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Diversity and Genetic Erosion of Ancient Crops and Wild Relatives of Agricultural Cultivars for Food: Implications for Nature Conservation in Georgia (Caucasus)

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1. Introduction

The interpretation of a healthy diet is one of the dilemmas for our modern civilization. Advances in agriculture are mainly directed at increasing food production to solve problems of a growing human population. However, food security remains a problem to ensure healthy food and to prevent human disease. These two tendencies often do not coincide. At present, the selective breeding programs of crops are mainly oriented toward the production of high-yielding varieties of genetically enhanced cultivars of cereals that have increased growth rates, increasing the percentage of usable plant parts and resistance against crop diseases. This initiative is linked to what began in the 1960s and was named by William Gaud (of USAID) a "Green Revolution" (Davies, 2003). It was a product of globalization as evidenced in the creation of international agricultural research centres to introduce new crop varieties around the world. This process caused a significant increase in total cereal production and daily calorie supply in developing countries between the 1960s and 1990s (Davies, 2003). However, this process has caused the gradual replacement of traditional crop varieties, and as a result has had a dramatic effect on agrobiodiversity in many countries. Particularly impacted have been the traditional landraces used by local peoples for thousands of years and this has affected the health of these communities.

Georgia, located in the South Caucasus, owns one of the oldest agricultural traditions. The name of the country is "Sakartvelo" in the Georgian language but its common name "Georgia" is semantically linked to Greek (γεωργία, transliterated geōrgía) and Latin (georgicus) roots meaning "agriculture" (Javakhishvili, 1987). Many Georgian endemic species and local varieties of wheat, barley, legumes, grapevine and fruits are known (Ketskhoveli, 1957). The traditional use of local cultivars is considered to be a reason for human longevity in the Caucasus region (Fox, 2004). Over five percent of the male Georgian centenarians were reputed to have been over age 120 in 1959 (Garson, 1991). The percentage of males over age 70 was 0.9% in 1959 and 1.07% of women were over 70. However, these values had diminished by 1970 to 0.66% and 0.86%, respectively. At present, no exact data are available, but longevity has obviously diminished (Fox, 2004).

Archaeological data clearly show that the Caucasus region (and Georgia in particular) was settled from prehistoric time and agriculture was developed during the early Neolithic era (Javakhishvili, 1987). The information about the wide chronological intervals in the archaeological materials connected with the history of mankind in the Caucasus starts from the Early Pleistocene. The 1.7-Myr-old specimens of small-brained hominids are found in the Caucasus at Dmanisi, located in Southern Georgia (Fig.1), which is the earliest known hominid site outside of Africa (Gabunia & Vekua, 1995; Finlayson, 2005). This speciman has been classified as *Homo erectus senso lato*, which is a very early type of *H. ergaster* and/or a new taxon, *H. georgicus* (Gabunia et al., 2002). The next chronological interval in the archaeological materials is connected with the period of Late Middle Palaeolithic and Early Upper Palaeolithic periods demonstrating patterns of mobility, land-use, and hunting of Neanderthal and modern human competition within the South Caucasus (Adler & Bar-Oz, 2009). Neanderthals invaded the Caucasus region at an unknown time and modern humans may have occupied the region alongside them from ~40 Ka before the present (BP). According to the archaeological material from different caves in Georgia (Tushabramishvili, 2011) and the northern Caucasus (Ovchinnikov et al., 2000), the final replacement of the Neanderthals by modern humans might be occurred here ~28 Ka BP. The Upper Palaeolithic archaeological findings at Dzudzuana Cave (Fig.1), Imereti region, Georgia, revealed remnants of wool (*Capra caucasica*) and dyed fibers of wild flax (*Linum usitatissimum*) dated to ~36–34 Ka BP (Adler & Bar-Oz, 2009). The Dzudzuana Cave flax fibers have clearly been modified, cut, twisted and dyed black, gray, turquoise and pink, most likely with locally available natural plant-derived pigments (Kvavadze et al., 2009). E. Kvavadze and colleagues (2009) surmise that this represents the production of colourful textiles for some purpose, perhaps clothing. In general, it is supposed that the microscopic flax fibres are the remains of linen and thread, which would have been used in clothing for warmth, for shoes, to sew together pieces of leather or to tie together packs.

The archaeological findings from Neolithic and Early Bronze periods are rich with plant fossils and seeds of both wild species and local landraces. The ancient findings from Neolithic period of cereal grains in Georgia were discovered from Trialeti Range, Kvemo Kartli region (Arukhlo excavations, Bolnisi district; Fig.1) and Samegrelo region (Dikha-Gudzuba, Zugdidi district; Fig.1) from 6th up to 2nd millennium BC (Melikishvili, 1970). 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 in Arukhlo, Kvemo Kartli region. Other cereals: millet - *Panicum milleaceaum*, 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. The wheat fields in Arukhlo were irrigated. Very recent studies on einkorn wheat domestication using amplified fragment length polymorphism (AFLP) show that *T. boeoticum* was domesticated in southeast Turkey in the Karacadag Mountains close to Diyarbakir (Heun et al., 1997). Old Georgian kingdom Diauehi (Diaokhi) is adjacent region to this place. Therefore, it might be considered to be an area where cultivation of cereals occurred in very early historical time. The earliest archaeological finding of cultivar grapevine pips are found in Shulaveri (Fig.1), located near Dmanisi in southern Georgia and dated to ~8.000 years BP (Ramishvili, 1988). A wide range of carbonised seeds, including wild and domesticated grape (*Vitis vinifera, V. vinifera* subsp. *sylvestris*), wheat (*Triticum* sp.), pea (*Pisum sativum*), rowan (*Sorbus* sp.) and walnut (*Juglans regia*) are found in soil samples in Nokalakevi (Fig.1), Western Georgia, dated to the Hellenistic period (Grant et al., 2009).

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

According to N. I. Vavilov (1992), the origin of ancient crop varieties and landraces in Georgia coincides with the period of their primary domestication. Georgia is often considered part of the Near East where many field crops were domesticated. N. I. Vavilov (1992) determined 8 centres of crop origin and diversity. Among them was the fourth centre, which included the South Caucasus, Asia Minor, Iran and Turkmenistan. The main crops domesticated in this centre (which includes Georgia) are wheat, rye, oats, seed and forage legumes, herbs, fruits, and grapes for winemaking; 83 species all tolled.

The problem is that there are no concrete data to assess either the current status of local varieties or information about the domestication process in Georgia. The fundamental work on domestication and origin of wheat and barley in this region was done by the famous Georgian botanist V. Menabde (1938, 1948). The agricultural evidence was reported by several other Georgian authors (Ketskhoveli, 1957; Khomizurashvili, 1973; Akhalkatsi et al., 2010). We have studied domestication of wild grapevine (*Vitis vinifera* subsp. *sylvestris*) and wild pear (*Pyrus caucasica*) using morphometric and systematic molecular methods (Ekhvaia & Akhalkatsi, 2010; Ekhvaia et al., 2010; Asanidze et al., 2011) confirming genetic relationships between wild populations and local cultivars of grape and pear. However, complete evaluation of diversity of Georgian local cultivars and crop wild relatives (CWR) has not yet been complete.

There are many threats to these oldest of crops in the modern period. In our opinion, the main threat to agrobiodiversity in Georgia is the loss of landraces and ancient crop varieties. Protection measures in the country are still not being implemented at an appropriate rate. 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 forms 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.

2. Landrace assessment

Agriculture in Georgia is characterized by a great diversity of local landraces, varieties and even endemic species of crops. These varieties reveal a high level of adaptation to local climatic conditions and often have high resistance to diseases. Georgians have used these crops for a very long time and their healthy life, reflected by the longevity of individuals in the population, was considered to be connected to their good food. However, there are many threats to these oldest of crops in the modern period, particularly since the 1950s. The loss of local and ancient crop varieties should be considered to be the main threat to agrobiodiversity in Georgia.

The known diversity and distribution of local landraces is based on data obtained from archaeological reports, historical manuscripts, ethnography, and botanical field expeditions in different regions of Georgia since 1920s. The oldest known text about Georgian cultivars is a XVII century by the work of Vakhushti Batonishvili "Geographic Description of Georgian Kingdom" (Batonishvili, 1991). Active investigation of Georgian crops began in the 1920s (Ketskhoveli, 1928, 1957; Menabde, 1938, 1948; Dekaprelevich, 1947). These investigations revealed that ancient cultivars of grapevine, fruits, wheat, barley, rye, oats, common millet, Italian millet, legumes, flax, and a number of herbal and spice plants, were still being cultivated in Georgia. The rapid loss of local cultivars of cereals, legumes and flax began in the 1950s and reached an extreme in the 1990s (Akhalkatsi et al., 2010). At present, almost all of Georgia's ancient crops are maintained in conservatory collections and seed banks, but none are present in peasant house gardens in lowland areas. Only the mountain areas contain depositories of the ancient crops of Georgia, where some number of landraces still exist. The process of genetic erosion of ancient crop varieties, however, has begun even in these regions since the 1990s and this presents great concern about the loss of aboriginal crops adapted to high mountain areas (Pistrick et al., 2009).

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.

2.1 Diversity of ancient crop varieties

Reports of the diversity of local landraces in Georgia has to present been published primarily in Georgian- and Russian-language scientific publications (Ketskhoveli, 1928, 1957; Menabde, 1938, 1948; Dekaprelevich, 1947; Kobakhidze, 1974). Databases and international periodicals lack descriptions of this diversity, taxonomy and discussions of the conservation value of landraces. In our opinion it is important to spread information about diversity and conservation needs of local cultivars of Georgia worldwide to support the evaluation of their roles in healthy life of human. Some crops, such as grapevine, wheat, barley and fruit trees are characterized by the highest diversity of landraces in Georgia.

Grapevine - *Vitis vinifera* L. (Vitaceae) shows greatest genetic and morphological variability. About 500 names of autochthonous grapevine varieties known from Georgia are characterized by a wide range of colour gamma and shapes of berries and pips (Javakhishvili, 1987; Ketskhoveli et al., 1960), which points to an evolutionary centre in this region (Vavilov, 1992). These cultivars showed great ampelometric variability and broad adaptability to different climate and soil conditions (Ketskhoveli et al., 1960). Each province of Georgia possesses its own grapevine cultivars adapted to local climate. The varieties are of three forms: 1) *Babilo* is an old grapevine with stem more than 20 cm in diameter clambering on trees (Fig.2A). 2) *Maghlari* represents varieties that climb tree trunks (alder, persimmon, mulberry, cherry, beech, chestnuts, etc.) distributed mainly in peasant orchards in western and southern Georgia (Fig.2B). 2) *Dablari* is used to create typical vineyards (Fig.2C) found in commercial areas. The total area of vineyards in Georgia was 40.000 ha in the 1980s. It has diminished to ca. 25.000 ha today (Bedoshvili, 2010). Forty-four percent of this territory is located in Kakheti region, 26% in Imereti, 15% in Kartli and 15% in almost all regions of Georgia except in the high mountain regions of Khevi, Khavsureti and Tusheti. Forty-one cultivars of grapevine are used as commercial varieties in Georgia. Among them, 27 are technical varieties used for winemaking and 14 are table grapes (Bedoshvili, 2010). Ninety-seven percent of total annual yield is used for winemaking and only 3% as table grapes. Wine is made from landraces: 'Rkatsiteli' (55%); 'Tsolikauri' (10.2%); 'Chinuri' (7%); 'Saperavi' (4%); 'Kakhuri Mtsvane' (3.3%); and, several local and introduced cultivars (20.5%).

A B C

Fig. 2. Different types of vineyeards: A - *Babilo,* an old grapevine 'Meskhuri Shavi' (diameter 32 cm) belonged to the family of Gogi Natenadze in village Chachkari, Meskheti; B - *Maghlari,* clambering introduced cultivar *Vitis labrusca* 'Odessa' on beech tree in village Naghvarevi, Adjara. C - *Dablari,* typical vineyeard of landraces 'Rkatsiteli' and 'Saperavi' in village Shilda, Kakheti. Photos by Maia Akhalkatsi.

The first known threat to the grapevine in Georgia occurred during the occupation of Georgian territory by the Muslims during the medieval period. They destroyed vineyards and/or led to the destruction of human settlements, where until now are presented local wilding grape cultivars clambering on trees. The vineyards grow on the terraces of

Mediterranean type in the historic province of Tao-Klarjeti located now in southern Georgia and in the province of Artvin, Turkey. Since 15th century, the Seljuk Turks occupied this territory and vine terraces disappeared and were covered with trees or grasses. However, we have found peasants in some villages of Meskheti province searching for old cultivars in abandoned settlements. They are replanting naturalized grape cultivars to house gardens. We have found ancient grapevine varieties 'Meskhuri Shavi' and 'Meskhuri Mtsvane' to be frost resistant and growing in high mountain areas in villages Zemo Vardzia (1322 m a.s.l.) and Chachkari (1264 m a.s.l.), Aspindza district; village Zazalo, (1486 m a.s.l.), Adigeni district; and, Karzameti castle near boundary to Turkey, 1450 m a.s.l. One of the oldest Georgian grape cultivar 'Krikina', which is morphologically nearly identical to wild grapevine (*V. vinifera* subsp. *sylvestris* [C. C. Gmel.] Hegi), was found in village Rveli, Borjomi district, in house garden of Gaioz Tabatadze who replanted this cultivar from the ruins of the historic village Baniskhevi where his ancestors lived. The grape variety 'Shonuri' ('Lushnu' in Svanetian) adapted to high mountain areas grows in Upper Svaneti province from 1045 to 1400 m a.s.l. Landraces adapted to high elevations are rare and are usually replaced with the introduced grape cultivar *V. labrusca* 'Odessa'. It is widespread in mountainous villages in all regions of Georgia. Some other rare grapevine cultivars - 'Kachichi', 'Saperavi', 'Sebeli', 'Jvarisa', have been found on lower elevations in village Gvimbrala, Lentekhi district, Lower Svaneti province. Rare grape cultivars - 'Aladasturi', 'Tsulukidzis Tetra' and 'Tskhvedanis Tetra' have been found in village Tabori and 'Usakhelouri' in village Zubi, Tsageri district, Lechkhumi province. Rare landrace 'Chkhaveri' was found in village of Merisi, at 474 m a.s.l. Adjara province.

