dominated by fir-trees including *Abies nordmanniana* (Steven) Spach and pine-trees, together with the broad-leaved trees *Zelkova* Spach, *Quercus* L., *Ulmus* L., *Tilia* L., *Carpinus* L., *Corylus*

L., *Fagus* L., *Betula* L., and *Castanea* Mill (Paganelli 1996). European beech tree (*Fagus sylvatica*) contains genetic relationships with Caucasian relict *F. orientalis* throughout the Tertiary and Quaternary period, and divergence with relict is determined during the last interglacial period which started around 130,000 years ago (Peffetti et al. 2007). The relict tree species locations in forest vegetation are modeling by GIS program, which potentially existed in six regions of western Asia: Colchis forest of Georgia, western Anatolia, western Taurus, the upper reaches of the Tigris River, Levant, and the southern Caspian basin (Tarkhnishvili et al. 2012). Nowadays, the real existence of relict species is in Colchis forest and the southern Caspian basin. Relict trees are reforested in other modeling regions in the unknown period. Therefore, the Colchis forest tree species might be determined as ancestors of fruit varieties containing only few mutations in the ancient DNA sequences (Peffetti et al. 2007). Nowadays, Georgia represents the natural area of relict ancestor species domesticated as fruits and grape (Akhalkatsi et al. 2012). In spite of this priority, many landraces and ancient varieties of fruits and grape are disappeared in this country.

Besides the diminishing of the amount of agricultural products, the main threat to agrobiodiversity is the loss of the territory of Georgia. This territory in Neolithic/Eneolithic period was settled by Shulaveri-Shomu culture with archeological fossils of ancient crops starting ca. 6200 BC located in the south-eastern Georgia (Javakhishvili 1972). In the period of the 4th millennium BC, there was much large territory of Kura (Mtkvari)-Araxes-Culture with worldwide oldest gold mine named ***Sakdrisi***, Bolnisi district, which is more than 5400-year old and has great historical importance (Hauptmann and Klein 2009). This civilization was inhabited by people who spoke non-Indo-European languages and were spread from the South Caucasus till middle of the Asia Minor, where the dominant inhabitants were Hurrians and Hattians in the central Anatolia at that time (Suny 1994). By 2300 BC, the people of the Kura-Araxes area had already made contacts with the more advanced civilization of Akkadian Mesopotamia (Melikishvili 1970). At the end of the third millennium, the Indo-European population living already in the Hittites country entered in the eastern Anatolia and Georgia remain with western region of Colchis and eastern the Trialeti Culture till 1500 BC (Kavtaradze 1983). In the last centuries of the second millennium, people living in Armenia come from Hittite tablets inhabiting the Armenian plateau (Suny 1994). According to Assyrian inscriptions, the Hittite kingdom fell in about 1190 BC with participation in the destruction by proto-Georgian tribes notably the Kashkai and Tabal called as Muskhi or Meskhi (Melikishvili 1970). After this period, the Muskhi, who settled in the upper Euphrates, migrated in the east-central Anatolia (Edens 1995). The most important tribal formation of proto-Georgians in the post-Hittite period was formation of Diauehi (Diaokhi in Georgian language) in the twelfth century BC in the region to the north of present day Erzerum city in Turkey (Suny 1994). Later, Georgia was occupied by Armenian, Arabian, Mongolian, Persian, Turkish and Russian nations and finally, at 2008 year, the territory was diminished by 20 % separated by Abkhazian and South Ossetian autonomy. The loss of the territory causes migration of local population and the area remains without traditions and linguistic names.

The occupation of the territories leads to the changes of traditional agriculture. For example, the territory of South Georgian region named Tao-Klarjeti was occupied by Turkey in 1580 AD, when agriculture was substituted by cattle breeding, which caused abandonment of cultivated fields and their transformation into pastures (Javakhishvili 1930). According to old administrative documents after occupation of Georgian part by Turks, in former Georgian village Sviri in Gurjistan Vilayet in Turkey, local population was paying taxes by crops, such as wheat, barley, rye, millet, chickpea, lentil, flax, alfalfa, etc. (Jalabadze 1972). During our expedition in Gurjistan Vilayet of Turkey in 2006, we did not find any of the old traditional field crops cultivated nowadays in the villages. The agriculture in this region is abandoned and substituted by cattle breeding. All vineyards are cut and remained grapes gone wild to make thicket at roadsides and at the edges of the forests. Some vegetables were grown in small house gardens, such as cabbage, sugar beat, carrot, cucumber, tomatoes, etc. However, seeds are bought in markets and there was no information on origin of the seed material, when they might be aboriginal varieties (Akhalkatsi 2009).

Additionally, there are several reasons for the genetic erosion of the ancient cultivars and the wide distribution of new varieties of introduced crops. Intensive Genetic erosion of ancient crops started in Georgia since 1950s, which was also a period of intense selection work in breeding stations in the whole of the Soviet Union. This process has started when '***kolkhoz***' reached extreme level of development in Soviet Republics, and almost all the local varieties of cereals (wheat, barley, rye, oat, Italian millet, and millet), legumes (peas, lentils, common vetch, and faba bean), and landraces of grapes have been replaced by breeding varieties. Recently, introduction of genetically modified (GM) crops is widespread in the territory of Georgia. The conservation of the full range of plant genetic diversity has historically often been associated with the conservation of socio-economically important species, because for these plant species the full range of genetic diversity is required for high market yields. Since 1990, the agricultural market of Georgia was reduced by export diminishing after independence period. This problem was depending on protection measures in the country, which are still not being implemented at an appropriate rate. First of all, new cultivars have higher yields and are therefore preferred both as a source of food for local people and as cash crops that determines local income. Recently, new breeder's varieties of wheat and other cereals with big harvest are introduced from different countries. The second reason why local peasants began to prefer cultivating GM plants may be explained by introduction of new diseases into Georgian agricultural fields in recent years, causing harm primarily to ancient crops and vegetables. However, the introduction of new parasites has revealed that endemic cultivated plants of Georgia contain valuable selective disease-resistant material for genetic engineering.

Otherwise, the real problem is that there are no enough data to assess either the current status of the local varieties or the information about domestication process in Georgia. Germplasm of the landraces extinct in the local farms are stored only in the gene banks and in the living collections of Georgia and foreign countries. The fundamental work was done by the famous Georgian botanist Menabde (1938, 1948) on domestication and origin of wheat and barley in this region. The agricultural evidence was reported by several other Georgian authors (Ketskhoveli 1957; Khomizurashvili 1973; Akhalkatsi et al. 2012). It was studied domestication of grapevine (*Vitis vinifera* L.) from wild form (*V. vinifera* subsp. *sylvestris*) and pear varieties from wild Caucasian pear (*Pyrus caucasica*) using morphometric and systematic molecular methods confirming genetic relationships between wild populations and local cultivars of grape and pear (Ekhvaia and Akhalkatsi 2010; Asanidze et al. 2011, 2014; Imazio et al., 2013; Ekhvaia et al. 2014). However, complete evaluation of diversity of Georgian local cultivars and crop wild relatives (CWRs) has not yet been complete.

National policies and comprehensive measures are urgently needed to address the problem of conserving the genetic resources of ancient crops in Georgia. Thus, we suggest that it is necessary to establish a general overview of the types of crops that are current landraces and primitive varieties occurring in Georgia and to publish lists of indigenous landraces and CWRs of cereals, legumes, vegetables, and fruits representing direct ancestors, and endemic, rare or endangered species, in order to evaluate the sustainability of their traditional use in terms of nature conservation. Monitoring of crop diversity is now conducted by international nature conservation institutions and Georgian scientific and nongovernmental organizations to preserve the genetic resources of local cultivars. One of the problems is the deficit of information about the current state of ancient crops and recommendations for their conservation are inadequate. Therefore, it is necessary to assess research needs and implications for conservation and to formulate recommendations for the conservation and on-farm maintenance of Georgian landraces.

7.2 Diversity and Genetic Erosion of Landraces

In Georgia, the changes of agricultural land use mainly defects traditional landraces that are maintained within traditional or subsistence farming systems with small areas. Conservation of landraces is oriented on special genes derived from them for selection of modern cultivars of major crops (Zeven 1998). Landraces were widely expected to disappear with the introduction of modern cultivars, but pockets of landrace cultivation have survived, even in countries with the most industrialized and least biodiversity agriculture (Hammer et al. 1999). However, Maxted (2006) has argued that landrace diversity is the most highly threatened component of biodiversity today, and there is only little knowledge of how much diversity actually exists.

The most studied and detailed by archeology and history is the Near East. In spite of the fact that there are many cases of extinctions of landraces in Georgia, there are only a few reports for entire crop species, and there is no example of the loss of a whole species. Monitoring in the area of Georgia needs report on arable lands ingredients or archeological excavations. The term genetic erosion is concerned to crop plants, and it will need contribution of scientific results to confirm the extinction and threats for landraces and local cultivars. It was basically grape, wheat, and barley agriculture although other crops like common millet, Italian millet, pea, lentil, chickpea, faba bean, etc. Therefore, it is necessary to investigate the landraces origin and use in the historically remnant country as Georgia.