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. Currently, almost all Georgian grape varieties are grafted on rootstocks of American grapevines - *V. riparia, V. rupestris* and *V. berlandieri* and their hybrids 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 was 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, 929 varieties were protected in the living collections. Among them, 701 were cultivars obtained from selective breeding and only 248 of the 524 autochthonous Georgian varieties remain. These collections of the State Agricultural University were located in Dighomi (573 cultivars) and Mukhrani (155 cultivars), and, the collections in Telavi (226 cultivars) and Skra (75 cultivars) belonged to the Georgian research Institute of Horticulture, Viticulture and Winemaking (Maghradze, et al., 2010). 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. Three other new collections were set up by Saguramo "Centre for Grapevine and Fruit Tree Planting Material Propagation" (ca 400 accessions), "Kindzmarauli" and "Shumi" wineries (as a total 149 accessions). Two new collections were established in Italy by the University of Milan (Maghradze, et al., 2010). Some Georgian cultivars are in living collections abroad in Russia, Moldova and Germany as well. A small living grapevine collection exists in the G. Eliava

National Museum in Martvili district, Samegrelo province, founded in 1972 and containing 24 old Colchic grapevine varieties (Eliava, 1992). Seven cultivars of Meskheti region were 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.

Wheat - *Triticum* L. (Poaceae) also shows high diversity in Georgia. Nineteen species of wheat from the 26 known species of the genus *Triticum* have been historically distributed in Georgia (Tab.1). Some of them are endemic species: *T. timopheevii, T. zhukovskyi, T. macha, T. carthlicum* and *T. palaeo-colchicum*. Sixteen species, 144 varieties, and 150 forms of wheat were registered in Georgia in the 1940s (Menabde, 1948).

N	*Taxon names by Menabde, 1948, 1961*	*Taxon accepted name by ARS-GRIN, USDA 2011*	*Status*	*Ploidy levels*
	T. aegilopoides Balansa ex Körn. (=*T. boeticum* Boiss.)	*T. monococcum* subsp. *aegilopoides* (Link) Thell.	W	2n
	T. monococcum L.	*T. monococcum* L.	PS	2n
	T. timopheevii Zhuk.	*T. timopheevii* (Zhuk.) Zhuk. subsp. *timopheevii*	EG, PS	4n
	T. chaldicum Menabde	*T. timopheevii* (Zhuk.) Zhuk. subsp. *armeniacum* (Jakubz.) Slageren	W	4n
	T. dicoccoides Körn.	*T. turgidum* L. subsp. *dicoccoides* (Körn. ex Asch. & Graebn.) Thell.	W	4n
	T. palaeo-colchicum Menabde	*T. turgidum* L. subsp. *palaeocolchicum* Á. Löve & D. Löve	EG, SP	4n
	T. dicoccum Schuebl.	*T. turgidum* L. subsp. *dicoccon* (Schrank) Thell.	SP	4n
	T. durum Desf.	*T. turgidum* L. subsp. *durum* (Desf.) Husn.	SP	4n
	T. turgidum L.	*T. turgidum* L. subsp. *turgidum*	SP	4n
	T. carthlicum Nevski (=*T. ibericum* Menabde; *T. persicum* Vavilov ex Zhuk.)	*T. turgidum* L. subsp. *carthlicum* (Nevski) Á. Löve & D. Löve	EG, SP	4n
	T. polonicum L.	*T. turgidum* L. subsp. *polonicum* (L.) Thell.	SP	4n
	T. turanicum Jakubz.	*T. turgidum* L. subsp. *turanicum* (Jakubz.) Á. Löve & D. Löve	IS	4n
	T. abyssinicum Vavilov	*T. dicoccon* subsp. *abyssinicum* Vavilov	IS	4n
	T. vulgare Villars	*T. aestivum* L.	SP	6n
	T. macha Dekapr. & Menabde	*T. aestivum* L. subsp. *macha* (Dekapr. & V.L. Menabde) Mackey	EG, PS	6n
	T. spelta L.	*T. aestivum* subsp. *spelta* (L.) Thell.	IS	6n
	T. sphaerococcum Percival	*T. aestivum* subsp. *sphaerococcum* (Percival) Mackey	IS	6n
	T. compactum Host	*T. aestivum* subsp. *compactum* (Host) Mackey	SP	6n
	T. zhukovskyi Menabde & Ericzjan	*T. zhukovskyi* V.L. Menabde & Eritzjan	EG, SP	6n

Table 1. List of wheat species distributed in Georgia by V. Menabde (1948, 1961). The accepted names are added from web-page: http://www.ars-grin.gov/cgi-bin/npgs/html/splist.pl?28515. 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 are indicated.

According to V. Menabde (1948), three species from the list are wild – *T. boeticum* (2n=14), *T. dicoccoides* (2n=28), *T. timopheevii* subsp. *armeniacum* (2n=28); they were mixed with cultivars in the wheat fields and did not exist in natural habitats in Georgia. Sites of *T. boeoticum* are concentrated in south-eastern Turkey, where this species was probably domesticated (Heun et al., 1997). The current distribution indicates that its weedy races have spread with cultivated cereals far to the west and east. There is evidence that it 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 *kolkhozis*—agricultural farming corporations in Soviet times, changing the species composition in wheat fields. At present, none of these species occur in agricultural fields of Georgia.

Three species from the list (Tab.1) are considered by V. Menabde (1948) as primary species (close to the first domesticated species): *T. monococcum* (2n=14), *T. timopheevii* (2n=28) and *T. macha* (2n=42). First two species, *T. monococcum* - 'Gvatsa Zanduri' and *T. timopheevii* - 'Cheltha Zanduri', in Georgian, are old autochthonous wheat species distributed mainly in western Georgia - Racha-Lechkhumi, Imereti and Samegrelo. *T. timopheevii* was growing in a small area in western Georgia together with its hexaploid derivative - *T. zhukovskyi*, and cultivated einkorn - *T. monococcum* (Menabde, 1961). These three species represent polyploid series of wheat *Zanduri*, which was possible to find in peasant farms till 1990s. *T. macha* is archaeological findings in Dikha-Gudzuba and Shulaveri excavations dated by Neolithic period and was cultivated in Racha-Lechkhumi, Imereti and Samegrelo up to 1950s (Dekaprelevich, 1947).

Nine native species of wheat - *T. palaeo-colchicum, T. dicoccum, T. durum, T. turgidum, T. carthlicum, T. polonicum, T. aestivum, T. zhukovskyi* and *T. compactum*, are considered by V. Menabde (1948, 1961) as secondary species originated by hybridization with wild and primary species of *Triticum, Aegilops* spp., *Thinopyrum intermedium* (Host) Barkworth & D. R. Dewey subsp. *intermedium* (=*Agropyron glaucum* [Desf. ex DC.] Roem. & Schult.), and *Thinopyrum elongatum* (Host) D. R. Dewey (=*Agropyron elongatum* [Host] P. Beauv.). *T. aestivum, T. carthlicum* and *T. durum* have many varieties and cultivars. The four species in the list (Tab.1) - *T. abyssinicum, T. spelta, T. sphaerococcum* and *T. turanicum* represent geographical races introduced from different regions in the historically different times.

The traditional wheat fields in all regions of Georgia usually contain several species and varieties (Eritzjan, 1956; Zhizhilashvili & 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. 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 and used with wheat to make bread, cakes, etc. It adds a nice flavour 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.* 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*.

A B C

Fig. 3. A- Wheat field of the Georgian endemic *Triticum carthlicum* 'Dika' in research station of the Biological Farming Association Elkana, village Tsnisi, Meskheti; B - Traditional wheat bread in Meskheti; C- Six row barley field with mixture of wild rye *Svila* (*Secale segetale*) in village Shilda, Kakheti. Photos by Maia Akhalkatsi.

Wheat fields were planted throughout Georgia at elevations from 300 m 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 (Fig.3A). 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' and weed *Makhobeli.* The flour was baked as bread in Tbilisi and as traditional bread in Meskheti (Fig.3B).

Barley – *Hordeum vulgare* L. (Poaceae) is an ancient agricultural crop in Georgia. It was 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, 1987). Two different names were used for barley in Georgian language - *Krtili* and *Keri. Krtili* denotes six-row winter barley (*H. vulgare* subsp. *hexastichon* [L.] Čelak.) that was sowed in autumn; *Keri* refers to two-row summer barley (*H. vulgare* subsp. *distichon* [L.] Körn.) sowed in spring (Menabde, 1938). Six-row barley was sown in lowland areas but was cultivated up to 2130 m a.s.l. in Svaneti. 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 2100 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 (Fig.3C). The bread of wheat with *Svila* is considered to be very nutricious 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 (Ketskhoveli, 1957) - *A. sativa* var. *aurea* Körn. and *A. sativa* var. *krausei* Körn. 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 grey; *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 (Zhizhilashvili & Berishvili, 1980). The acreage of millet fields declined after introduction of maize in Georgia in 17th 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 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. It was cultivated for a long time but was replaced by maize.

Legumes - peas, lentils, chickpeas, faba beans, common vetch, bitter vetch, chickling vetch, alfalfa, sainfoin and blue fenugreek are traditional crops in Georgia (Tab.2). Green Pea (*Pisum sativum*) is originated in the South Caucasus. It is grown in house gardens in small amounts for food today. Two species of pea are cultivated in Georgia - *P. sativum* with white flowers, round white or yellow seeds, and *P. arvense* with purple flowers, ridged dark coloured seeds. The third 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. The local cultivar of green pea, *P. sativum* subsp. *transcaucasicum* Govorov, has

14 varieties (Kobakhidze, 1974). 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 & Menabde, 1929). In the 1970s, the same three subspecies - *C. arietinum* subsp. *mediterraneum* G. Pop., *C. arietinum* subsp. *eurasiaticum* G. Pop. and *C. arietinum* subsp. *orientalis* G. Pop., remained, but included only 6 of 24 varieties - *C. arietinum* subsp. *mediterraneum* var. *ochroleucum* A. Kob., *C. arietinum* subsp. *mediterraneum* var. *rozeum* G. Pop., *C. arietinum* subsp. *eurasiaticum* var. *aurantiacum* G. Pop., *C. arietinum* subsp. *orientalis* var. *fulvum* G. Pop., *C. arietinum* subsp. *orientalis* var. *rufescens* G. Pop., and *C. arietinum* subsp. *orientalis* var. *rufescens brunneo-punctatus* A. Kob. (Kobakhidze, 1974). Chickpeas were traditionally available in Svaneti, but by the 1970s only one farmer was sowing it in Kala community village Khe (Zhizhizlashvili & Berishvili, 1983). 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). The last subspecies with small seeds was sown in high mountain areas in Javakheti. It was available in Meskheti till 1970s. Lentils were cultivated in Upper Svaneti from prehistoric times, but, at present, it is nearly extinct. In 1980s, three cultivars were described in Svaneti - 1. *L. culinaris* var. *persica* Bar. - reddish-brown seeds; 2. *L. culinaris* var. *ochroleucus nigro-punctulata* A. Kob. - light brown seeds with black dots; 3. *L. culinaris* var. *nigro-marmorata* A. Kob. - seeds have reddish-yellow background with black marbling (Zhizhizlashvili & Berishvili, 1983). The Biological Farming Association Elkana is producing local cultivars of lentil for the market. Faba bean (*Vicia faba)* is one of the oldest cultivated plants. Faba bean is ancient agricultural plant in western and southern Georgia. Three varieties and 31 subvarieties were 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 in Upper and Lower Svaneti. Two varieties are found in the Lower Svaneti: 1. *V. faba* var. *minor* subvar. *straminea* A. Kob. - compressed on sides, tip obtuse, colour light cream. 2. *V. faba* var. *equina* subvar. *ochroleucus* A. Kob. - slightly compressed on sides, tip rounded, colour yellowish (Zhizhizlashvili & Berishvili, 1983). Chickling vetch (*Lathyrus sativus*) is used as human food in a soup to called s*hechamandi.* It is also a 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 forms 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, 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.

Flax – *Linum usitatissimum* L. (Linaceae), was one of the oldest and important field crops in Georgia. Since prehistoric times, it was used to produce excellent linens (Kvavadze et al., 2009) and to make oil from its seeds. Big millstones were used to extract the oil from the flax seeds and they remain in many historical ruins. Until recently, flax was cultivated only in Javakheti, where flax seeds were used to produce pharmacologically pure oil for medicines. According to the eighteenth century Georgian scientist and geographer Vakhushti Batonoshvili (1991), several volatile oil-bearing plants were cultivated in Georgia - roses, camphor, lavender and basil. Kenaf - *Cannabis sativa* L. (Cannabaceae), was used to produce fiber for cord and thread for sacks. The seeds were used to produce oil. A traditional use of kenaf seeds was to mix them with wheat flour and making breads that had antidepressant effects.

Traditional vegetables (Tab.2) are represented by sugar beets, spinach, carrots, radishes, turnips, onions, Welsh onion, leeks and garlic. Beet - *Beta vulgaris,* is an ancient cultivated plant whose tubers and young leaves were used in Georgian cooking. Leaves primarily came from the variety *B. vulgaris* subsp. *cicla* (L.) W.D.J. Koch 'Tsiteli Mkhali' that was grown in lower elevations up to 1400 m a.s.l. Another beet variety - *B. vulgaris* L. subsp. *vulgaris* 'Sasufre Charkhali' is rare. Carrot - *Daucus carota,* was edible as a wild species in Georgia since prehistoric times. The cultivated carrot is widespread in peasant's house gardens in lowland areas. Onion - *Allium cepa* and garlic - *A. sativum*, are ancient cultivated plants available in all regions of Georgia. Red onions are very popular in Georgian people. *A. sativum* is called 'Georgian garlic'. Another variety is 'Russian garlic' representing *A. ampeloprasum* L. Leek - *A. porrum,* is typical in western Georgia. Welsh onion - *A. fistulosum* is currently grown in several high mountain areas. Until the 1970s, it was widespread in Imereti, but at present, Chinese shallot - *A. cepa* var. *aggregatum* G. Don has completely supplanted Welsh onion. Radish - *Raphanus sativus,* is grown in lower elevations in gardens and is cultivated by farmers for the market.

N	Latin name	Family	English common name	Georgian common name
	Allium cepa L.	Liliaceae	*Onion*	*Khakhvi*
	Allium fistulosum L.	Liliaceae	*Welsh Onion*	*Chlakvi*
	Allium porrum L.	Liliaceae	*Leek*	*Prasi*
	Allium sativum L.	Liliaceae	*Garlic*	*Niori*
	Beta vulgaris L. subsp. *vulgaris*	Chenopodiaceae	*Beet*	*Charkhali*
	Brassica rapa L. subsp. *rapifera* Metzger	Brassicaceae	*Turnip*	*Talgami*
	Cannabis sativa L.	Cannabaceae	*Kenaf*	*Kanafi*
	Cicer arietinum L.	Fabaceae	*Chickpea*	*Mukhudo*
	Daucus carota L.	Apiaceae	*Carrot*	*Stafilo*
	Lathyrus sativus L.	Fabaceae	*Chickling vetch*	*Tsulispira*
	Lens culinaris Medik.	Fabaceae	*Lentil*	*Ospi*
	Linum usitatissimum L.	Linaceae	*Flax*	*Seli*
	Medicago sativa L.	Fabaceae	*Alfalfa*	*Ionja*
	Onobrychis transcaucasica Grossh.	Fabaceae	*Sainfoin*	*Espartseti*
	Pisum arvense L.	Fabaceae	*Pea*	*Barda*
	Pisum sativum L.	Fabaceae	*Pea*	*Barda*
	Raphanus sativus L.	Brassicaceae	*Radish*	*Boloki*
	Spinacia oleracea L.	Chenopodiaceae	*Spinach*	*Ispanakhi*
	Vicia ervilia (L.) Willd.	Fabaceae	*Bitter vetch*	*Ugrekheli*
	Vicia faba L.	Fabaceae	*Faba bean*	*Tsertsvi*
	Vicia sativa L.	Fabaceae	*Common vetch*	*Tsertsvela*

Table 2. Seed and forage legumes and traditional vegetables of Georgia.

Herbs are represented by numerous species (Tab.3) - parsley, coriander, tarragon, sweet basil, savory, gardencress pepperweed, dill, fennel, celery, garden lettuce, peppermint. Herbs are cultivated in small sections of house gardens even in urban settlements. Sometimes, people have herbs indoors in pots.

N	Latin name	Family	English common name	Georgian common name
	Anethum graveolens L.	Apiaceae	*Dill*	*Kama*
	Apium graveolens L.	Apiaceae	*Celery*	*Niakhuri*
	Artemisia dracunculus L.	Asteraceae	*Tarragon*	*Tarkhuna*
	Coriandrum sativum L.	Apiaceae	*Coriander*	*Kindzi*
	Foeniculum vulgare Mill.	Apiaceae	*Fennel*	*Didi Kama*
	Lactuca sativa L.	Asteraceae	*Garden lettuce*	*Salati*
	Lepidium sativum L.	Brassicaceae	*Gardencress pepperweed*	*Tsitsmati*
	Mentha piperata L.	Lamiaceae	*Peppermint*	*Pitna*
	Ocimum basilicum L.	Lamiaceae	*Sweet basil*	*Rehani*
	Petroselinum crispum (Mill.) A.W. Hill	Apiaceae	*Parsley*	*Okhrakhushi*
	Satureja hortensis L.	Lamiaceae	*Savory*	*Kondari*
	Trigonella caerulea (L.) Ser.	Fabaceae	*Blue fenugreek*	*Utskho Suneli*

Table 3. List of traditionally cultivated herbs in Georgia.

Fruits are valuable cultivars in Georgia. Wild and cultivated fruit crops reveal high species and genetic diversity in Georgia and represent rich material for future breeding activities. Many fruits have wild relatives representing the same species and direct ancestors of local cultivars (Tab.4,5).

2.2 Introduced cultivated plants

Georgia is located at the crossroads of Europe and Asia. Many cultivated plants have been introduced since ancient times to Georgia from other regions of the world (Javakhishvili 1987). Some introduced crops have become very popular and widespread. They are introduced from different countries. Such crops as cucumber (*Cucumis sativus*), found in Georgia since medieval times, eggplant (*Solanum melongena*), marigold (*Tagetes patula*), used in almost all traditional meals; and black pepper (*Piper nigrum*) were introduced from India. Watermelon (*Citrullus lanatus*) from South Africa was cultivated in the Caucasus since medieval times. Maize (*Zea mays*), sunflower (*Helianthus annuus*), tomato (*Solanum lycopersicum*), bean (*Phaseolus vulgaris*), pepper (*Capsicum annuum*), and potato (*Solanum tuberosum*) were introduced to Georgia from the Americas at about the same time as in Europe (Javakhishvili, 1987). Tea (*Camellia sinensis*) and citrus fruits (*Citrus limon, Citrus reticulata*, *Citrus sinensis*) came from China in the 1830s (Bakhtadze, 1947). *Nicotiana rustica,* (*tutuni* in Georgian) has been cultivated for a long time and is found in the most regions, including high mountain areas, of Georgia. *N. tabacum*, was introduced during the Soviet period and was cultivated in *kolkhozis* for commercial use.

Georgia has become a secondary centre of diversity for most of these crops. Landraces of bean, maize, potato, tomato, and cucumber that do not exist in their countries of origin can be found in Georgia. Bean (*Phaseolus* spp.; *Vigna* spp.) was introduced via Turkey to Guria and Samegrelo during the second half of the XVI century (Javakhishvili, 1987). At present, 61 varieties and 406 forms of common bean had originated in Georgia due to widespread distribution and hybridization of different species of bean: *Phaseolus vulgaris* L., *P. lunatus* L., *P. coccineus* L. (=*P. multiflorus* Lam.), *P. acutifolius* A. Gray, *Vigna radiata* (L.) R. Wilczek var. *radiata* (=*P. aureus* Roxb.), *V. angularis* (Willd.) Ohwi & H. Ohashi var. *angularis* (=*P. angularis* [Willd.] W. Wight) and *V. umbellata* (Thunb.) Ohwi & H. Ohashi (=*P. calcaratus* Roxb.) (Kobakhidze, 1965). Beans are cultivated in gardens in large amounts providing sufficient food for families and representing a cash crop for additional income. Diversity of beans remains high. Maize (*Zea mays* L.) was introduced to Georgia in 1633-1650 (Javakhishvili, 1987). The Georgian name *Simindi* originated from the old name for flour *Samindo* as flour was introduced earlier to Georgia than the initial cultivation of maize. Besides landraces such as 'Kazha simindi' from Svaneti there are some cultivars that originated in Georgia: 'Ajametis tetri', 'Abashis kviteli', 'Kartuli kruki', 'Gegutis kviteli', 'Imeruli hibridi' and 'Lomtagora'. Many cultivars were introduced from Russia, Hungary, Yugoslavia, etc., during Soviet time. The last introduction occurred in 2011, when the high-yield US corn hybrid 'Pioneer' was sown in Georgia. Corn had replaced common and Italian millet and is used as an everyday food, especially in western Georgia. **Potato (*Solanum tuberosum* L.)** was introduced to Georgia during the second half of the XIX century. Several landraces of high quality are grown in high-mountain regions: Svaneti, Racha-Lechkhumi, Khevsureti, Khevi and Adjara. Breeder's cultivars were introduced into lowland areas during Soviet time. Recently, genetically modified potato cultivars have been introduced in Georgia by international seed-distribution organizations. These modern cultivars have almost completely supplanted local landraces even in high mountain regions. Tea and citrus had high commercial value in Georgia, but in the 1990s these crops were abandoned and tea was not produced in Georgia until recently. Citrus (lemons, oranges and mandarins) were sold only in the local Georgian market. At present, this business is restored.

Information about introduced varieties has been published annually during the XX century. The latest official edition of the Catalogue of the Georgian Released Varieties of 1997 (published in 1996) listed 195 varieties of field and vegetable crops and 195 varieties of fruits. These varieties were part of the collections that existed at the end of the 1980s and beginning of the 1990s. At present, only a few of these varieties exist. The data about modern breeder's varieties introduced into Georgia during last decade are usually absent and a number of varieties have been cultivated in Georgia without going through the official procedures for release. Therefore, it is difficult to evaluate the diversity of recently introduced cultivars.

3. Crop wild relative assessment

The CWR are taxa related to species of direct socio-economic importance, which includes the progenitors of crops. According to modern concept of wild relatives, under CWR we should understand all species related to any cultivated plants, as well as to wild species of ornamental, food, fodder and forage, medicinal plants, condiments, forestry species and plants used for industrial purposes, such as oils and fibers i.e. to all plants of economic importance (Laguna, 2004). Although, "classical" definition of CWR is restricted only to species related to cultivated crops, including such important field crops as wheat, barley, rye, oats, sorghum, common and Italian millet, grain and forage legumes (such as *Phaseolus, Vicia, Vigna, Lens, Lathyrus, Cicer*) and some vegetables and industrial crops.

The flora of the Caucasus harbours a remarkable concentration of economically important plants, particularly CWRs such as cereals, legumes, fruits, vegetables, herbs and technical plants like flax. The list of CWRs in Georgia was published in Plant Genetic Resources (PGR) Forum - CWR Catalogue of Europe and the Mediterranean (Maxted et al., 2008). This catalogue listed 1784 species of vascular plants, representing 43% of the 4130 vascular plant species found in Georgia. These are mainly wild species that also have considerable economic importance providing food, fuel, timber, forage, hay and habitats for animal life. A large number of taxa used in folk and scientific medicine are also included among economically valuable plants. However, this list is not detailed enough to assess the economic value of CWRs representing the same species or direct ancestors of crop plants. There is no information on the status of endangered and endemic species. Thus, we developed a general description of vegetation types and separated CWR endemic species and species genetically closely related to crops.

3.1 Flora and vegetation

Georgia is located between 41°02′ and 43°34′ latitude north and between 40° and 46°43′ longitude east. It borders the Russian Federation to the north, Turkey and Armenia to the south, Azerbaijan to the east, and has approximately 310 km of coastline along the Black Sea to the west. Georgian territory (69.700 km^2) covers two separate mountain systems: the Greater Caucasus Range which trends north-west to east-southeast between the Black Sea and Caspian Sea; and the Lesser Caucasus Mountains, which run parallel to the greater range at a distance to the south that averages about 100 kilometres. Two thirds of the country is mountainous with an average height of 1.200 m.a.s.l., with the highest peaks of Mount Shkhara (5.184 m.a.s.l.) in the western Greater Caucasus and Mount Didi Abuli (3.301 m.a.s.l.) in the Lesser Caucasus. Colchis, Kartli and Alazeni valleys and Iori plateau represent intermontane lowlands located between these two mountain systems. Geologically, the Caucasus consists of Meso- to Cenozoic deposits. Ancient Precambrian and Paleozoic formations are rare (Neidze et al., 2008).

The Likhi Range divides the country into eastern and western halves that differ in climate and landscapes. Western Georgia has a humid subtropical climate with annual precipitation ranging from 1000–4000 mm. Temperatures fluctuate between the winter averages of 2.8° to 6.7° C and the summer averages of 22.7° to 23.8° C. Eastern Georgia has a more continental climate, due to the barrier of the Likhi Range, which bars the warm Black Sea winds from this area. The temperatures vary from the January averages of 0-2.2° C to the July mean of 27.8° C. Annual precipitation is considerably less in eastern Georgia and ranges from 400–1600 mm. Southern Georgia has a continental climate. The local winters are cold. The frosts are - 25° C and in July temperatures rise to 40° C. Annual rainfalls are usually less than 600-1000 mm (Neidze et al., 2008).