7.2.1 Genetic Erosion of Grapevine Landraces, Vitis Vinifera L. (Vitaceae)

Worldwide, the earliest archeological finding of pips of grapevine cultivars (*V. vinifera*) is discovered in the vicinity of v. Shulaveri and Arukhlo excavations (Figs. 7.1 and 7.2a). This area is located near v. Dmanisi in south-east Georgia, where are found 1.7-Myr-old specimens of small-brained hominids, which is the earliest known hominid site outside of Africa (Gabunia and Vekua 1995). The detected grapevine pipes are dated to ~6000 BC (Ramishvili 1988), when Shulaveri-Shomu culture was located in this area (Javakhishvili 1972). Other archeological evidences of prehistoric winemaking are found near v. Shulaveri and Arukhlo excavations represented by clay vessels for wine storage call ***Qvevri*** in Georgian language (Fig. 7.2b). Other archeological findings of prehistoric winemaking are found near the proximity of the Caucasian region, such as the

Fig. 7.1 Map of Georgia. The administrative regions: *1*. Abkhazia; *2*. Samegrelo-Upper Svaneti; *3*. Guria; *4*. Adjara; *5*. Racha-Lechkhumi; *6*. Imereti; *7*. Samtskhe-Javakheti; *8*. Shida Kartli; *9*. Kvemo Kartli; *10*. Mtskheta-Mtianeti; *11*. Kakheti. The places of archeological excavations are indicated: Dikha-Gudzuba, Nokalakevi, Dzudzuana cave, Arukhlo, Dmanisi and Shulaveri

Fig. 7.2 **a** Archeological finding of pips of grapevine cultivars (*Vitis vinifera*) in the Arukhlo excavations at 6000 BC located in the National Museum of Georgia, Tbilisi; **b** Archeological finding of clay vessels *Qvevri* in the vicinity of v. Shulaveri "Khramis Didi Gora" dated to 6000 BC in the National Museum of Georgia, Tbilisi; **c** *Qvevri* put in the ground of the *Marani* of Nekresi monastery, VI century AD, Kakheti region; **d** stone carving on the medieval church Ananuri, Mtskheta-Mtianeti region, Georgia; **e** *Satsnekheli* for grape pressing made from tree -*Tilia begoniifolia,* trunks; **f** preparation of *Churchkhela* with grape juice of variety Rkatsiteli in Kakheti region, v. Shilda. *Photos* by Maia Akhalkatsi

northern Iran at the Hajji Firuz Tepe site in the northern Zagros mountains, dated ca. 5400–5000 BC (McGovern 2003), and in Levant and Jericho in the Near East, where archeological findings are dated from ca. 4000 to 3200 BC (Zohary and Spiegel-Roy 1975; Zohary and Hopf 1993, 2000). However, this type of wine storage is used in the Georgian lowland regions until today. These territories belonged to the civilizations contacted to proto-Georgian nation. The name for wine in Indo-European languages was originally borrowed from the Georgian *Gwino* (Javakhishvili 1930). Therefore, Georgia is one of the oldest traditions in wine cultivation. Most researchers accept the opinion that a first domestication event occurred in Georgia (De Candolle 1882; Negrul 1946; Ketskhoveli et al. 1960; Vavilov 1992; Akhalkatsi et al. 2012; Imazio et al. 2013; Ekhvaia et al. 2014).

According to de Candolle (1882), the origin of domestication of crop plants should be determined using four type of evidence. These are archeological (or archaeobotany), botanical (the distribution of the wild, ancestral relatives), historical (a written record documenting the existence or importance of the crop) and linguistic evidence (the existence of words designating the crop or objects or concepts related to the crop in native languages). Although, additional scientific methods such as molecular systematic and radioautographic studies have increased the possibility to determine centers of crop domestication based on archeological and ethnobotanical arguments (Smith 1995). Therefore, crop origin determination needs knowledge on their history and linguistics or semiotics.

Wine is traditionally made and stored in houses called ***Marani***, where the ***Qvevri*** vessels owned by local families are located in ground (Fig. 7.2c). One of the *Qvevri* in each *Marani* is called ***Zedashe*** and contains wine that might be used only in religious rituals. The grapevine was a ritual plant and represented a tree of the Goddess of Sun in ancient religion. Nowadays, according to Georgian folk poetry, the sun is identified to mother called as “sun is my mother” (Javakhishvili 1930). Wine was used in ancient time for toasts at religious holidays. The toastmaster or *Tamada* is elected by the participants in order to present the planned toasts. When Georgian men and women drink wine, it is necessary to say a toast to the God. Ancient cups made of gold and silver as well as jewelery often display grapevines. With the Christianization (322–328 AD), St. Nino from Cappadocia introduced the first cross made from grapevine in the capital Mtskheta and, also stone carvings on Christian churches present grapes Fig. 7.2d). Ancient stone and wood constructions for the pressing of grapes called ***Satsnekheli*** in Georgian language made by tree trunk mainly by *Tilia* spp. (Fig. 7.2e). Grape is used for traditional dessert called ***Churchkhela*** made by cooking grape juice and wheat flour and added walnuts or hazelnuts as vertical lines on cotton thread (Fig. 7.2f). Dry *Churchkhela* is stored all year and used for dessert in all regions of Georgia.

The primary scientific argument of Vavilov (1992) on domestication of crops represents the idea that the centers of origin of cultivars should be characterized by high genetic and morphological variability of both wild and cultivated taxa. About 525 names of autochthonous grapevine landraces known from Georgia show greatest genetic and morphological variability characterized by a wide range of color gamma and shapes of berries and pips (Ketskhoveli et al. 1960; Akhalkatsi et al. 2012; Ekhvaia et al. 2014). These cultivars showed great ampelometric variability and broad adaptability to different climate and soil conditions (Ketskhoveli et al. 1960). It was a high importance to study aboriginal grape varieties in the place of its supposed domestication, and it was already determined genetic relations among native grapevine cultivars and local wild populations (Imazio et al.

2013; Ekhvaia et al. 2014). In the past, the wild grape species—*V. vinifera* subsp. *sylvestris*—providing an important initial impulse to the domestication of grapevine was abundant in the Minor and Greater Caucasus mountain regions (Ramishvili 1988). The distribution area was along the main river basins. The habitat types were riparian, oak-hornbeam, beech, and spruce forests up to 1000 m a.s.l. The populations nowadays are no longer as abundant after the invasion of *Phylloxera* in the middle of the nineteenth century and the current human impact by urbanization. Georgian wild grapevines showed high polymorphism (Ekhvaia and Akhalkatsi 2010). They are dioecious, showing high-variable frequency of female and male plants among populations. Some individuals have berries with white skin, while most have a blue–black coloration. White-fruited phenotype is considered to be determined by the variation present in the gene VvmybA1, a transcriptional regulator of anthocyanin biosynthesis (This et al. 2006). All five haplotypes detected using cpDNA microsatellite markers have been found in the Caucasian ecoregion suggesting that this area is possibly the center of origin of both wild and cultivated grapevines (Grassi et al. 2006). Several autochthonous Georgian varieties—'Saperavi,' 'Rkatsiteli,' 'Tavkveri,' 'Chvitiluri,' 'Kachichi,' 'Shonuri,' and 'Uchakhardani' are genetically related to wild grape populations located in gorges of River Mtkvari, R. Lekhura, and R. Alazani (Akhalkatsi et al. 2012). One of the oldest Georgian grape cultivar 'Krikina,' which is morphologically nearly identical to wild grapevine, shows the genetic similarity to the most ancient Georgian cultivars 'Meskhuri Shavi' cultivated on Meskhetian terraces.

Agricultural regions in Georgia have classified by production of wine (Javakhishvili 1930). Lowlands called *Bari* (0–1300 m a.s.l.) are oriented on wine production and high mountain lands called *Mta* (1300–2200 m a.s.l.) produce beer from barley. Winemaking was main business of agriculture in Georgia. Wine was exporting from Georgia since ancient times. The vineyards were cut down to reduce income for exporting the wine in neighbor countries during the occupation of the country by the Muslim nations. This process causes diminishing of autochthonous Georgian varieties. The other threats started in 1860, the *V. vinifera* was virtually wiped out in the places of its origin, when an aphid, *Phylloxera vastatrix* was accidentally introduced into France, and within a few years had ravaged all vineyards in Europe and in Georgia as well. In currently, almost all Georgian grape varieties have grafted on rootstocks of American grapevines—*V. riparia, V. rupestris,* and *V. berlandieri* and their hybrids, which are resistant to *Phylloxera*. This disaster made it necessary to undertake urgent steps for ex situ conservation of old, endangered and autochthonous grapevine varieties by establishing living collections in Georgia; this had begun in the 1930s. The collections of plant genetic resources were established in research institutes, which have been under reforms since 1990s and operating with diminishing funding to maintain the collections. In 2003, 949 varieties were protected in the living collections. Among them, 701 were cultivars obtained from selective breeding and only 248 of the 525 autochthonous Georgian varieties remain. Recently, these collections have been closed. Nevertheless, some effort has been made to establish new collections in Telavi (573 accessions), Skra (440), and Vachebi (312) in 2008 (Maghradze et al.

2010). The last collection was prepared by organization “Agro Kartu” in surrounding of v. Jighaura, Mtskheta district “Centre for Grapevine and Fruit Tree Planting Material Propagation” with ca 400 varieties. The University of Milan established the new collection in Italy (Maghradze et al. 2010). Some Georgian cultivars are in living collections abroad in Russia, Moldova, and Germany. A small living grapevine collection exists in the G. Eliava National Museum in Martvili district, Samegrelo province, founded in 1972 and containing 24 old Colchis grapevine varieties (Eliava 1992). Seven cultivars of Meskheti region have been collected in the research station of Biological Farming Association Elkana in village Tsnisi, Akhaltsikhe district. Many grape landraces are extinct and do not exist even in living collections.