Soil types vary in Georgia. The most widespread types in the lowlands of western Georgia are bog, podzolic, red, yellow and hilly piedmonts, which are mainly acidic. Mountain-forest and mountain-meadow soils occur in higher elevations. Chestnut and chernozem soils are widespread in the lowlands of eastern Georgia and are characterized by neutral pH. Brown humid-sulphates, saline soils of steppes and semi-deserts, as well as intermediate forest-steppe and mountain-meadow soils occur in semi-desert areas. Alluvial soils are found along the rivers throughout Georgia. Brown soils are typical for the Georgian forest zone in the range of 800-2000 m a.s.l. (Sabashvili, 1970).

Western Georgia's landscape ranges from see-level swamps and lowland temperate rainforests to eternal subnival zone and glaciers, while the eastern part of the country contains temperate forests and semi-arid plains in lower elevations and alpine and subnival zones. Main rivers are R. Mtkvari, R. Rioni, R. Enguri and R. Alazani. There are 70 natural lakes and 11 artificial reservoirs. The lower section of the Rioni River is located in the Colchis valley and was naturally occupied by marshes and lagoons, but in 1960s this area was the site of a large reclamation-drainage project and it was converted to agricultural land. The majority of the forests that covered the Colchis plain are now virtually gone; the exceptions are those included in national parks and reserves. The Mtkvari River basin, which includes the major parts of southern and eastern Georgia, is drier. It is covered with semi-arid vegetation and temperate forests. Forests, in total, amount to 40% of Georgia's territory while the alpine zone accounts for roughly 10% of the land. Much of the natural habitat in the lowland areas of western Georgia has disappeared over the last 100 years because of agricultural development and urbanization.

The vegetation of Georgia belongs to three floristic provinces – Euxine, Caucasian and Armeno-Iranian (Takhtajian, 1986). The Euxine and Caucasian provinces belong to the Circumboreal Region, the Boreal Subkingdom and the Holarctic Kingdom and the Armeno-Iranian Province belongs to the Irano-Turanian Region, the Tethyan (Mediterranean) Subkingdom and the Holarctic Kingdom. There are following vegetation zones: 1. Colline zone (0-400 m a.s.l.), which includes coastal and halophytic habitats in western Georgia and dry open woodlands and semi-deserts in eastern Georgia; 2. Lower montane zone (400-800 m a.s.l.) is used as arable land. The natural vegetation in western Georgia is represented by small remnant areas of Colchic broad-leaved mixed forest. Oak-hornbeam forests and dry scrublands occur in eastern Georgia; 3. Middle montane zone (800-1500 m a.s.l.) is primarily used for agriculture. Broad-leaved mixed forests, mountain xerophytes scrublands, and mountain steppes are represented; 4. Upper montane zone (1200-2050 m a.s.l.) is covered by beech and broadleaf-coniferous mixed forests; 5. Subalpine zone (1900-2400[2500] m a.s.l.) is a treeline ecotone, with tall herbaceous vegetation, shrublands and polydominant subalpine grass and herb meadows used as pastures or arable land; 6. Alpine zone (2500–2900 m a.s.l.) has alpine meadows and snowbed communities. Vegetation is mostly used for grazing and is of considerably lower quality than the subalpine vegetation, both by biomass volume and typological diversity; 7. Subnival zone (2900-3300 m a.s.l.) is patchy highest limits of vegetation. 8. Nival zone (3300-5184 m a.s.l.) covered by glaciers. 9. Azonal vegetation type is represented by fragments of wetlands rich in boreal type flora, halophytic desert vegetation and rocky areas (Nakhutsrishvili, 1999).

Flora of Georgia is represented by 4,130 species of vascular plants. Among them are 79 pteridophytes, 17 gymnosperms and 4034 angiosperms (Nakhutsrishvili, 1999). The 10 leading families are Asteraceae (538 species), Poaceae (332 species), Fabaceae (317 species), Rosaceae (238), Brassicaceae (183), Scrophulariaceae (179), Apiaceae (177), Lamiaceae (149), Caryophyllaceae (135) and Liliaceae (129). High endemism is characteristic of the Caucasus and represents one of the world's hot spots of biodiversity. Out of all, 1304 (32.3%) species are endemics of the Caucasus ecoregion and 261 (6.6%) are endemics of Georgia (Schatz et al., 2009). There are 17 endemic genera in the flora of the Caucasus. Most of them are represented by one species: *Agasyllis latifolia* (M. Bieb.) Boiss., *Alboviodoxa elegans* (Albov) Woronow, *Charesia akinfievii* (Schmalh.) E. Busch, *Cladochaeta candissima* (M. Bieb.) DC., *Gadellia lactiflora* (M. Bieb.) Schulkina, *Mandenovia komarovii* (Manden.) Alava, *Paederotella pontica* (Rupr. ex Boiss.) Kem.-Nath., *Petrocoma hoefftiana* (Fisch.) Rupr., *Pseudobetckea caucasica* (Boiss.) Lincz., *Pseudovesicaria digitata* (C. A. Mey.) Rupr., *Sredinskya grandis* (Trautv.) Fed., *Symphyoloma graveolens* C. A. Mey., *Trigonocaryum involucratum* (Steven) Kusn., *Woronowia speciosa* (Albov) Juz. Two genera contain two species of each: *Chymsydia agasylloides* (Albov) Albov, *C. colchica* (Albov) Woronow, *Grossheimia macrocephala* (Muss.-Puschk. ex Willd.) Sosn. & Takht., *G. polyphylla* (Ledeb.) Holub. One endemic genus is represented by 5 species: *Kemulariella caucasica* (Willd.) Tamamsch., *K. rosea* (Steven ex M. Bieb.) Tamamsch., *K. abchasica* (Kem.-Nath.) Tamamsch., *K. tugana* (Albov) Tamamsch., and *K. colchica* (Albov) Tamamsch.

For conservation action to be effective, it is important to understand not just the needs of individual species, but also the context in which conservation efforts will need to take place. Therefore, it is important to evaluate the conservation values of the species that contribute most to human health and to develop conservation measures to avoid their extinction.

3.2 Diversity of crop wild relatives in Georgia

Flora of the Caucasus region is rich as there are high concentrations of economically important and edible plants, particularly wild crop relatives such as grapevine, wheat, barley, rye, oats, seed and forage legumes, fruits and vegetables. The Caucasus is considered to be the centre of evolution for many unique life forms and is a natural museum for rich genetic resources (Vavilov, 1992).

We identified the number of species of the genera that are traditional crops in Georgia (Tab.4). A total of 20 plant families, 76 genera and 479 species were identified as wild relatives of ancient crops in Georgia. Most of these plant species are closely related genetically to landraces and might be their progenitor species.

CWR are commonly defined in terms of wild species related to agricultural and horticultural crops. As such a broad definition of a CWR would be any wild taxon belonging to the same genus as a crop. A working definition of a CWR was provided by N. Maxted and colleagues (Maxted et al., 2006): "*A crop wild relative is a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop; this relationship is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the crop*".

According to gene pool concept three gene pools are distinguished as follows: (1) Primary Gene Pool (GP-1) within which GP-1A are the cultivated forms and GP-1B are the wild or weedy forms of the crop; (2) 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; (3) Tertiary Gene Pool (GP-3) which includes the species from which gene transfer to the crop is impossible, or if possible requires sophisticated techniques, such as embryo rescue, somatic fusion or genetic engineering. The taxon group concept is used to establish the degree of CWR relatedness of a taxon. Application of the taxon group concept assumes that taxonomic distance is positively related to genetic distance. CWR rank of taxon groups is defined as follows: (1) Taxon Group 1A – crop; (2) Taxon Group 1B – same species as crop; (3) Taxon Group 2 – same series or section as crop; (4) Taxon Group 3 – same subgenus as crop; (5) Taxon Group 4 – same genus; (6) Taxon Group 5 – same tribe but different genus to crop (Maxted et al., 2006).

Families	*Number of genera*	*Number of species*	*Genera with number of species*
Apiaceae	8	17	*Anethum (1), Apium (2), Carum (5), Coriandrum (1), Daucus (1), Foeniculum (1), Pastinaca (5), Petroselinum (1)*
Asparagaceae	1	3	*Asparagus (3)*
Asteraceae	3	16	*Cichorium (1), Lactuca (7), Scorzonera (8)*
Betulaceae	1	6	*Corylus (6)*
Brassicaceae	5	20	*Brassica (4), Lepidium (8), Raphanus (2), Rorippa (4), Sinapis (2),*
Cannabaceae	2	3	*Cannabis (2), Humulus (1)*
Chenopodiaceae	2	3	*Beta (2), Spinacia (1)*
Cornaceae	1	1	*Cornus (1)*
Fabaceae	10	154	*Cicer (1), Lathyrus (20), Lens (3), Lotus (5), Medicago (21), Onobrychis (19), Pisum (1), Trifolium (40), Trigonella (10), Vicia (34)*
Grossulariaceae	2	4	*Grossularia (1), Ribes (3)*
Juglandaceae	1	1	*Juglans (1)*
Lamiaceae	4	19	*Mentha (4), Origanum (1), Satureja (3), Thymus (11)*
Liliaceae	2	39	*Allium (36)*
Linaceae	1	12	*Linum (12)*
Moraceae	2	3	*Ficus (1), Morus (2)*
Poaceae	16	64	*Aegilops (7), Agropyron (2), Avena (8), Brachypodium (3), Cynosorus (2), Elymus (4), Elytrigia (9), Echinochloa (3), Hordeum (5), Hordelymus (1), Panicum (5), Psathyrostachis (1), Secale (5), Setaria (6), Sorghum (1), Taeniatherum (2)*
Punicaceae	1	1	*Punica (1)*
Rosaceae	12	110	*Amygdalus (1), Cerasus (4), Crataegus (8), Cydonia (1), Fragaria (3), Malus (1), Mespilus (1), Prunus (2), Pyrus (11), Rosa (30), Rubus (36), Sorbus (12)*
Staphyleaceae	1	2	*Staphylea (2)*
Vitaceae	1	*1*	*Vitis (1)*
Total: 20	76	479	

Table 4. List of wild relatives of ancient crops in Georgia.

Family	*Crop*	*Taxon*	*GP*	*TG*
Apiaceae	*Daucus carota*	*Daucus carota* L.	GP1B	TG1B
Apiaceae	*Coriandrum sativum*	*Coriandrum sativum* L.	GP1B	TG1B
Asparagaceae	*Asparagus officinalis*	*Asparagus caspius* Schult. & Schult. fil.	GP1B	TG1B
Asparagaceae	*Asparagus officinalis*	*Asparagus officinalis* L.	GP1B	TG1B
Asparagaceae	*Asparagus officinalis*	*Asparagus verticillatus* L.	GP1B	TG1B
Betulaceae	*Corylus avellana*	*Corylus avellana* L.	GP1B	TG1B
Betulaceae	*Corylus avellana*	*Corylus iberica* Wittm. ex Kem.-Nath.	GP2	TG2
Betulaceae	*Corylus avellana*	*Corylus colchica* Albov	GP2	TG2
Brassicaceae	*Brassica oleracea*	*Brassica juncea* (L.) Czern.	GP2	TG2
Brassicaceae	*Brassica oleracea*	*Brassica napus* L.	GP2	TG2
Brassicaceae	*Brassica oleracea*	*Sinapis arvensis* L.	GP2	TG2
Cannabaceae	*Cannabis sativa*	*Cannabis sativa* L.	GP1A	TG1A
Cannabaceae	*Humulus lupulus*	*Humulus lupulus* L.	GP1A	TG1A
Chenopodiaceae	*Beta vulgaris*	*Beta maritima* L.	GP2	TG2
Fabaceae	*Pisum sativum*	*Pisum elatius* M. Bieb.	GP1B	TG1B
Fabaceae	*Cicer arietinum*	*Cicer caucasica* Bornm.	GP2	TG2
Fabaceae	*Lathyrus sativus*	*Lathyrus tuberosus* L.	GP2	TG2
Fabaceae	*Lens culinaris*	*Lens nigricans* (M. Bieb.) Webb & Berth.	GP2	TG2
Fabaceae	*Lens culinaris*	*Lens ervoides* (Brign.) Grande	GP2	TG2
Fabaceae	*Lens culinaris*	*Lens culinaris* Medik. subsp. *orientalis* (Boiss.) Ponert	GP1B	TG1B
Fabaceae	*Vicia faba*	*Vicia johannis* Tamamsh.	GP2	TG2
Fabaceae	*Vicia faba*	*Vicia narbonensis* L.	GP2	TG2
Fabaceae	*Vicia sativa*	*Vicia sativa* L.	GP1A	TG1A
Grossulariaceae	*Ribes rubrum*	*Ribes alpinum* L.	GP2	TG2
Grossulariaceae	*Ribes rubrum*	*Ribes caucasicum* M. Bieb.	GP2	TG2
Juglandaceae	*Juglans regia*	*Juglans regia* L.	GP1A	TG1A
Lamiaceae	*Satureja hortensis*	*Satureja laxiflora* K. Koch	GP2	TG2
Lamiaceae	*Satureja hortensis*	*Satureja spicigera* (K. Koch) Boiss.	GP2	TG2
Linaceae	*Linum usitatissimum*	*Linum bienne* Mill.	GP1B	TG1B
Linaceae	*Linum usitatissimum*	*Linum usitatissimum* L.	GP1A	TG1A
Moraceae	*Morus alba*	*Morus alba* L.	GP1A	TG1A
Moraceae	*Morus nigra*	*Morus nigra* L.	GP1A	TG1A
Moraceae	*Ficus carica*	*Ficus carica* L.	GP1A	TG1A
Poaceae	*Triticum aestivum*	*Aegilops cylindrica* Host	GP1B	TG5
Poaceae	*Triticum aestivum*	*Aegilops triuncialis* L.	GP2	TG5
Poaceae	*Triticum aestivum*	*Aegilops tauschii* Coss.	GP1B	TG5
Poaceae	*Hordeum hexastichon*	*Hordeum bulbosum* L.	GP1B	TG2
Poaceae	*Hordeum distichon*	*Hordeum spontaneum* K. Koch	GP1B	TG1B
Poaceae	*Avena sativa*	*Avena barbata* Pott ex Link	GP2	TG2
Poaceae	*Avena sativa*	*Avena sterilis* L.	GP2	TG2
Poaceae	*Secale cereale*	*Secale strictum* subsp. *anatolicum* (Boiss.) K. Hammer	GP2	TG2
Poaceae	*Secale cereale*	*Secale strictum* subsp. *kuprijanovii* (Grossh.) K. Hammer	GP2	TG2
Poaceae	*Secale cereale*	*Secacle cereale* L. subsp. *segetale* Zhuk.	GP1A	TG1A
Poaceae	*Panicum miliaceum*	*Panicum capillare* L.	GP2	TG2
Poaceae	*Panicum miliaceum*	*Panicum sumatrense* Roth	GP2	TG2

Family	*Crop*	*Taxon*	*GP*	*TG*
Poaceae	*Panicum miliaceum*	*Panicum dichotomiflorum* Michx.	GP2	TG2
Poaceae	*Setaria italica*	*Setaria viridis* (L.) P. Beauv.	GP2	TG2
Poaceae	*Setaria italica*	*Setaria verticillata* (L.) P. Beauv.	GP2	TG2
Poaceae	*Setaria italica*	*Setaria glauca* (L.) P. Beauv.	GP2	TG2
Poaceae	*Setaria italica*	*Setaria intermedia* Roem. & Schult.	GP2	TG2
Punicaceae	*Punica granatum*	*Punica granatum* L.	GP1A	TG1A
Rosaceae	*Pyrus communis*	*Pyrus caucasica* Fed.	GP1B	TG1B
Rosaceae	*Pyrus communis*	*Pyrus balansae* Decne.	GP1B	TG1B
Rosaceae	*Malus domestica*	*Malus orientalis* Uglitzk.	GP2	TG2
Rosaceae	*Cydonia oblonga*	*Cydonia oblonga* Mill.	GP1B	TG1B
Rosaceae	*Prunus domestica*	*Prunus domestica* L. subsp. *insititia* (L.) C. K. Schneid.	GP1A	TG1A
Rosaceae	*Prunus domestica*	*Prunus spinosa* L.	GP1B	TG1B
Rosaceae	*Prunus cerasifera*	*Prunus cerasifera* Ehrh. var. *divaricata* (Ledeb.)L.H.Bailey	GP1A	TG1A
Rosaceae	*Cerasus avium*	*Cerasus avium* (L.) Moench	GP1B	TG1B
Rosaceae	*Cornus mas*	*Cornus mas* L.	GP1A	TG1A
Rosaceae	*Mespilus germanica*	*Mespilus germanica* L.	GP1A	TG1A
Rosaceae	*Rubus idaeus*	*Rubus idaeus* L.	GP1A	TG1A
Rosaceae	*Amygdalus communis*	*Amygdalus georgica* Desf.	GP2	TG2
Staphyleaceae	*Staphylea pinnata*	*Staphylea pinnata* L.	GP1A	TG1A
Staphyleaceae	*Staphylea colchica*	*Staphylea colchica* Steven	GP1A	TG1A
Vitaceae	*Vitis vinifera*	*Vitis vinifera* subsp. *sylvestris* (C.C.Gmel.) Hegi	GP1B	TG1B

Table 5. Gene pool and taxon group of wild relatives to Georgian ancient crops. GP- Gene Pool; TG-Taxon Group.

Thus, the combined use of the gene pool and taxon group concept proposed above provide the most pragmatic means available to determine whether a species is a CWR and how closely related a CWR is to its crop. We have determined 66 species of CWR belonging to 43 genera and 17 families, which can be assigned as Primary (GP-1) and Secondary Gene Pool (GP-2) and Taxon Group 1 and 2 (Tab.5). Seventeen (25.75%) are wild species but used as crops by collecting in the natural habitats and they were identified as GP1A. The same CWR species as crop were 19 (28.8%). Different species were 30 (45.45%), but representing direct progenitors whose genome is involved in the evolution of cultivars. Almost the same numbers were obtained during taxon group classification: TG1A - 17 species (25.75%), TG1B - 16 (24.25%), TG2 - 30 (45.45%), TG 5 - 3 (4.55%). The last 3 species belonging to the Taxon Group 5 are *Aegilops*, a wild relative of wheat. Goatgrass (*Aegilops tauschii*) is considered to be a donor of D genome of bread wheat genomic constitution = AABBDD (Petersen et al., 2006). The distribution area of this species is wide, however, D genomes of all forms of *T. aestivum* were found to be most closely related to accessions collected in Georgia, Armenia, Nakhitshevan and Azerbaijan (Dvorák et al., 1998). Thus, the germplasm of the populations of goatgrass in the South Caucasus needs conservation and should be preserved both *in situ* in protected areas and *ex situ* in seed collections.

Barley is one of the oldest crops to be domesticated from its wild progenitor *Hordeum spontaneum* (Badr et al., 2000, Kilian et al., 2006). We have found *H. spontaneum* in Georgia in three different places. This species was not included in the list of "Flora of Georgia' and it is a new species for Georgia. It is assumed that *H. spontaneum* might have evolved from *H. bulbosum* by fixation of the genes controlling self-compatibility and annual habit (Cass et al., 2005). This last species is widespread in Georgian regions.

Most fruit trees in Georgia are wild in forests and have cultivars domesticated from these wild ancestors. An economically important Georgian fruit crop is grape, which has a wild relative species *Vitis vinifera* subsp. *sylvestris.* We have found 9 populations of wild grapevine and conducted studies to reveal genetic and morphological relations between wild grapevine and landraces in Georgia (Ekhvaia et al., 2010).

Many fruits are domesticated in the Caucasus from wild ancestors representing Primary Gene Pool (GP-1B) to be the wild or weedy forms of the crops (Tab.5). The fruit crops (GP1A) and ancestor species (GP-1B) are the following: Pome fruits - pear (*Pyrus 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*), fig (*Ficus carica*), bladdernut (*Staphylea pinnata,* used flowers for marinade), and nuts - such as hazelnut (*Corylus avellana*), almond (*Amygdalus communis*), and walnut (*Juglans regia*), etc.

We evaluated CWRs endemic for the Caucasus (Tab.6). The endemic species of the same genus as crop were calculated. The number of endemic species from the total 479 CWRs of agricultural cultivars for food is 114 (23.8%).

4. Domestication events

4.1 Domestication of grapevine in Georgia

The grapevine was among the first fruits to be cultivated in Georgia (Javakhishvili, 1987). There are many arguments to confirm the fact that domestication events of grape took place in Georgia. One of the indicators is archaeological evidence. The 1,5-Myr-old petrified specimen of wild grapevine leaf was found in Georgia in the Meskheti province (Fig.4A). A confirmation for long lasting cultivation of grapevine in Georgia is archaeological remains of berries and seeds of domesticated grapes dated ~6.000 BC (in the vicinity of village Shulaveri [Fig.1], southeast Georgia; Ramishvili 1988). Other archaeological evidence of prehistoric winemaking was found in proximity of the Caucasus in northern Iran at the Hajji Firuz Tepe site in the northern Zagros Mountains dated to about 5.400–5.000 BC (McGovern, 2003) and in the Levant where archaeological findings are dated from ca. 4.000-3.200 BC (Zohary & Hopf 2000). Georgian traditions based on winemaking and grape culture to a high degree might be considered to be a second indicator of Caucasian origin of the grapevine. However, the primary scientific argument should be premised on N. I. Vavilov's (1992) idea that the centres of origin of cultivars should be characterized by high genetic and morphological variability of both wild and cultivated taxa. Five hundred is a very high number of known autochthonous grapevine varieties found in such a small territory (Javakhishvili, 1987; Ketskhoveli et al., 1960). These cultivars showed high morphological variability of leaf form, colour and shape of berries and shape and structure of pips. They are adapted to wide array of climatic conditions (Ketskhoveli et al., 1960). Each province of Georgia possesses unique grapevine cultivars adapted to local climate. The landraces of western Georgia grow in humid subtropical climate and other cultivars are adapted to moderate climates in eastern Georgia. Several local cultivars are growing in high mountain regions in Meskheti and Svaneti up to 1500 m a.s.l.

Besides the cultivars, there is high morphological and genetic diversity of wild grapevine populations in the Caucasus. All five haplotypes detected by using cpDNA microsatellite markers have been found in the Caucasian ecoregion suggesting that this area is possibly the centre of origin of both wild and cultivated grapevines (Grassi et al., 2006). However, only one provenance from Georgia has been analyzed in this study despite the number of populations of wild grapevine found in Georgia today that display morphological diversity (Ramishvili, 1988). We carried out a detailed comparative morphometric study of nine populations of wild grapevine, *V. vinifera* subsp. *sylvestris*, growing in the four river basins of the Ajaristskali, Mtkvari, Alazani and Iori located in western, southern and eastern Georgia.

Family	*Taxon*	*Family*	*Taxon*
Apiaceae	*Carum alpinum* (M. Bieb.) Benth. & Hook. ex B. D. Jacks.	Lamiaceae	*Thymus nummularius* M. Bieb.
Apiaceae	*Carum grossheimii* Schischk.	Lamiaceae	*Thymus tiflisiensis* Klokov & Des. - Shost.
Apiaceae	*Carum porphyrocoleon* (Freyn & Sint.) Woronow	Liliaceae	*Allium albovianum* Vved.
Apiaceae	*Pastinaca armena* Fisch. & C. A. Mey.	Liliaceae	*Allium candolleanum* Albov
Apiaceae	*Pastinaca aurantiaca* (Albov) Kolak.	Liliaceae	*Allium gramineum* K. Koch
Apiaceae	*Pastinaca pimpinellifolia* M. Bieb.	Liliaceae	*Allium gunibicum* Miscz. ex Grossh.
Asparagaceae	*Asparagus caspius* Schult. & Schult. fil.	Liliaceae	*Allium kunthianum* Vved.
Asteraceae	*Scorzonera charadzeae* Papava	Liliaceae	*Allium leucanthum* K. Koch
Asteraceae	*Scorzonera czerepanovii* R. Kam.	Liliaceae	*Allium otschiauriae* Tscholokaschvili
Asteraceae	*Scorzonera dzhawakhetica* Sosn. ex Grossh.	Liliaceae	*Allium ponticum* Miscz. ex Grossh.
Asteraceae	*Scorzonera ketzkhowelii* Sosn. ex Grossh.	Liliaceae	*Allium szovitsii* Regel
Asteraceae	*Scorzonera kozlowskyi* Sosn. ex Grossh.	Linaceae	*Linum hypericifolium* Salisb.
Asteraceae	*Scorzonera seidlitzii* Boiss.	Poaceae	*Elymus buschianus* (Roshev.) Tzvelev
Betulaceae	*Corylus abchasica* (Kem.-Nath.) Kem.-Nath.	Poaceae	*Elymus troctolepis* (Nevski) Tzvelev
Betulaceae	*Corylus colchica* Albov	Poaceae	*Elytrigia gracillima* (Nevski) Nevski
Betulaceae	*Corylus egrissiensis* Kem.-Nath.	Poaceae	*Elytrigia sinuata* (Nevski) Nevski
Betulaceae	*Corylus imeretica* Kem.-Nath.		
Betulaceae	*Corylus kachetica* Kem.-Nath.	Poaceae	*Secale strictum* subsp. *anatolicum* (Boiss.) K. Hammer
Betulaceae	*Corylus x fominii* Kem.-Nath.	Poaceae	*Secale strictum* subsp. *kuprijanovii* (Grossh.) K. Hammer
Fabaceae	*Cicer caucasicum* Bornm.	Rosaceae	*Amygdalus georgica* Desf.
Fabaceae	*Lathyrus colchicus* Lipsky	Rosaceae	*Crataegus caucasica* K. Koch