Georgian native varieties are incorporated in Georgian plant breeding programs in Georgia as in other foreign countries (Imazio et al. 2013). Recently, 193 new varieties were bred in 15 countries, with the contribution of 13 Georgian native varieties (Vakhtangadze et al. 2010). Particularly interesting under this point of view seems to be the history of the Georgian variety ‘Saperavi’ extensively used in Ukraine breeding programs (Goryslavets et al. 2010). Many varieties in neighbor countries are exported from Georgia in Soviet period. Armenia and Azerbaijan have archeological remnants of grape from Kura-Arexes culture on their territories, but the traditions on viticulture these migrated nations did not had and Soviet time they started to produce wine and schnapps from Georgian varieties. Therefore, the name of grapevine cultivars remained as Georgian names, e.g., Armenian varieties ‘Kachet’ means region Kakheti, ‘Mskhali’ means pear in Georgian language, etc. The molecular comparison of varieties with different names in the South Caucasus leads to similarity of these varieties and Armenian ‘Kachet’ and Georgian ‘Kisi’ are located in one cluster of the dendrogram of genetic analyses (Vouillamoz et al. 2006). Historically, it is known that ‘Saperavi’ was exported from v. Tsinandali, Kakheti region to France in nineteenth century (Javakhishvili 1930). Thus, the knowledge on traditions and linguists data is necessary to carry out studies on the crop domestication.

The total area of vineyards in Georgia is 37,421 ha. The largest area of vineyards is located in Kakheti region (Fig. 7.3a) and intensively produced varieties are ‘Rkatsiteli’ for white wine and ‘Saperavi’ for red wine (Table 7.1). Tsolikauri and Tsitska are distributed in Imereti region of the west Georgia (Fig. 7.1). Total 35 autochthonous and 9 introduced varieties are distributed on arable lands. The home gardens contain other local varieties in small amount. Strongly diminished arable land area is in Meskheti, Samtskhe-Javakheti region (Fig. 7.3a). The vineyards in Meskheti was growing on the terraces of Mediterranean type (Fig. 7.3b) in the historic province of Tao-Klarjeti located now in southern Georgia and in the province of Artvin, Turkey. The vineyards of Meskheti were destroyed to the destruction of human settlements. Since fifteenth century, the Seljuk Turks occupied this territory and the vine terraces disappeared, and it was covered with trees or grasses (Fig. 7.3b). However, we have found peasants in some villages of Meskheti province searching for old cultivars in abandoned settlements and some landraces are replanted in house gardens. We have found ancient

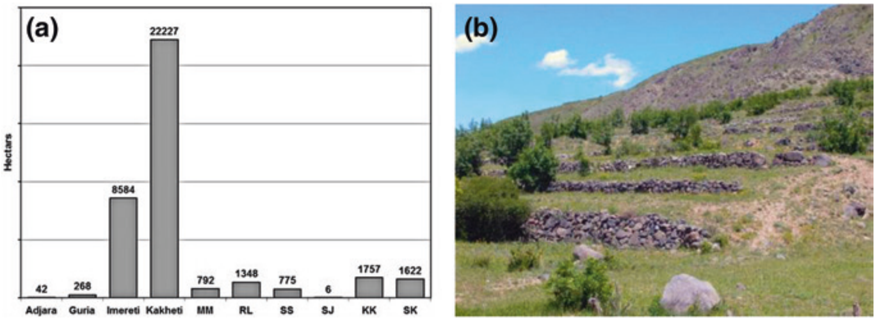

Fig. 7.3 **a** Hectares of vineyards in Georgian regions: *MM* Mtskheta-Mtianeti, *RL* Racha-Lechkhumi, *SS* Samegrelo-Upper Svaneti, *SJ* Samtskhe-Javakheti, *KK* Kvemo Kartli, *SK* Shida Kartli; **b** ancient agricultural terraces in Meskheti, Samtskhe-Javakheti region. *Photo* by Maia Akhalkatsi

Table 7.1 The hectare amounts of grapevine local and introduced varieties in areas of vineyards of Georgia

N	Georgian varieties	Area of vineyards, >20 ha	Georgian varieties	Area of vineyards, <20 ha	Introduced and hybrid varieties	Area of vineyards (ha)
1	Rkatsiteli	19,741	Kisi	20	Isabella (Adessa) Red	413
2	Tsolikauri	6161	Chkhaveri	20	Cabernet Sauvignon	223
3	Saperavi	4300	Shavkapito	10	Pinot Noir	171
4	Tsitska	2839	Kachichi	9	Isabella (Adessa) white	151
5	Chinuri	955	Tbilisuri	9	Aligote	97
6	Dzvelshavi	685	Skhalatubani	9	Pino Gris	91
7	Lomiauri	299	Avisirkhva	7	Chardonnay	2
8	Kakhuri mtsvane	249	Kartuli Tita	7	Chasselas	2
9	Goruli mtsvane	224	Ganjuri	6	Muscat white	1
10	Aleksandrouli	161	AsureTuli shavi	5	Muscat × Aleksandrouli	0.25
11	Rachuli tetra	152	Otskhanuri Sapere	5		
12	Ojaleshi	141	Budeshuri	2		
13	Mujuretuli	58	Mgaloblishvili	1		
14	usakhelouri	57	Khikhvi	1		
15	Aladasturi	46	Dondglabi	1		
16	Krakhuna	36	Kartuli Saadreo	0.01		
17	Tavkveri	29				
18	Orbeluri	25				

grapevine varieties growing before on terraces—'Samariobo Red,' 'Kharistvala Red,' 'Tskhenisdzudzu White,' 'Budeshuri White,' 'Chitiskvertskha White,' etc. Additionally, 'Meskhuri Shavi' (Red) and 'Meskhuri Mtsvane' (Green) are frost resistant and growing in high mountain areas in villages Zemo Vardzia (1322 m a.s.l.), Chachkari (1264 m a.s.l.), Aspindza district; and, Karzameti castle near boundary to Turkey, 1450 m a.s.l.

In conclusion, it should be mentioned that the Georgian cultivated and wild grapevines represent a unique and interesting genetic resources, which are characterized by a high similarity level between wild and cultivated grapevines. The admixture found among local Georgian cultivars and wild grapevine indicates the possibility that these cultivars are derived from ancestral domestication of local wild types. It should be noted that wild grapevine populations occurring nowadays on the territory of Georgia are threatened by different impacts in their natural habitats and need to be protected. Thus, the obtained data are supporting that Georgia is one of the oldest centers of domestication of grapevine and harbor of valuable genetic resources for grape breeding.

7.2.2 Genetic Diversity and Erosion of Cereals

The archeological findings from ancient period of cereal grains in Georgia were discovered from Arukhlo excavations, Nokalakevi settlement and Dikha-Gudzuba (Fig. 7.1). The date includes periods from sixth to second millennium BC (Melikishvili 1970). These archeological monuments presented ancient cities with many buildings contain a lot of gold jewelleries, linen and wool clothing, and many remnants of old food as well in burials (Javakhishvili 1972). The arable lands in Arukhlo excavations were irrigated. The cultivated cereals grains are presented in Arukhlo excavations by seven species of cultivated wheat—*Triticum aestivum, T. spelta, T. carthlicum, T. macha, T. monococcum, T. dicoccum, T. compactum* and one wild relative *Aegilops cylindrica* have been discovered (Menabde 1948). Other cereals: millet—*Panicum milleaceum*, barley—*Hordeum vulgare*, Italian millet—*Setaria italica*, oats—*Avena sativa*, wild lentil—*Lens ervoides,* and pea—*Pisum sativum* have been found in the same site and in Dikha-Gudzuba. Additionally, *T. macha* is archeologically findings in Dikha-Gudzuba and Shulaveri excavations dated by Neolithic period (Javakhishvili 1972) and was cultivated in Racha-Lechkhumi, Imereti, and Samegrelo up to 1950s (Dekaprelevich 1947). A wide range of carbonized seeds, including wheat (*Triticum* sp.), pea (*Pisum sativum*), rowan (*Sorbus* sp.), and walnut (*Juglans regia*), are found in soil samples in Nokalakevi, Western Georgia, dated to the Hellenistic period (Grant et al. 2009).

The cereals of Georgia were studied by Menabde (1948), who investigated origin and phylogenetic relationships of wheat and barley wild and cultivated species distributed in Georgia. The first sign of cereal domestication is the evidence that ears of cultivated cereal crops became less brittle in difference with their wild relatives characterized by easy shattering of spikes into spikelets upon maturity, which is essential for seed dispersal and survival in the wild, whereas forms with non-brittle ears survive only under cultivation. It is generally assumed that most Triticeae crops have been domesticated from their wild relatives by selection of non-shattering individuals, which sporadically appear in wild populations as rare mutants (Zohary and Hopf 1993). Georgia gives rise to such important crops such as wheat, barley, lentil, chickpea, and pea.