Family	*Taxon*	*Family*	*Taxon*
Fabaceae	*Lathyrus cyaneus* (Steven) K. Koch	Rosaceae	*Crataegus eriantha* Pojark.
Fabaceae	*Lotus caucasicus* Kuprian. ex Juz.	Rosaceae	*Pyrus demetrii* Kuthatheladze
Fabaceae	*Medicago dzawakhetica* Bordz.	Rosaceae	*Pyrus eldarica* Grossh.
Fabaceae	*Medicago hemicycla* subsp. *medidaghestanica* Sinskaya	Rosaceae	*Pyrus fedorovii* Kuthatheladze
Fabaceae	*Onobrychis angustifolia* Chinth.	Rosaceae	*Pyrus georgica* Kuthatheladze
Fabaceae	*Onobrychis biebersteinii* Sirj.	Rosaceae	*Pyrus ketzkhovelii* Kuthatheladze
Fabaceae	*Onobrychis cyri* Grossh.	Rosaceae	*Pyrus oxyprion* Woronow
Fabaceae	*Onobrychis grossheimii* Kolak. ex Fed.	Rosaceae	*Pyrus sachokiana* Kuthatheladze
Fabaceae	*Onobrychis iberica* Grossh.	Rosaceae	*Pyrus salicifolia* Pall.
Fabaceae	*Onobrychis kachetica* Boiss. ex Huet.	Rosaceae	*Pyrus takhtadzhianii* Fed.
Fabaceae	*Onobrychis kemulariae* Chinth.	Rosaceae	*Rosa buschiana* Chrshan.
Fabaceae	*Onobrychis komarovii* Grossh.	Rosaceae	*Rosa didoensis* Boiss.
Fabaceae	*Onobrychis meschetica* Grossh.	Rosaceae	*Rosa doluchanovii* Manden.
Fabaceae	*Onobrychis oxytropoides* Bunge	Rosaceae	*Rosa ermanica* Manden.
Fabaceae	*Onobrychis petraea* (M. Bieb. ex Willd.) Fisch.	Rosaceae	*Rosa galushkoi* Demurova
Fabaceae	*Onobrychis sosnowskyi* Grossh.	Rosaceae	*Rosa hirtissima* Lonacz.
Fabaceae	*Onobrychis transcaucasica* Grossh.	Rosaceae	*Rosa irysthonica* Manden.
Fabaceae	*Trifolium fontanum* Bobrov	Rosaceae	*Rosa kozlowskii* Chrashan.
Fabaceae	*Trifolium ruprechtii* Tamamsch. & Fed.	Rosaceae	*Rosa marschalliana* Sosn.
Fabaceae	*Trifolium sintenisii* Freyn	Rosaceae	*Rosa oplisthes* Boiss.
Fabaceae	*Vicia abbreviata* Fisch. ex Spreng.	Rosaceae	*Rosa ossethica* Manden.
Fabaceae	*Vicia alpestris* Steven	Rosaceae	*Rosa oxyodon* Boiss.
Fabaceae	*Vicia antiqua* Grossh.	Rosaceae	*Rosa prilipkoana* Sosn.
Fabaceae	*Vicia caucasica* Ekutim.	Rosaceae	*Rosa pulverulenta* M. Bieb.
Fabaceae	*Vicia ciliatula* Lipsky	Rosaceae	*Rosa teberdensis* Chrshan.
Fabaceae	*Vicia grossheimii* Ekutim.	Rosaceae	*Rosa transcaucasica* Manden.
Fabaceae	*Vicia iberica* Grossh.	Rosaceae	*Rosa tuschetica* Boiss.
Fabaceae	*Vicia sosnowskyi* Ekutim.	Rosaceae	*Sorbus buschiana* Zinserl.
Grossulariace-ae	*Ribes biebersteinii* Berland. ex DC	Rosaceae	*Sorbus caucasica* Zinserl.
Lamiaceae	*Satureja bzybica* Woronow	Rosaceae	*Sorbus caucasigena* Kom.
Lamiaceae	*Thymus caucasicus* Willd. ex Ronniger	Rosaceae	*Sorbus colchica* Zinserl.
Lamiaceae	*Thymus collinus* M. Bieb.	Rosaceae	*Sorbus migarica* Zinserl.
Lamiaceae	*Thymus coriifolius* Ronniger	Rosaceae	*Sorbus subfusca* (Ledeb.) Boiss.
Lamiaceae	*Thymus grossheimii* Ronniger	Rosaceae	*Sorbus fedorovii* Zaikonn.
Lamiaceae	*Thymus karjaginii* Grossh.	Rosaceae	*Sorbus velutina* (Albov) C.K. Schneid.
Lamiaceae	*Thymus ladjanuricus* Kem.-Nath.	Staphyleaceae	*Staphylea colchica* Steven

Table 6. One hundred fourteen endemic species of the Caucasus ecoregion related to the ancient crops in Georgia (Schatz et al., 2009).

The results reveal high morphological diversity of wild grapevine growing in Georgia. Morphological characters such as shape of leaf blade, number of lobes, pubescence type, coloration of internodes, leaves and berry skin, leaf vein lengths and angles between them and form of petiole sinus show high variability both within and among populations. The variability was related to the skin colour of berries. Some wild grapes had white berries, most had 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). The wild ancestor, however, should be considered to be black colour grapevine, which is most common in Georgian wild populations, eventhough the mutation leading to the white-fruited wild grapevine has been found in other Georgian wild populations (Ramishvili, 1988). On a phenotypical basis of our investigation (Ekhvaia & Akhalkatsi, 2010) it can be confirmed that the infraspecific evolution of *Vitis vinifera* subsp. *sylvestris* has produced three population groups south of the Great Caucasus Range. Overall, there are three phenetically distinct morphometric groups of western, southern and eastern Georgian wild grapevines. These three groups can be readily distinguished by the length of main leaf veins and lengths of nectaries in male flowers. This conclusion differs from the classical classification of Georgian wild and cultivated grapevine (Ramishvili, 1988) that considers two centres of origin of grapes in the South Caucasus region: (1) an Alazani origin with whole eastern and southern Georgia and adjacent territories of Azerbaijan and Armenia, and (2) a Colchic centre of origin which includes the entire western Georgian region with the Black Sea coastal zone. Our data clearly show a separated group in the southern Georgian population located in the territory of historical Tao-Klarjeti, a region of Georgia with many aboriginal grapevine cultivars. Therefore, it is of high importance to study aboriginal grape varieties in the place of its supposed domestication and to determine genetic relations among native grapevine cultivars and local wild populations.

A

B

Fig. 4. A- The 1,5-Myr-old petrified specimen of wild grapevine leaf. National Museum of Akhaltsikhe, Georgia; B-Stone carving on the medieval church Ananuri, Mtskheta-Mtianeti region, Georgia. Photos by Maia Akhalkatsi.

Molecular study based on nuclear microsatellite (SSR) markers revealed close genetic relationships between wild grape and local cultivars in Georgia (Ekhvaia et al., 2010, 2011). Twenty-four Georgian autochthonous and 45 accessions of wild *V. vinifera* subsp. *sylvestris* were analyzed at 17 microsatellite loci (VrZAG21, VrZAG47, VrZAG62, VrZAG64, VrZAG79, VrZAG83, VVMD7, VVMD24, VVMD25, VVMD27, VVMD28, VVMD32, VVMD34, VVS2, VVS4, scu04vv and scu14vv). Six accessions of the American rootstocks -

Fercal ('Cabernet -Sauvignon' x *Vitis berlandieri*), Telecki 5C (*V. berlandieri* x *V. riparia*), Malegue 44-53 (*V. riparia* X [*V. cordifolia* X *V. rupestris*]), Couderc 3309 (*Riparia tomenteuse x Rupestris* Martin), cultivar *V. labrusca* 'Odessa' and *V. riparia* naturalized in Georgia were used as outgroup. Thirty-seven accessions of wild grapevine were collected from different regions of Georgia and 8 wild accessions were sampled in Turkey's Artvin province adjacent to Georgia. All individuals within the studied populations of wild grapevine were identified as dioecious plants with male or female flowers. Genotype analysis at the most studied loci showed that Georgian cultivated and wild grapevine was characterized by high level of genetic variability. Genetic structure also was analyzed using F statistics. The low level of genetic differentiation (F_{st}=0.03) between Georgian cultivated and wild grapevines demonstrates that *in situ* domestication of wild germplasm took place within local populations. This means that autochthonous Georgian cultivars should be originated from local wild grapevine (Ekhvaia et al., 2010).

The dendrogram generated using Dice coefficient identified eight major clusters within the 75 different genotypes defined at 0.22 similarity level (Fig.5). Clusters A consist of 13 Georgian local cultivars and 8 wild grapevine accessions from different regions of Georgia. One example confirming the genetic linkage between cultivated and local wild grapevine is placement of the famous Georgian red cultivar 'Tavkveri' in cluster A, where it is closely linked to the wild accession WT46Tbilisi5 (GS value 0.96; Fig. 5) due to identical alleles at 33 out of 34 alleles. Thus, the hypothesis that this cultivar could have been selected from local wild grapevine can be considered, especially because like wild grapevine 'Tavkveri' is characterized by presence of functionally female flowers. The fact that the 5 ancient Georgian cultivars 'Chvitiluri', 'Kachichi', 'Shonuri', 'Saperavi' and 'Uchakhardani' fall within cluster B (Fig.5), which mainly contains wild accessions allowed us to suppose that these cultivars were derived from the earliest local domestication events. Cluster G shows the genetic similarity of most ancient Georgian cultivars 'Meskhuri Shavi' and 'Krikina' adapted to high mountain climate conditions in Meskheti.

In conclusion, it should be mentioned that the Georgian cultivated and wild grapevines represent a unique and interesting genetic resources that is 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. Thus, the obtained data are supporting that Georgia is one of the oldest centres of domestication of grapevine and harbour of valuable genetic resources for grape breeding.

It should be mentioned 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. The confirmation of threatened status of the Georgian wild grapevine might be detected low level of heterozygous individuals found for the most of the studied loci, which reflects the isolated status and the reduced number of individuals in the wild populations. Therefore, it is necessary to conserve wild forms and aboriginal cultivars of grape for the maintenance of genetic variability and to avoid genetic erosion of valuable genetic resources for grape breeding in Georgia.

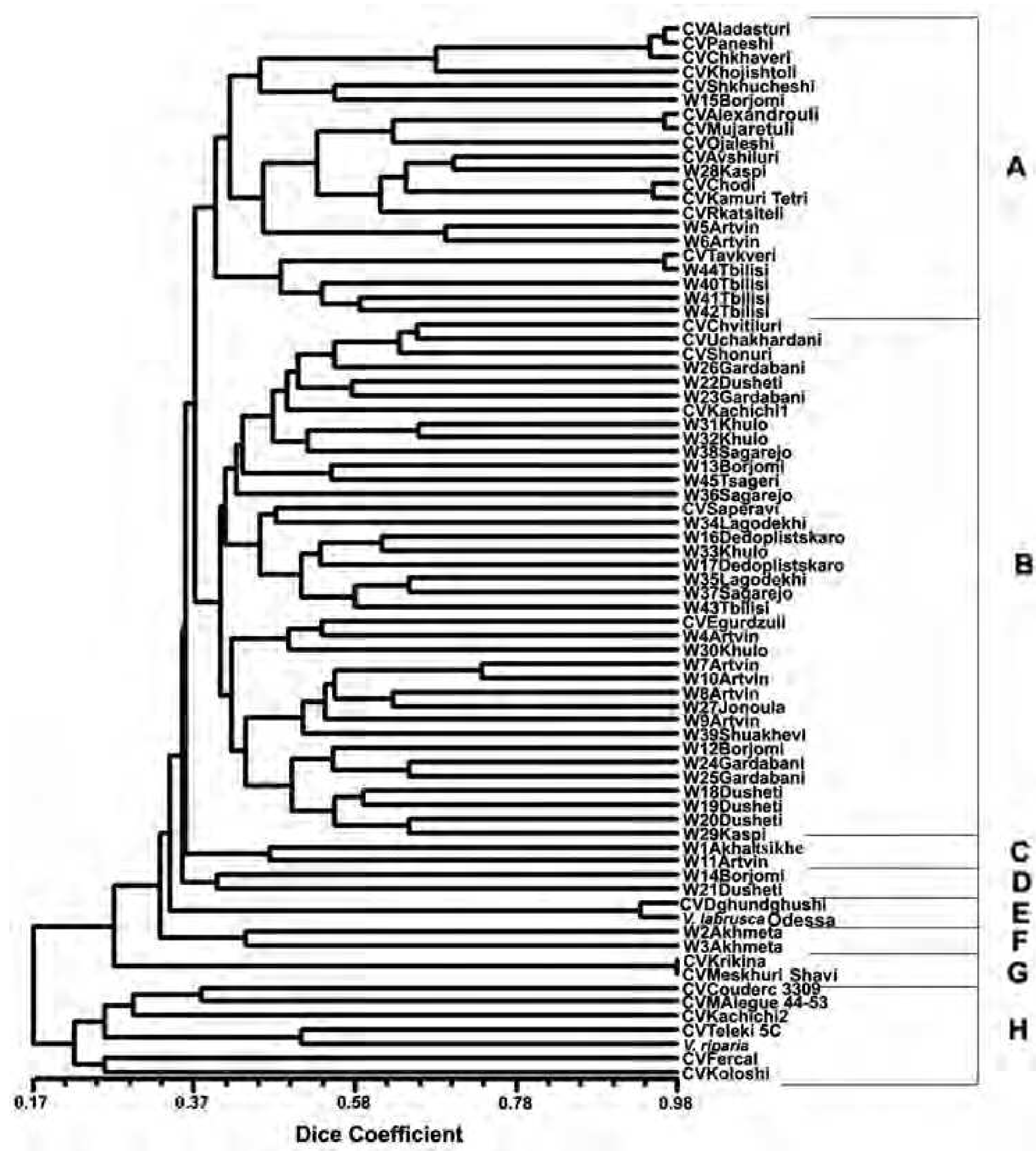

Fig. 5. Dendrogram of 75 accessions: Twenty-four Georgian local cultivars (*Vitis vinifera* subsp. *vinifera)*, 45 Georgian wild grapevine (*V. vinifera* subsp. *sylvestris*), 4 rootstock cultivars (Couderc 3309, Fercal, MAlegua 44-53 and Teleki 5C), introduced cultivar *V. labrusca* 'Odessa' and naturalized *V. riparia* constructed by unweighted arithmetic average clustering (UPGMA) method based on Dice's coefficient of shared SSR polymorphisms.