Wheat—*Triticum* spp. According to Menabde (1948), historically distributed 16 cultivated wheat species, 144 varieties, and 150 forms were registered in Georgia in the 1940s (Table 7.2). Among them five species of wheat are Georgian endemics: (1) *Triticum timopheevii* (Zhuk.) Zhuk. subsp. *timopheevii* (***Chelta Zanduri*** in Georgian language), (2) *T. zhukovskyi* V.L. Menabde & Eritzjan (***Zanduri***), (3) *T. turgidum* L. subsp. *carthlicum* (Nevski) Á. Löve & D. Löve (***Dika***), (4) *T. turgidum* L. subsp. *palaeocolchicum* Á. Löve & D. Löve (***Kolkhuri Asli***), and (5) *T. aestivum* L. subsp. *macha* (Dekapr. & V.L. Menabde) Mackey (***Makha***). Seven species are with aboriginal varieties: (1) *T. monococcum* L. (***Gvatsa Zanduri***), (2) *T. turgidum* L. subsp. *dicoccon* (Schrank) Thell. (***Asli***), (3) *T. turgidum* L. subsp. *durum* (Desf.) Husn. (***Tavtukhi***), (4) *T. turgidum* L. subsp. *turgidum* (***Khorbali***), (5) *T. turgidum* L. subsp. *polonicum* (L.) Thell. (***Khorbali***), (6) *T. aestivum* L. subsp. *aestivum* (***Ipkli, Khulugo***), and (7) *T. aestivum* subsp. *compactum* (Host) Mackey (***Kondara, Chagvera, Nagala Puri***). Four species represent geographical races distributed in Georgia from historic periods: (1) *T. aestivum* subsp. *spelta* (L.) Thell., (2) *T. aestivum* subsp. *sphaerococcum* (Percival) Mackey, (3) *T. abyssinicum* Vav. and (4) *T. turgidum* L. subsp. *turanicum* (Jakubz.) Á. Löve & D. Löve.

Additionally, three species from the list are wild: (1) *T. boeticum* ($2n = 14$), (2) *T. dicoccoides* ($2n = 28$), and (3) *T. timopheevii* subsp. *armeniacum* ($2n = 28$); they were mixed with cultivars in the wheat fields and did not exist in natural habitats in Georgia (Menabde 1948). Sites of *T. boeoticum* are concentrated in the eastern Anatolia of Turkey. Studies on einkorn wheat domestication using amplified fragment length polymorphism (AFLP) show that *T. boeoticum* was domesticated in Turkey in the Karacadag Mountains close to city Diyarbakir (Heun et al. 1997). Old proto-Georgian kingdom Diauehi (Diaokhi) was adjacent region to this place in the twelfth century BC (Suny 1994). After migration of Georgian population to current regions, the wheat fields contained mixed wild spicies of *Triticum.* There is evidence that *T. boeoticum* was found in fields with *T. monococcum* in Georgia (Menabde 1948). Since the 1930s, their number has diminished and all of these species had disappeared after the 1960s, when non-aboriginal cultivars were introduced in *kolkhoz*—agricultural farming corporations in Soviet times, changing the species composition in wheat fields. At present, none of these species occurs in agricultural fields of Georgia.

The crop wild relative of wheat, *Aegilops* is related to wheat and a great number of cases have been reported documenting the transfer of genes from the wild relative to the crop, particularly for resistance characters (Hammer 1997). *Aegilops* is presented in Georgia by nine species, one subspecies, and one variety:

Table 7.2 List of wheat species distributed in Georgia by V. Menabde (1948, 1961)

No.	Taxon scientific name	*N* local varieties	Ploidy levels	2*n*	Genomic constitution	Status
1.	*T. boeoticum* Boiss.	1	2*n*	14	A^bA^b	W
2.	*T. monococcum* L.	6	2*n*	14	A^bA^b	PS
3.	*T. timopheevii* (Zhuk.) Zhuk. subsp. *timopheevii*	7	4*n*	28	A^bA^bGG	EG, PS
4.	*T. timopheevii* (Zhuk.) Zhuk. subsp. *armeniacum* (Jakubz.) Slageren	1	4*n*	28	A^bA^bGG	W
5.	*T. turgidum* L. subsp. *dicoccoides* (Körn. ex Asch. & Graebn.) Thell.	5	4*n*	28	A^uA^uBB	W
6.	*T. turgidum* L. subsp. *palaeocolchicum* Á. Löve & D. Löve	3	4*n*	28	A^uA^uBB	EG, SP
7.	*T. turgidum* L. subsp. *dicoccon* (Schrank) Thell.	1	4*n*	28	A^uA^uBB	SP
8.	*T. turgidum* L. subsp. *durum* (Desf.) Husn.	17	4*n*	28	A^uA^uBB	SP
9.	*T. turgidum* L. subsp. *turgidum*	21	4*n*	28	A^uA^uBB	SP
10.	*T. turgidum* L. subsp. *carthlicum* (Nevski) Á. Löve & D. Löve	4	4*n*	28	A^uA^uBB	EG, SP
11.	*T. turgidum* L. subsp. *polonicum* (L.) Thell.	4	4*n*	28	A^uA^uBB	SP
12.	*T. turgidum* L. subsp. *turanicum* (Jakubz.) Á. Löve & D. Löve	1	4*n*	28	A^uA^uBB	IS
13.	*T. dicoccon* subsp. *abyssinicum* Vavilov	1	4*n*	28	A^uA^uBB	IS
14.	*T. aestivum* L.	26	6*n*	42	A^uA^uBBDD	SP
15.	*T. aestivum* L. subsp. *macha* (Dekapr. & V.L. Menabde) Mackey	12	6*n*	42	A^uA^uBBDD	EG, PS
16.	*T. aestivum* subsp. *spelta* (L.) Thell.	12	6*n*	42	A^uA^uBBDD	IS
17.	*T. aestivum* subsp. *sphaerococcum* (Percival) Mackey	9	6*n*	42	A^uA^uBBDD	IS
18.	*T. aestivum* subsp. *compactum* (Host) Mackey	14	6*n*	42	A^uA^uBBDD	SP
19.	*T. zhukovskyi* V.L. Menabde & Eritzjan	1	6*n*	42	$A^bA^bA^bA^bGG$	EG, SP

The status of species is based on phylogenetic studies of V. Menabde (1948, 1961): *EG* endemic of Georgia; *W* wild; *PS* primary species; *SP* secondary species; *IS* introduced species. Ploidy levels and genomic constitution are indicated

Ae. tauschii Coss. subsp. *tauschii, Ae. tauschii* Coss. subsp. *strangulata* (Eig) Tzvelev, *Ae. tauschii* Coss. var. *meyerii* (Griseb.) Tzvelev, *Ae. biuncialis* Vis.; *Ae. columnaris* Zhuk.; *Ae. comosa* Sm., *Ae. cylindrica* Host; *Ae. geniculata* Roth, *Ae. neglecta* Req. ex Bertol.; *Ae. triuncialis* L.; and *Ae. umbellulata* Zhuk. Among them is *Ae. tauschii*, which is considered to be direct ancestor of bread wheat with highest level of gene diversity in populations (0.94) found in a group of accessions from Georgia, Armenia and Daghestan (Pestsova et al. 2000). The D genomes of all varieties of *T. aestivum* were found to be most closely related to accessions of the *Ae. tauschii* subsp. *strangulata* genepool (Fig. 7.4a), which is distributed in the south-eastern Georgia near the archeological areas of Arukhlo and Shulaveri.

The traditional wheat fields in all regions of Georgia usually contain several species and varieties (Eritzjan 1956; Zhizhizlashvili and Berishvili 1980). Bread wheat fields contain: *T. aestivum* var. *erythrospermum* 'Tetri dolis puri,' *T. aestivum* var. *ferrugineum* 'Tsiteli dolis puri,' *T. aestivum* var. *lutescens* 'Upkho tetri dolis puri,' *T. aestivum* var. *milturum* 'Upkho tsiteli dolis puri,' *T. compactum* 'Kondara khorbali.' Usually, this combination of wheat taxa is associated with wild weed ***Makhobeli***—*Cephalaria syriaca* (L.) Schrad. ex Roem. & Schult. (Dipsacaceae) occurring most often in such wheat fields (Fig. 7.4b). The seeds of this species are of the same size as wheat and after threshing, remain in the harvest. Seeds are ground into a powder used with wheat to make bread, cakes, etc. It adds a nice flavor but quickly goes rancid. Another combination of varieties was dominated by *T. durum* 'Shavpkha' composed by *T. durum* var. *apulicum, T. durum* var. *leucurum, T. durum* var. *murciense, T. aestivum* var. *erythrospermum, T. aestivum* var. *pseudo-barbarossa, T. aestivum* var. *lutescens, T. compactum* var. *erinaceum* (Menabde 1948). This population is adapted to dry climate in the lowland areas and in the high elevations up to 1800 m a.s.l. in Javakheti Plateau, where it is sown in early spring. The same character of adaptation to high elevation is typical for the wheat species *T. carthlicum* '*Dika,*' sown on high mountain areas in spring. The combination of varieties dominated by '*Dika*' is as follows: *T. carthlicum* var. *rubiginosum, T. carthlicum* var. *stramineum, T. aestivum* var. *erythrospermum, T. aestivum* var. *ferrugineum, T. compactum* var. *erinaceum* (Zhizhizlashvili and Berishvili 1980).

Wheat is main product for the bread in Georgia. Bread is called ***Puri*** (pronounced "poo-ree"), especially, the long-pointed bread called ***Shotis Puri*** or ***Dedas Puri***. Traditionally, bread is baked in a deep circular clay pot oven called a ***Tone*** (pronounced "ton-AY," Fig. 7.4c). Traditional bread is done from wheat flour with salt and water, otherwise, not used yeast. The technology of bread making is traditional for Georgia and started from Chalcolitic period. Two landraces of bread wheat—*T. aestivum* var. *erythrospermum* and *T. aestivum* var. *lutescens* are used for religious rituals in Svaneti (Girgvliani 2010). The flour of these cultivars is preserved separately from other reserves of bread wheat flour and used on religious holydays. Milled faba bean and kenaf seeds are added to the bread flour for baking ritual bread. There are barley cultivars: *H. vulgare* var. *pallidum* in Svaneti and *H. vulgare* var. *nutans* in Meskheti, used for traditional bread preparation added to the *T. carthlicum* 'Dika' flour.

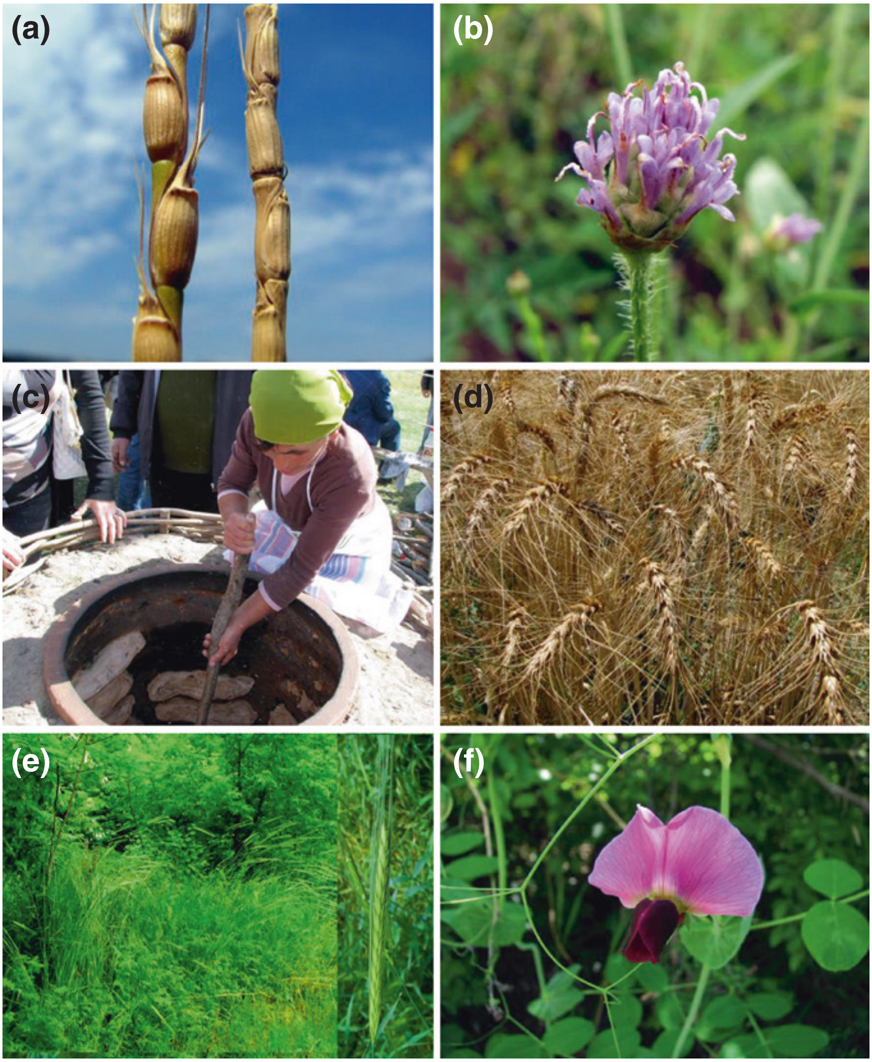

Fig. 7.4 **a** *Aegilops tauschii* subsp. *strangulata* (*left*) and *Ae. tauschii* (*right*) as genepool of **d** genomes of all varieties of *T. aestivum*; **b** wild weed ***Makhobeli***—*Cephalaria syriaca* (Dipsacaceae); **c** clay vessel '***Tone'*** baking the bread; **d** restores landrace *T. aestivum* var. *ferrugineum* 'Akhaltsikhis tsiteli dolis puri'; **e** *Hordeum spontaneum* in River Vere bank; **f** *Pisum elatius* in Oak-Hornbeam forest edges near Nekresi monastery in Kakheti region. *Photos* by Maia Akhalkatsi

Wheat fields were planted throughout Georgia at elevations from 300 to 2160 m a.s.l. We have found this highest location of soft wheat field in the Eastern Greater Caucasus, village Chero in Tusheti (Akhalkatsi et al. 2010). At present, almost none of these traditional wheat varieties and species occur in the territory of Georgia. Only aboriginal varieties of bread wheat still exist in several high mountain regions like Tusheti, Meskheti, Javakheti, and Svaneti (Pistrick et al. 2009). Living collections and gene banks preserve the local varieties. The living collection of the Biological Farming Association Elkana has many landraces in village Tsnisi, Akhaltsikhe district. In 2010, they sowed a 10 ha wheat field. The harvest from this field contained local cultivar *T. aestivum* var. *ferrugineum* 'Akhaltsikhis tsiteli dolis puri' (Fig. 7.4d) and weed ***Makhobeli*** **(**Fig. 7.4b**)**. The flour was baked as bread in Tbilisi and as traditional bread in Meskheti.

Nowadays, there is only bread wheat, *T. aestivum* to be cultivated in Georgia on 94,865 ha. Some varieties are local cultivars breeding in Georgian Selection Stations during 1960–1985 years. These varieties produced from Georgia: 'Vardzia,' 'Dolis Puri 35-4,' 'Dzalisura 35-3,' 'Kakhi-8,' 'Tbilisuri-5,' 'Mukhranuli-7,' etc., are local breeding cultivars and are very similar to bread wheat landraces. Mainly, there are introduced American bread wheat varieties 'Copper' and 'Jagger,' Turkish 'Sultan-95,' Russian 'Basostaya-1' introduced from 1960s in *kolkhoz* remains in Eastern Georgia fields. The landraces seeds are protected in gene bank and living collection. Recently, Georgian monastery priests are oriented on cultivation of landraces of Georgian crops and a wheat variety are sowing from gene banks and in the future is expected restoration of local cultivars.

Barley—*Hordeum vulgare* L. (Poaceae) is the second most important cereal in Georgia after wheat and main crop in high mountain regions used for bread, forage and production of beer, as well as an attribute of religious rituals and in the folk medicine (Javakhishvili 1930). Two different names used for barley in Georgian language—*Krtili* and *Keri*. *Krtili* denotes six-row winter barley (*H. vulgare* subsp. *hexastichon* [L.] Čelak.), which is sowed in autumn; *Keri* refers to two-row summer barley (*H. vulgare* subsp. *distichon* [L.] Körn.), which is sowed in spring (Menabde 1938). The direct ancestor of barley—*H. spontaneum* K. Koch is distributed in River Kura (Mtkvari) valley with joint river gorges (Fig. 7.4e). Six-row barley is sowed in lowland areas. Two-row barley was cultivated mainly in high mountain regions. The cultivars of two-row barley *H. vulgare* var. *nutans* 'Akhaltesli' and *H. vulgare* var. *nigrum* Willd. 'Dzveltesli shavpkha' are distributed up to 2100 m a.s.l. in all high mountain areas. *H. vulgare* var. *nutans* is mixed in the field with wheat—*T. carthlicum* 'Dika,' and the flour is produced from mixed wheat and barley seeds. *H. vulgare* var. *nudum* Spenn. 'Kershveli' was cultivated in Meskheti and Svaneti. Four-row barley (*H. vulgare* subsp. *tetrastichon* [Stokes] Čelak.) is rare and the cultivar—*H. vulgare* var. *pallidum* Ser. 'Tetri Keri' occurs only in the high mountain region of Meskheti, Tusheti, and Svaneti up to 2130 m a.s.l. These cultivars persist today only in high mountain regions. However, their distribution has been seriously diminished. At present, introduced varieties of barley are widely cultivated in the lowlands and their names are unknown to the local population.

Rye—*Secale cereale* L. (Poaceae) is only a local cultivar of high mountain regions of Georgia (1800–2200 m a.s.l.). Fields of *S. cereale* ($2n = 14$) are now found only in Upper and Lower Svaneti and Meskheti. Rye was used for making alcohol and as forage. The wild species, *S. segetale* (Zhuk.) Roshev. ($2n = 42$), called 'Svila' is widespread in wheat and barley fields and is harvested together with them. The bread of wheat with 'Svila' is considered to be very nutritious and has good taste. An endemic species of rye is *S. vavilovii* Grossh. ($2n = 14$). It is also called Caucasian rye. This species was found in wheat field in Georgia (Bockelman et al. 2002). We have monitored the place in village Beghleti, Khashuri district in 2008, where Georgian botanists had noted the presence of this species in the wheat fields, but cultivated plots no longer exist in that area. The village has lost of most of its residents and no agriculture is undertaken there. Introduced cultivars and commercial varieties of rye are not used in Georgia.