4.2 Domestication of pear in Georgia

Many pear cultivars occur in Georgia from pre-historic period indicating the early domestication event of this cultivated fruit tree (Javakhishvili, 1987). In total, 11 species of wild pear occur in Georgia (Kuthatheladze, 1980). They are distributed in different regions of Georgia, what is caused by the variable geographical relief and habitat diversity of the country. *Pyrus caucasica* Fed., the endemic species of the Caucasus is most widespread among the wild pears of Georgia and is considered as main progenitor species of local pear cultivars (Khomizurashvili, 1973). Moreover, *P. caucasica* and *P. pyraster* (L.) Burgsd. are regarded as the main wild progenitors, from which the cultivated European pear (*P. communis* L.) has probably evolved (Zohary & Hopf, 2000; Volk et al., 2006; Yamamoto & Chevreau, 2009).

According to the literature data (Khomizurashvili, 1973) introduced cultivars of pear from Europe and Russia appeared in Georgia at the end of 19th century and before there were existed only the local cultivars. However, we assume that the process of cultivar introduction might have started much earlier, as Georgia had cultural contacts to Asian and European countries since antique period. It is also remarkable that Greece is considered to be a first provider of selective cultivars of pear to the ancient world (Jackson, 2003) and earliest relations between Georgia and Greece should be considered as possible way of introduction of European pear cultivars in the Caucasus.

The local Georgian names of the cultivated pear *Mskhali* and wild Caucasian pear *Panta* exists in all Georgian dialects; they do not have analogues in any other languages (Javakhishvili, 1987). The Georgian names of cultivated and wild pears are linked with geographic objects such as mountains (Skhaltbis Range in Kartli, Mt. Mskhal-Gori in Kakheti's Kavkasioni), rivers (R. Skhaltba), or villages (Pantiani, Skhalta, Skhlobani, etc.; Javakhishvili, 1987). The name of wild Caucasian pear *Panta* is used among cultivars called 'Panta Mskhali', i.e. cultivar with name of wild pear. Moreover, the classification of Georgian pear cultivars (Khomizurashvili, 1973) contains a group of landraces with the same name. This classification system divides Georgian cultivars into four groups: 'Gulabi', 'Panta Mskhali', 'Kalos Mskhali', and 'Khechechuri'. The name of each group represents the name of a cultivar, which is considered to be a typical representative of a group. In the 'Gulabi' group, there are included both local and introduced cultivars to have most high economic values, big juicy fruits with sweet taste. The 'Panta Mskhali' group contains local varieties with small fruits becoming black after maturation. This is a character feature of wild Caucasian pear. The 'Kalos Mskhali' group includes local cultivars having bigger fruits than the second group. The 'Khechechuri' group matures in late autumn with juicy fruits containing a big amount of stone cells. According to N. Khomizurashvili (1973), the last three groups are originated by direct domestication of wild pear in Georgia. Although, some signs of selective breedings are remarkable as well. Relationships between wild *P. caucasica* and local cultivars are mirrored by a high morphological variability of leaf and fruit forms. This idea was for the first time confirmed by statistical methods of taxonomic identification and relationships among taxa in our study (Asanidze et al., 2011). We decided to conduct comparative morphometric study of cultivars recently occurred in Georgia and reveal their relationship to local wild pear species. The results have to determine local cultivars originated by direct domestication events in ancient time and discriminate from cultivars, which will have relationships with other wild species - *P. pyraster* or *P. pyrifolia,* considered as wild ancestors of European and Far East pear cultivars respectively.

We carried out the investigation to determine morphological characteristics of leaves, young shoots and fruits differentiating local and introduced pear cultivars of Georgia to reveal the relationships between cultivars and wild ancestor species of pear by statistical methods used in plant morphology (Asanidze et al., 2011). A total of 214 wild and cultivated pear trees have been sampled in natural habitats, living collections and peasant grounds in different regions of Georgia. Wild pear species were determined according to Sh. Kuthatheladze (1980). The pear accessions evaluated in this study consisted of Caucasian endemic *P. caucasica* Fed. (=*P. communis* subsp. *caucasica* (Fed.) Browicz; N=100), *P. balansae* Decne. (= *P. communis* L.; N=8) and *P. pyraster* (L.) Burgsd. (=*Pyrus communis* L. subsp. *pyraster* (L.) Ehrh.; N=3), which has been obtained from Germany, Hessen, in surrounding of v. Erda. Eighty-one individuals of 26 Georgian local and 22 individuals of 9 introduced cultivars (total 103 individuals of 35 cultivars) have been collected. Some of them are sampled in the collection of the Institute of Horticulture, Viticulture and Oenology, village Skra, Gori district, Georgia; local cultivars were sampled in the collection of aboriginal cultivars of Biological Farming Association Elkana in village Tsnisi, Akhaltsikhe district, Georgia. Many local cultivars are collected in peasant house gardens in different regions of Georgia. The individuals were evaluated by 27 morphological traits, which included one landmark analysis data, 12 leaf and shoot descriptors and 14 fruit descriptors. Morphological characters have been taken as recommended by International Union for the Protection of New Varieties of Plants (UPOV, 2000) for *P. communis* and J. Voltas and colleagues (Voltas et al., 2007), which delimited differences between wild and cultivated taxa of the genus *Pyrus* based on morphometric analysis. In total 21 morphological traits have been analysed by multivariate analysis. The Principal Components Analysis and Hierarchical Cluster Analysis (HCA) methods revealed the distance or similarity measure to be used in clustering with the Ward's method as amalgamation rules. According to HCA's results, pear cultivars, analysed in this study, are clustered into two groups (Fig.6). The first group **A** contains local cultivars related to *P. caucasica* and *P. balansae* by 21 morphological traits of leaves and fruits. Especially close Euclidean similarity distance is revealed between wild Caucasian pear, *Panta* in Georgian and a cultivar named 'Panta mskhali', which confirms etymological and taxonomic similarity within these taxa. *P. balansae* shows very close similarity distance with 'Tsvrili mskhali' and 'Korda'. Very closely related group of local cultivars to wild Georgian pears contains: 'Bebani', 'Samariobo', 'Tavrejuli', 'Kvichicha', 'Khinos mskhali' and 'Akiro'. The other group: 'Shavmskhala', 'Nenes mskhali', 'Borbala', 'Majara', 'Shakara' and 'Kartuli mskhali', is more distanced from wild pears, but located in the same cluster. We assume that these local cultivars must have been originated by direct domestication of wild Caucasian and Balanse's pears in Georgia.

The second cluster B (Fig.6) contains introduced cultivars of pear originated in European countries and some old Georgian cultivars. The group B reveals relationship with wild pear - *P. pyraster,* which is distributed in Europe and does not reach Georgian territory. The area of distribution is up to the middle of Turkey. The most cultivars from intermediate group B are more widespread in Georgia than the local cultivars originated by direct domestication of wild pears from group A. Two local pears 'Gulabi' and 'Khechechuri' are the most widespread among all local pears of Georgia and there are two or more varieties of them in each localities of the country. Moreover, Georgian name of cultivar 'Gulabi', which is also used to be a name of local pear group in classification of N. Khomizurashvili (1973), means pear in Persian. We suggest that local cultivars from cluster B (Fig.6) might have appeared in Georgia very long time ago and were improved by local population using breeding procedures.

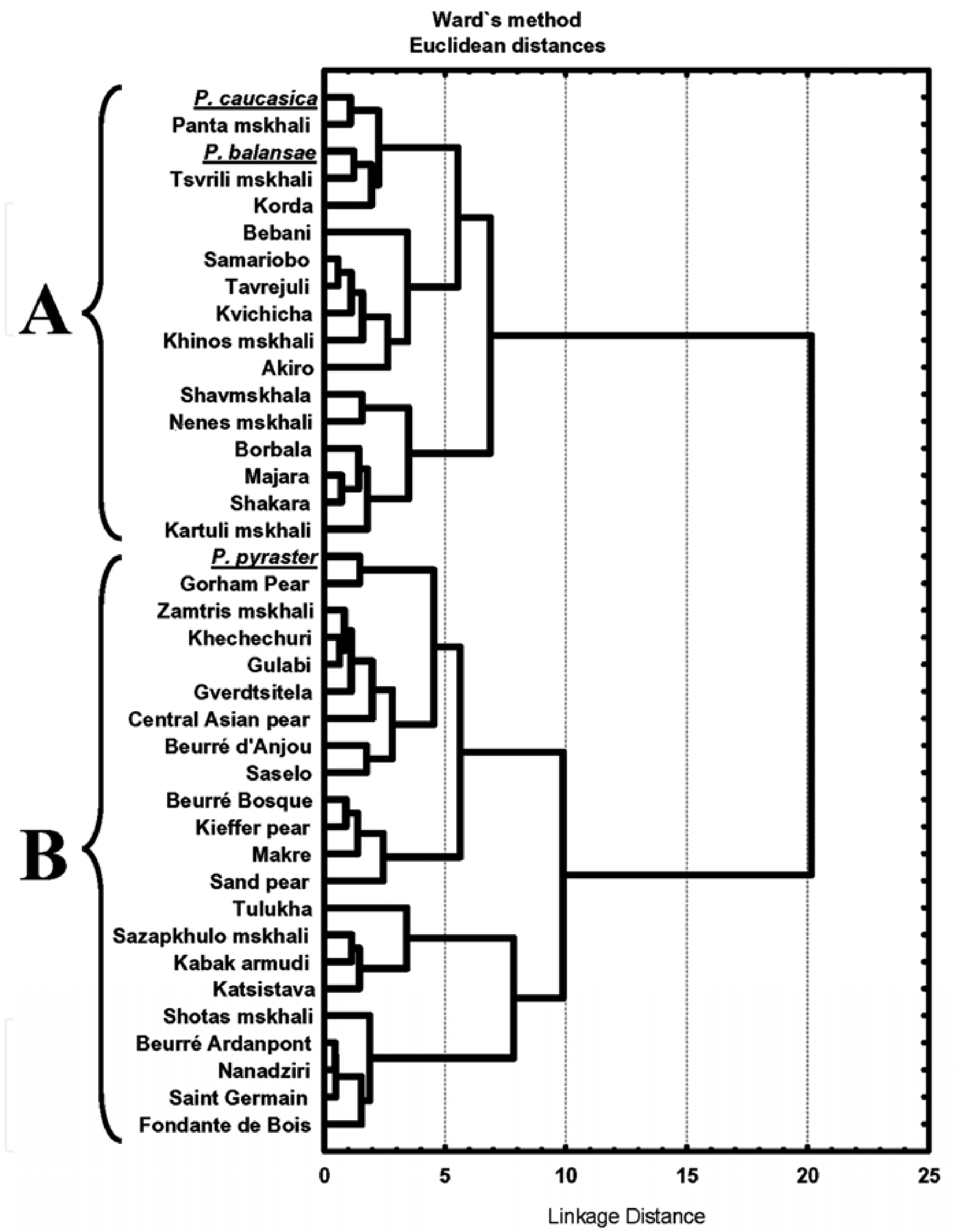

Fig. 6. HCA dendrogram of Euclidean distance with the Ward's method showing the relationships between the 35 cultivars and 3 wild species of pear based on 20 morphological traits of leaf, shoot and fruit and 20 landmark harmonics of mature leaf; The taxa in the dendrogram are clustered into two main groups - A and B. (N=214).

Leaf margin shape is the main morphological trait that differentiates Caucasian pear (*P. caucasica*) from European pear (*P. communis*). Leaf margins are entire in *P. caucasica* and serrate in *P. communis*. This theory was proved by the statistical analysis of the collected samples for the present study. Nowadays, *P. pyraster* is considered as the wild pear of Europe and cultivars are named as *P. communis* (Yamamoto & Chevreau, 2009). 'Communis' or the 'Common pear' group of cultivars has become the name of the cultivated pears of Europe, however, the structure and the diversity of the wild and cultivated pears of this group is not studied in details and needs further genetic and molecular investigations.