Oats—*Avena sativa* L. (Poaceae) is a traditionally cultivated plant distributed from 400 to 1400 m a.s.l. It is used only as forage for horses and poultry. Two varieties of oats have been described for Upper Svaneti—*A. sativa* var. *aurea* Körn. and *A. sativa* var. *krausei* Körn. (Ketskhoveli 1957). In lowlands, usually, the origin of the seeds is unknown to local farmers. It is purchased in the market and farmers receive no information about their origin.

Millet—*Panicum miliaceum* L. (Poaceae) is very old agricultural plant cultivated in all regions of Georgia. It was used as a supplementary feed (for animals and poultry) and for making alcoholic drinks. At present, it is cultivated only in high mountain regions (1000–1800 m a.s.l.). Several varieties are described in upper and lower Svaneti: *P. miliaceum* var. *aureum* V.M. Arnold & Shibaiev.—grain yellow or cream; *P. miliaceum* var. *subaereum* Körn.—grain gray; *P. miliaceum* var. *griseum* Körn.—grain brown; *P. miliaceum* var. *atrocastaneum* Batalin ex V.M. Arnold & Shibaiev.—grain black; *P. miliaceum* var. *badium* Körn.—grain white (Zhizhizlashvili and Berishvili 1980). The acreage of millet fields declined after introduction of maize in Georgia in seventh century. **Italian millet—*Setaria italica* (L.) P. Beauv. (Poaceae)** was cultivated in Colchis, Samegrelo since ancient times. The cultivar—*S. italica* subsp. *colchica* (Dekapr. & Kaspar.) Maisaya & Gorgidze was represented with 32 landraces (Maisaia et al. 2005). It was cultivated for a long time but was replaced by maize cultivated on 162,875 ha. It can currently be found in the Samegrelo region of western Georgia. Another subspecies—*S. italica* subsp. *moharia* (Alef.) H. Scholz., is called *Kvrima* in Georgian.

7.2.3 Biodiversity of Landraces and CWRs of Fruits and Vegetables

Extinct local landraces are detected as legumes—peas, lentils, chickpeas, faba beans, common vetch, bitter vetch, chickling vetch, alfalfa, sainfoin, and blue fenugreek containing CWRs in Georgia. The local cultivar of green pea, *P. sativum* subsp. *transcaucasicum* Govorov, has 14 varieties (Kobakhidze 1974). Another cultivar species, *P. arvense* is distributed only in home gardens with purple flowers, ridged dark colored seeds. One wild species *P. elatius* Steven ex M. Bieb. with dark purple flowers is often found in locations of old settlements, ruins of monasteries, and churches and inside castle walls (Fig. 7.4f). Local varieties of Chickpea (*Cicer arietinum*) are rarely cultivated today. Three subspecies and 24 varieties were available in western Georgia—Racha-Lechkhumi, Svaneti and Imereti up to 1920s (Dekaprelevich and Menabde 1929). Chickpeas were traditionally available in Svaneti, but by the 1970s only one farmer was sowing it in Kala community village Khe (Zhizhizlashvili and Berishvili 1980). The Biological Farming Association Elkana is producing local cultivars of chickpea and selling them in market. Lentil (*Lens culinaris*) was represented in Georgia by two subspecies—*L. culinaris* subsp. *macrosperma* N.F. Mattos and *L. culinaris* subsp. *microsperma* N.F. Mattos; and 15 varieties (Kobakhidze 1974). Two wild species (*Lens nigricans* (M. Bieb.) Webb & Berth. *Lens ervoides* (Brign.) Grande) are available on the territory of Georgia. Lentil was cultivated in Meskheti till 1970s and in Svaneti till 2008. Now it is completally extinct and the Biological Farming Association Elkana is producing local cultivars of lentil for the market. Faba bean (*Vicia faba*) with three varieties and 31 subvarieties are described in Georgia with small (*V. faba* var. *minor* Beck.), medium (*V. faba* var. *equina* Pers.), and large (*V. faba* var. *major* Harz.) seeds (Kobakhidze 1974). At present, the large seed Faba bean is widely distributed only in upper and lower Svaneti. Chickling vetch (*Lathyrus sativus*) is used as human food in a soup to called s*hechamandi.* It is also green forage, used as silage and fed as seed flour to pigs and poultry. It is now available only at the research station of the Biological Farming Association Elkana. Bitter vetch—*Vicia ervilia*—is distributed in Meskheti and Javakheti. There are cultivated and wild species of this species. It is used as a forage and for soil enrichment with nitrogen. Common vetch (*Vicia sativa*) is used as forage and for hay, especially in upper and lower Svaneti and Javakheti. It is a valuable forage crop, rich in proteins. More often, it appears as a weed in the fields of high mountain areas among grain crops—millet, barley, and rye. Sainfoin (*Onobrychis* spp.), alfalfa (*Medicago sativa*), and clover (*Trifolium* spp.) are forage legumes. A local variety of *Onobrychis transcaucasica* Grossh. 'Akhalkalakuri,' is widely used. Blue fenugreek (*Trigonella caerulea*) is traditional spice plant used in almost all of the foods of Georgian cuisine. It is available in all regions of Georgia. CWR grain legumes such as *Phaseolus, Vicia, Vigna, Lens, Lathyrus, Cicer*, and some vegetables and industrial crops.

Vegetable and herb landraces are represented by sugar beets, spinach, carrots, radishes, turnips, onions, Welsh onion, leeks, garlic, parsley, coriander, tarragon, sweet basil, savory, gardencress pepperweed, dill, fennel, celery, garden lettuce, peppermint, etc. (Akhalkatsi et al. 2012). These landraces are not threatened as are cultivated in home gardens, and all villages contain these varieties.

Large agricultural product in Georgia is oriented on fruits and vegetables (Fig. 7.5a). Many cultivated plants have been introduced since ancient times to Georgia from other regions of the world (Javakhishvili 1930).

Some introduced crops have become very popular and widespread: cucumber (*Cucumis sativus)*, eggplant (*Solanum melongena*), marigold (*Tagetes patula*), and black pepper (*Piper nigrum*) were introduced from India; Watermelon (*Citrullus lanatus*) from South Africa; Maize (*Zea mays*), sunflower (*Helianthus annuus*),

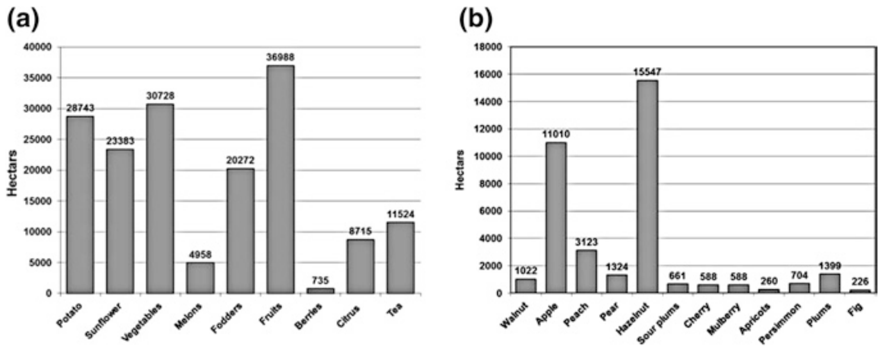

Fig. 7.5 **a** Hectares of vegetables and fruits in Georgia; **b** hectares of fruits in Georgia

tomato (*Solanum lycopersicum*), bean (*Phaseolus vulgaris*), pepper (*Capsicum annuum*), and potato (*Solanum tuberosum*) were introduced from the Americas at about the same time as in Europe (Javakhishvili 1930). Tea (*Camellia sinensis*) and citrus fruits (*Citrus limon, Citrus reticulata, and Citrus sinensis*) came from China in the 1830s. *Nicotiana rustica,* (tutuni in Georgian) has been cultivated for a long time and *N. tabacum*, was introduced during the Soviet period, and was cultivated in *kolkhoz* for commercial use. In spite of many introduced vegetables and fruits, there are local varieties of many cultivated plants, which are diminished and occur under threats.

Fruits are valuable landraces in Georgia. Most fruit trees in Georgia are wild in forests and have cultivars domesticated from these wild ancestors (Asanidze et al. 2011). Perennial fruits, nuts, and citruses are reduced by territories from 101,400 ha in 1990 to 60,000 ha at 2005. Mainly reduced the landraces and introduced varieties are added to apple and pear in high value (Fig. 7.5b).

Almost all landraces are associated to CWRs distributed on the territory of Georgia. Total of 20 plant families, 76 genera, and 479 species were identified as wild relatives of ancient crops in Georgia (Akhalkatsi et al. 2012). Most of these plant species are closely related genetically to landraces and might be their progenitor species, according to gene pool concept (Maxted et al. 2006). Some CWRs are identified as Primary Gene Pool (GP-1), within which GP-1A are the cultivated varieties and GP-1B are the wild or weedy forms of the crop; and Secondary Gene Pool (GP-2) which includes the coenospecies (less closely related species) from which gene transfer to the crop is possible but difficult using conventional breeding techniques. The GP-1 and GP-2 are determined for landraces of fruits, cereals, legumes, herbs and grape (Table 7.3). Twenty-five species are taxonomically similar as cultivars and CWRs with GP-1A but distributed in natural habitats. Twenty species are very close related to cultivars and are determined as GP1B. GP2 means possibility of gene transfer between cultivars and CWRs. Many fruits are domesticated in the Caucasus from wild ancestors representing Primary Gene Pool (GP-1B) to be the wild species of the trees. The fruit crops (GP1A) and ancestor species (GP-1B) are the following: Pome fruits—pear (*Pyrus*

Table 7.3 Gene pool and taxon group of CWRs to Georgian ancient crops

GP	TG	Crop	CWRs	Family
GP1A	TG1A	*Cannabis sativa*	*Cannabis sativa* L.	Cannabaceae
GP1A	TG1A	*Castanea sativa*	*Castanea sativa* Mill.	Fagaceae
GP1A	TG1A	*Carum carvi*	*Carum carvi* L.	Apiaceae
GP1A	TG1A	*Cornus mas*	*Cornus mas* L.	Rosaceae
GP1A	TG1A	*Diospyros lotus*	*Diospyros lotus* L.	Ebenaceae
GP1A	TG1A	*Ficus carica*	*Ficus carica* L.	Moraceae
GP1A	TG1A	*Fragaria vesca*	*Fragaria vesca* L.	Rosaceae
GP1A	TG1A	*Humulus lupulus*	*Humulus lupulus* L.	Cannabaceae
GP1A	TG1A	*Juglans regia*	*Juglans regia* L.	Juglandaceae
GP1A	TG1A	*Lepidium sativum*	*Lepidium sativum* L.	Brassicaceae
GP1A	TG1A	*Linum usitatissimum*	*Linum usitatissimum* L.	Linaceae
GP1A	TG1A	*Mespilus germanica*	*Mespilus germanica* L.	Rosaceae
GP1A	TG1A	*Morus alba*	*Morus alba* L.	Moraceae
GP1A	TG1A	*Morus nigra*	*Morus nigra* L.	Moraceae
GP1A	TG1A	*Petroselinum crispum*	*Petroselinum crispum* (Mill.) A. W. Hill	Apiaceae
GP1A	TG1A	*Pisum sativum*	*Pisum sativum arvense* (L.) Poir.	Fabaceae
GP1A	TG1A	*Prunus cerasifera*	*Prunus cerasifera* Ehrh. var. *divaricata* (Ledeb.)L.H.Bailey	Rosaceae
GP1A	TG1A	*Prunus domestica*	*Prunus domestica* L. subsp. *insititia* (L.) C. K. Schneid.	Rosaceae
GP1A	TG1A	*Punica granatum*	*Punica granatum* L.	Punicaceae
GP1A	TG1A	*Rubus idaeus*	*Rubus idaeus* L.	Rosaceae
GP1A	TG1A	*Secale cereale*	*Secacle cereale* L. subsp. *segetale* Zhuk.	Poaceae
GP1A	TG1A	*Staphylea colchica*	*Staphylea colchica* Steven	Staphyleaceae
GP1A	TG1A	*Staphylea pinnata*	*Staphylea pinnata* L.	Staphyleaceae
GP1A	TG1A	*Trigonella caerulea*	*Trigonella caerulea (L.) Ser.*	Asteraceae
GP1A	TG1A	*Vicia sativa*	*Vicia sativa* L.	Fabaceae
GP1B	TG1B	*Asparagus officinalis*	*Asparagus verticillatus* L.	Asparagaceae
GP1B	TG1B	*Asparagus officinalis*	*Asparagus caspius* Schult. & Schult. fil.	Asparagaceae
GP1B	TG1B	*Asparagus officinalis*	*Asparagus officinalis* L.	Asparagaceae
GP1B	TG1B	*Cerasus avium*	*Cerasus avium* (L.) Moench	Rosaceae
GP1B	TG1B	*Coriandrum sativum*	*Coriandrum sativum* L.	Apiaceae
GP1B	TG1B	*Corylus avellana*	*Corylus avellana* L.	Betulaceae
GP1B	TG1B	*Cydonia oblonga*	*Cydonia oblonga* Mill.	Rosaceae
GP1B	TG1B	*Daucus carota*	*Daucus carota* L.	Apiaceae
GP1B	TG1B	*Hordeum distichon*	*Hordeum spontaneum* K. Koch	Poaceae
GP1B	TG2	*Hordeum hexastichon*	*Hordeum bulbosum* L.	Poaceae
GP1B	TG1B	*Lens culinaris*	*Lens culinaris* Medik. subsp. *orientalis* (Boiss.) Ponert	Fabaceae

(continued)

Table 7.3 (continued)

GP	TG	Crop	CWRs	Family
GP1B	TG1B	*Linum usitatissimum*	*Linum bienne* Mill.	Linaceae
GP1B	TG1B	*Pisum sativum*	*Pisum elatius* M. Bieb.	Fabaceae
GP1B	TG1B	*Prunus domestica*	*Prunus spinosa* L.	Rosaceae
GP1B	TG1B	*Pyrus communis*	*Pyrus caucasica* Fed.	Rosaceae
GP1B	TG1B	*Pyrus communis*	*Pyrus balansae* Decne.	Rosaceae
GP1B	TG5	*Triticum aestivum*	*Aegilops tauschii* Coss. subsp. *tauschii*	Poaceae
GP1B	TG5	*Triticum aestivum*	*Aegilops tauschii* Coss. subsp. *strangulata* (Eig) Tzvelev	Poaceae
GP1B	TG5	*Triticum aestivum*	*Aegilops tauschii* Coss. var. *meyerii* (Griseb.) Tzvelev	Poaceae
GP1B	TG1B	*Vitis vinifera*	*Vitis vinifera* subsp. *sylvestris* (C.C.Gmel.) Hegi	Vitaceae
GP2	TG2	*Amygdalus communis*	*Amygdalus georgica* Desf.	Rosaceae
GP2	TG2	*Avena sativa*	*Avena barbata* Pott ex Link	Poaceae
GP2	TG2	*Avena sativa*	*Avena sterilis* L.	Poaceae
GP2	TG2	*Beta vulgaris*	*Beta maritima* L.	Chenopodiaceae
GP2	TG2	*Brassica oleracea*	*Brassica juncea* (L.) Czern.	Brassicaceae
GP2	TG2	*Brassica oleracea*	*Brassica napus* L.	Brassicaceae
GP2	TG2	*Brassica oleracea*	*Sinapis arvensis* L.	Brassicaceae
GP2	TG2	*Carum carvi*	*Carum caucasicum* (M. Bieb.) Boiss.	Apiaceae
GP2	TG2	*Carum carvi*	*Carum grossheimii* Schischk.	Apiaceae
GP2	TG2	*Carum carvi*	*Carum meifolium* (M. Bieb.) Boiss.	Apiaceae
GP2	TG2	*Carum carvi*	*Carum porphyrocoleon* (Freyn & Sint.) Woronow	Apiaceae
GP2	TG2	*Cicer arietinum*	*Cicer caucasica* Bornm.	Fabaceae
GP2	TG2	*Corylus avellana*	*Corylus colchica* Albov	Betulaceae
GP2	TG2	*Corylus avellana*	*Corylus iberica* Wittm. ex Kem.-Nath.	Betulaceae
GP2	TG2	*Corylus avellana*	*Corylus imeretica* Kem.-Nath.	Betulaceae
GP2	TG2	*Corylus avellana*	*Corylus kachetica* Kem.-Nath.	Betulaceae
GP2	TG2	*Corylus avellana*	*Corylus pontica* K. Koch	Betulaceae
GP2	TG2	*Fragaria vesca*	*Fragaria moschata* Duch.	Rosaceae
GP2	TG2	*Fragaria vesca*	*Fragaria viridis* Duch.	Rosaceae
GP2	TG2	*Lactuca sativa*	*Lactuca georgica* Grossh.	Asteraceae
GP2	TG2	*Lactuca sativa*	*Lactuca saligna* L.	Asteraceae
GP2	TG2	*Lactuca sativa*	*Lactuca serriola* L.	Asteraceae
GP2	TG2	*Lathyrus sativus*	*Lathyrus tuberosus* L.	Fabaceae
GP2	TG2	*Lens culinaris*	*Lens nigricans* (M. Bieb.) Webb & Berth.	Fabaceae
GP2	TG2	*Lens culinaris*	*Lens ervoides* (Brign.) Grande	Fabaceae
GP2	TG2	*Malus domestica*	*Malus orientalis* Uglitzk.	Rosaceae
GP2	TG2	*Panicum miliaceum*	*Panicum capillare* L.	Poaceae

(continued)

Table 7.3 (continued)

GP	TG	Crop	CWRs	Family
GP2	TG2	*Panicum miliaceum*	*Panicum sumatrense* Roth	Poaceae
GP2	TG2	*Panicum miliaceum*	*Panicum dichotomiflorum* Michx.	Poaceae
GP2	TG2	*Ribes rubrum*	*Ribes alpinum* L.	Grossulariaceae
GP2	TG2	*Ribes rubrum*	*Ribes caucasicum* M. Bieb.	Grossulariaceae
GP2	TG2	*Satureja hortensis*	*Satureja laxiflora* K. Koch	Lamiaceae
GP2	TG2	*Satureja hortensis*	*Satureja spicigera* (K. Koch) Boiss.	Lamiaceae
GP2	TG2	*Secale cereale*	*Secale strictum* subsp. *anatolicum* (Boiss.) K. Hammer	Poaceae
GP2	TG2	*Secale cereale*	*Secale strictum* subsp. *kuprijanovii* (Grossh.) K. Hammer	Poaceae
GP2	TG2	*Setaria italica*	*Setaria viridis* (L.) P. Beauv.	Poaceae
GP2	TG2	*Setaria italica*	*Setaria verticillata* (L.) P. Beauv.	Poaceae
GP2	TG2	*Setaria italica*	*Setaria glauca* (L.) P. Beauv.	Poaceae
GP2	TG2	*Setaria italica*	*Setaria intermedia* Roem. & Schult.	Poaceae
GP2	TG2	Spinacia oleracea	*Spinacea tetrandra* Stev.	Chenopodiaceae
GP2	TG5	*Triticum aestivum*	*Aegilops biuncialis* Vis.	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops columnaris* Zhuk.	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops comosa* Sm.	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops cylindrica* Host	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops geniculata* Roth	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops neglecta* Req. ex Bertol.	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops triuncialis* L.	Poaceae
GP2	TG5	*Triticum aestivum*	*Aegilops umbellulata* Zhuk.	Poaceae
GP2	TG2	*Vicia faba*	*Vicia johannis* Tamamsh.	Fabaceae
GP2	TG2	*Vicia faba*	*Vicia narbonensis* L.	Fabaceae

GP gene pool; *TG* taxon group (Maxted et al. 2006)

communis, P. caucasica), apple (*Malus domestica, M. orietalis*), quince (*Cydonia oblonga*); stone fruits—plum (*Prunus domestica, P. domestica* var. *insititia, P. spinosa*), myrobalan (*Prunus vachushti*), sour plum (*Prunus cerasifera* var. *divaricata*), cherries (*Cerasus avium, C. vulgaris*), cornel cherry (*Cornus mas*), medlar (*Mespilus germanica*), mulberry (*Morus alba, M. nigra*), pomegranate (*Punica granatum*); berries—red raspberry (*Rubus idaeus*), currant (*Ribes rubrum, R. nigra, R. alpinum, R. biebersteinii*), common fig (*Ficus carica*), bladdernut (*Staphylea pinnata*), and nuts—such as hazelnut (*Corylus avellana*), almond (*Amygdalus communis*), and walnut (*Juglans regia*), etc. Wild and cultivated fruits reveal high species and genetic diversity in Georgia and represent rich material for future breeding activities.

7.3 Genetic Erosion and Conservation Opportunity of Landraces

Agriculture land covers approximately 2.6 million hectares (ha) in Georgia including 839,709 ha of arable lands and 1,760,292 ha of pastures in alpine zone. In 1990–1995, since independence and conflicts during the collapse of the Soviet Union, the territories of agricultural arable lands diminished by 250 thousand ha. In 2004–2012, the next problem of the agriculture sector started by reduction of arable lands about 400 thousand ha depending as well on war and economic crisis, and, additionally, the government has pursued a policy of primary production as a result of neglect. Since 2013, the totally used arable lands reach ca. 480 thousands ha. The main lost arable lands are in mountain regions of the Great Caucasus, where villages are empty, and population in migrated to urban cities and left Georgia to work in foreign countries.

The decrease of agricultural area concerns permanent crops. In 1988, the area under orchards was 130.5 thousand ha and according to the statistical department, results in 2004 it equalled 37.0 thousand ha. The area under vineyards decreased from 117.7 thousand to 37.7 thousand ha. The area under citrus plantations diminished from 27.1 thousand to 8.7 thousand, and the area under tea plantations—from 64.8 thousand to 11.5 thousand. Otherwise, areas under some temporary crops have increased: for wheat from 88.5 thousand ha in 1988 to 94.9 thousand ha in 2004, for maize (for grain) from 108.8 thousand ha to 162.9 thousand ha, for sunflower from 12.4 thousand ha to 23.4 thousand ha. Recently the total area of agricultural land divided into Arable land (472,120 ha), land under perennial plants (100,215 ha) greenhouses (311 ha), and pasture/hay meadows in settlements (267,062 ha).

Very old archeological findings, cultural heritages and so far existing high morphological and genetic diversity of ancient crops and their wild relatives show that Georgia has very old agricultural traditions that have preserved to our times. The threat of agricultural reduction was detected to lose of territories of Georgia in historical time. In the early 1990th, until Georgia get independence, it was one of the main producers and exporters of agricultural products throughout the Soviet Union. Its exports were 70 % higher than its imports (Land 2011). Afterword, agricultural sector oriented in the past for export was destroyed. As a result, the active increase of import of agricultural food products caused almost complete collapse of agriculture in Georgia. In 2004, total agricultural production had fallen by more than half compared to the preindependence period (Land 2011). A severe impact on agricultural exports had as well the Russian Federation's embargo on Georgian products, imposed early in 2006, affecting the livelihoods of rural people. Since 2010, the export has begun to increase, although, import still represents very significant amount and value. In 2009, the imported agricultural food amounted to 1156 million US$ (79 %) and the export was only 246 million US$ (21 %; FAO 2009). Recently the export is increased mainly on wine exporting. Therefore, nowadays, opportunity of significance for Georgian entrepreneurs and foreign investors in the food and agricultural sector might be presented by export opportunities either as part of an import substitution orientation.

There are several reasons for the genetic erosion of ancient cultivars and the wide distribution of new varieties of introduced crops. The reasons are new diseases into Georgian agricultural fields, causing harm primarily to ancient cereals and vegetables. However, the introduction of new parasites has revealed that the tetraploid and hexaploid endemic wheat species *T. timopheevii* and *T. zhukovskyi*, for example, are characterized by a high level of resistance to a new race (TTKS, commonly known as Ug99) and many other races of *Puccinia graminis* f. sp. *tritici* due to the wheat stem rust resistance gene Sr36 (Tsilo et al. 2008). *T. carthlicum* is characterized by immunity to diseases, a short growing period, and resistance to cold. Therefore, endemic cultivars of Georgian crop plants are important genomic species for breeding new cultivars with valuable selective disease-resistant material for genetic engineering.

Worldwide germplasm collections of crop plant species of Georgia maintained ex situ in gene banks and living collections. According to the National Biodiversity Action Plan of Georgia (Jorjadze 2005), international nature conservation institutions and Georgian scientific and nongovernmental organizations have taken care to preserve the genetic resources of local cultivars. The germplasm preserve is oriented on technologies, which generally means the generation of progressively larger amounts of genetic data. Genotyping individuals to identify the available allelic variation that makes up the phenotypes provide the groundwork on which genetic resources can be used in plant breeding (Barcaccia 2010). Phenotyping is very much linked to the usefulness of good molecular characterization, together forming the basis of progress in modern genomics research in crop plants (De Vicente et al. 2006).

Several gene banks and living collections occur in Georgia. There is one biggest genebank located at the Georgian Agrarian University Institute of Farming established in 2004 through support of International Centre for Agricultural Research in the Dry Areas (ICARDA). They owned a total 3057 accessions of local and introduced cultivars and CWRs in 2010. The other five gene banks are located in different research institutes unified with Agrarian University in 2011. Total number of germplasm accessions is 6286 in Georgian gene banks. However, the material kept in ex situ collections are not sufficient and need more contribution. Many seed banks worldwide contain about 7000 accessions of germplasm of Georgian cultivars and CWRs.

It should be emphasized that establishment and maintenance of ex situ collections and databases is just a first step in the conservation process of ancient crop varieties. The next step should be return of conserved seed material to the fields of local farmers. From 2004 to 2009, the Global Environmental Facility/United Nations Development Fund (GEF/UNDP) project "Recovery, Conservation and Sustainable Use of Georgia's Agro-Biodiversity" was carried out with the aim of conservation and sustainable use of threatened local plant genetic resources in the oldest historical mountainous region of Georgia, Samtskhe-Javakheti. This project enabled establishment of sources of primary seed and planting material for threatened crops and fruit varieties, and assisted farmers in accessing markets for organic products from such crops as lentil, pea, chickpea, faba bean, common millet, and Italian millet. Another project was the return of the Georgian wheat variety *T. aestivum* var. *ferrugineum* 'Akhaltsikhis Tsiteli Dolis Puri' in Meskheti province, where it was sown on 10 ha and produced bread that was introduced in shops featuring organic products in Tbilisi as of 2008. Afterward, this project was supported by the Georgian church, which expressed an interest in cultivating ancient crops on monastery grounds. However, these attempts have been realized only on a small scale and not in larger areas of the country.

7.4 Conclusions

The major activity of the corresponding governmental institutions should be directed on supporting local farmers in reintroducing ancient crops on the market and maintain maximum diversity of the target taxon's gene pool. In our opinion, the most important challenges in the near future are certainly the molecular characterization of germplasm collections for preserving them from genetic erosion and the identification of phenotypic variants potentially useful for breeding new varieties. The Georgian landraces originated in Neolithic period and existing until today represent unique genome to improve the multiplication of accessions and the maintenance of seed stocks for responding to an expected higher demand of materials. This will facilitate the use of, and add value to crop plant from germplasm resources. The importance of agricultural achievements not should be oriented only on high yield of crops but the traditional foods to which people have adapted a long time determines their healthy lifestyle. Thus, conservation and restoration of ancient landraces to modern agriculture can insure longevity of people.

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