Thus, the results of this study have shown that some local cultivars of Georgia are direct domesticated from the native wild pear species - *P. caucasica* and *P. balansae.* The other local cultivars might be obtained due to selective works by breeding of local landraces with introduced cultivars from different countries in historically different periods. The molecular study of these taxa will clear in more details origin of these cultivars.

The results confirm the hypothesis that some local cultivars of Georgia are directly domesticated from the native wild pear species - *P. caucasica* and *P. balansae*. The other local cultivars might be obtained due to selective works by breeding of local landraces with introduced cultivars from different countries in historically different periods.

5. Traditional sustainable use of ancient crops

Since ancient times, agriculture in Georgia has been divided in two zones: lowlands (0-1300 m a.s.l.) and high-mountains (1300-2200 m a.s.l.). This classification was based on production of wine (Javakhishvili, 1987). Winemaking was always the major branch of agriculture in Georgia. Wine was exported from Georgia since ancient times. The vineyards were cut off to reduce income for exporting the wine in neighbour countries during the occupation of the country by the Muslim nations. The exchange of agricultural products took place between lowland and high-mountain regions and not only within the Georgians, but also with North Caucasians. This tradition remained till the end of 20th century when Dagestanian people from Didoeti region visited Kakheti lowland in eastern Georgia in late autumn. They have exchanged agricultural products from high-mountains to lowland crops. In 20th century, they brought from Dagestan cows, cheese and potato and have exchanged them on Kakhetian wine, schnapps from grapevine called *chacha,* bread wheat flour, fruits and vegetables.

A B C

Fig. 7. A - *Satsnekheli* - stone construction for the pressing of grapes in Nekresi monastery (IV century AD), Kakheti; B - Clay vessels for wine storage *Kvevri,* Ikalto monastery (XII century AD), Kakheti; C- Red wine *Saperavi* and *boghlortso* (wheat bread into red wine) in clay cups on Georgian table. Photos by Maia Akhalkatsi.

The information about the traditional use of wine is remained in folklore and ethnographic studies collecting this knowledge. The problem in reducing of written information was again the wars, destruction of settlements and burning of manuscripts during historical times. Therefore, the information on traditional agriculture is based on both literature data and interviews of local people obtained during our field trips in different provinces of Georgia. The ancient stone construction *satsnekheli* for the pressing of grape might be found near many historical monuments (Fig.7A) even in ancient caves of Chachkari near Vardzia monastry complex. Each family in lowland regions have a room for winemaking in houses called *marani* in which the clay vessels are buried in soil named *kvevri* (Fig.7B) where the wine is made and stored by traditional Georgian technology. One of *kvevri* in each *marani* was called *zedashe* and the wine in it might be used only in religious rituals since it belonged to the God. *Zedashe* was filled by schnapps called *Araki* derived from different fruits e.g. wild pear - *P. caucasica,* in high mountain regions and used for rituals (Fig. 8A-C). Wine and bread are ritual accessories of Christian religion and first cross entered in Georgia by St. Nino from Cappadocia in 4th century AD was made from vines. However, the folklore knowledge let us know that grapevine was a ritual plant in ancient religion and represented a tree of the God of sun. The remnants of grapevine images are often demonstrated as stone carvings on Christian churches (Fig.4B) and ancient golden and silver cups and Jewellery. Wine was used not only as alcohol drink but in religious rituals and as traditional food. *Boghlortso* (Fig.7C) was a healthy food prepared by wheat bread placed within a red wine and used by the whole family members including children and chronic invalid and consumptive people.

Bread is served with all Caucasian meals. It is the same ritual food like wine in Georgia. Two landraces of bread wheat - *Triticum 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.

A B C

Fig. 8. A- Murtaz Chankseliani collected wild pear (*Pyrus caucasica*) in forest, R. Kheledula gorge, Lower Svaneti; B - Wild Caucasian pear for preparing of alcohol schnapps *Araki;* C - Distillation equipment for preparing of pear schnapps. Photos by Maia Akhalkatsi.

The healthy quality of food in Georgia is connected with usage of fruit and herb sauces for roasted and fried meet. Sour plum sauce (*P. cerasifera* var. *divaricata*) is always added to spit-roasted chicken and pork. Many herbs and spices are added to meet meals. This should be understand to be a modern direction in diet works when an alkaline food is recommended to neutralize acid food, which is everyday meal including meet, sugar and bread. Modern civilization eats considerably more acid-forming foods than alkalizing foods. According to well-known naturopath P. Airola (1984), acidosis, or over-acidity in the body tissues, is one of the basic causes of diseases, especially the arthritic and rheumatic diseases. There is in the internet now a lot of information on alkaline food. The lists of alkaline products show that fruits and vegetables have highest pH most of which are traditional cultivars in Georgia. There are alkaline vegetables such as - alfalfa, barley, beet greens, beets, cabbage, carrot, celery, cucumber, eggplant, garlic, green beans, green peas, herbs, lentils, lettuce, onions, radishes, spices, spinach, watercress, wild greens, etc. which are the traditional cultivars in Georgia. Alkaline traditional fruits are - apple, apricot, berries, cherries, sour cherries, figs, grapes, grapefruit, nectarine, peach, pear, strawberries, watermelon, seeds and nuts, etc. To maintain health, the diet should consist of 60% alkaline forming foods and 40% acid forming foods. To restore health, the diet should consist of 80% alkaline forming foods and 20% acid forming foods (Airola, 1984).

Therefore, we should think about sustainability of traditional use of crops and wild plant species in the past time. The fact that the nature remained undisturbed in the country centuries long and population was characterized by much higher healthy features as current situation exists in Georgia should be explained as occurrence of healthy food and nature tolerant use of the plant resources.

6. Threats

6.1 Threats and conservation of ancient crops

There are several reasons for the genetic erosion of ancient cultivars and the wide distribution of new varieties of introduced crops. First of all, new cultivars have higher yields and are therefore preferred both as a source of food for local people and as a cash crop that determines local income. The second reason why local peasants began to prefer cultivating genetically modified (GM) plants may be explained by introduction of new diseases into Georgian agricultural fields in recent years, causing harm primarily to ancient cereals and vegetables. However, the introduction of new parasites has revealed that endemic forms of Georgian crop plants contain valuable selective disease-resistant material for genetic engineering. 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 wheatstem rust resistance gene Sr36 (Tsilo et al., 2008). *T. carthlicum* is characterized by immunity to diseases, a short growing period, and resistance to cold.

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, e.g. the highly productive awnless wheat cultivar Bezustaja I developed in Russia has been sown in all wheat fields in Georgia since the 1970s, and this variety eventually replaced Georgian endemic wheat species. Recently new breeder's varieties of wheat and other cereals are introduced from different countries.

The process of genetic erosion of ancient crop varieties has not been a great concern for the mountain areas of Georgia, which until the 1990s acted as a depository of ancient crops. One important consideration that explains why ancient cultivars were conserved longer in mountainous regions than in the lowlands is that the local population preserved their traditional ways of life and socioeconomic structures. The traditional agricultural system is characterized by dependence on local genetic resources and locally developed technologies. Even today, peasants in mountain villages use an ox-drawn sledge made of wood for loading and transporting cereals and a threshing sledge on threshing floors to thresh wheat, oats, rye, and barley. Traditional agricultural equipment makes it possible to cultivate areas even on steep slopes and at high elevations, where modern tractors cannot be used. Moreover, some old landraces of wheat and barley are used to prepare bread and beer for religious rituals. Substitution of these landraces by others would go against centuries-old traditions (Akhalkatsi et al., 2010).

Despite these conditions that support the maintenance of ancient landraces, many endemic and native representatives of crop plants are currently in danger of extinction and face severe problems of genetic erosion in all mountainous regions of Georgia. While agrobiodiversity is declining rapidly in many areas of the world due to anthropogenic pressure (Körner et al., 2007), including population growth, in Georgia the main reason for genetic erosion of ancient crop varieties is demographic decline in mountain regions due to harsh economic conditions and lack of modern infrastructure (Nakhutsrishvili et al., 2009). The shift from ancient cultivars to modern high-yielding crops such as maize and potato, which took place in the lowland areas much earlier, began in mountain villages only in the last 20 years. Greater income from marketing allows families to stay in mountain villages. Moreover, the economic security of the traditional farming systems in these mountain regions appears to be in jeopardy when traditional agriculture is replaced by cattle breeding, which causes abandonment of cultivated fields and their transformation into pastures.

Several research centres maintain *ex situ* germplasm collections of Georgia, such as 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. Several gene banks and living collections occur in Georgia. There is one biggest genebank located at the Georgian 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 5 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 crop wild relatives. A recently initiated project, ''Mountain Biodiversity in the Caucasus and its Functional Significance,'' supported by the Swiss National Science Foundation Program SCOPES, will build an electronic biodiversity archive for Georgia, and include data on mountain plant biodiversity in Georgia. Because it will be built in compliance with Global Biodiversity Information Facility (GBIF) standards, it will contribute to the Global Mountain Biodiversity Assessment (GMBA) mountain portal with GBIF (www.mountainbiodiversity.org). A research agenda concerned with the use of georeferenced mountain biodiversity data for science and management was developed at a GMBA workshop in Kazbegi, Central Caucasus, in July 2006 (Körner et al., 2007). Such a database of the plant species of the Caucasus will become a prominent entry in the GBIF database and highlight the current status of plant genetic resources in Georgia.

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, grass pea, chickpea, faba bean, common millet, Italian millet, etc. 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.

In our opinion, 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. 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 reintroduction of ancient cultures to modern agriculture can insure longevity of people.

3.3 Threats and conservation needs of crop wild relatives

The natural populations of many species of CWRs are increasingly at risk. The primary causes of diversity loss of wild plant species are habitat loss, degradation and fragmentation. Many cereal CWRs, including relatives of wheat and millet species, occur in arid or semi-arid lands and are severely affected by over-grazing and desertification. The forest species are affected by habitat disturbances because of illegal forest cutting occurring in 1990s in Georgia. Climate change is having significant impacts of species distributions and survival in a concrete habitat. One of the most important threats to the diversity of CWRs are genetic erosion and pollution. The threat of genetic pollution or introgression, either from genetically modified organisms (GMOs) or from conventionally bred crops, to wild species has become an increasing risk to the in situ genetic conservation of crop wild relatives.

Another problem is that many species of important CWR occur in centres of plant diversity and crop diversity located mainly in developing countries, which often lack resources to invest in the necessary conservation activities. South Caucasus and Georgia, in particular, is the centre of origin and diversity of many of the world's important crop plants. There are several international projects realized by the ICARDA, the International Plant Genetic Resources Institute (IPGRI), US Department of Agriculture (USDA), United Nations Environmental Program (UNEP), etc. contributed in undertaking efforts in monitoring and conservation of plant. Although, additional resources are urgently needed in such areas of high diversity to identify priority species for conservation, determine the necessary conservation activities, monitor the status of key species, improve the use of these valuable resources.

Habitat disturbances are main threats leading to the extinction of rare and endangered plant species. Deforestation took place during last decades in Georgia and caused habitat degradation. The fact detected with the population of wild grapevine has revealed the threat to the riparian forests, which is situated along rivers in very close proximity of settlements and local people uses the resources of this forest in a highest degree. We have detected that some trees were cut representing the support of clambering wild grapevine and the individuals were lying on the earth, which will cause its drying up and death. More great scale cuttings in dark coniferous forests lead to arising of forest openings with high irradiation leading to drying up the underground cover of mosses and lichens, which drastically changes habitat and determines disappearing of natural species adapted to this habitat. Overgrazing of meadows and pastures was a problem in Soviet period, when several million head of sheep were grazing summer pastures of mountainous regions of Georgia. However, now the number of cattle is reduced and does not threaten much the rare species in their natural habitats. In spite of this fact, grazing affect survival of rare species such as *Hordeum spontaneum,* which was found on road side and during the next visit it was grazed completely. Such disturbances as habitat degradation due to road and pipeline construction works threatens the populations but has temporary effect. These types of disturbances are especially threatening the rare and endangered species of high conservation value.

The best way of *in situ* preservation of genetic diversity of valuable plants is creation of nature reserves on the territories, where natural populations of CWR occur. The first nature reserve of Georgia was established in Lagodekhi in 1912. In present, the protected areas occupy 7% of the country's territory, which is equal to 495.892 ha. There are 16 nature reserves, 9 national parks, 12 managed resource protected areas, 14 natural monuments and 2 protected landscapes in Georgia. The problem remains for the species, which are growing in rural habitats and on arable lands mixed with field crops have different assessment to threats. These species are depending in their existence to the monitoring of arable lands, which crop will be sown, how will be transformed filed crop to pasture or hay meadow, or what kind of herbicides and mineral fertilizers will be used in the field. The maintenance of wild populations growing as weeds in cultivated fields depends on sustainable management of agriculture in the region. The governmental institutions should control the processes which might bring to the genetic erosion of CWRs having high value of conservation. In this case the legislation bases should be effective to control local farmers not affect CWRs with ecologically unsuitable for this species actions in the field e.g. use of fertilizers or introduction of new crops leading to changing in technology of field cultivation methodology and leading to disturbances of wild weed species of high conservation value.

Ex situ conservation of the germplasm of CWRs is very valuable material for improvement of crop quality and their resistance against fungal and microbial disease. It will be of interest to collect their seed material and distribute to genbanks, which will contribute to provide necessary germplasm to research centres dealing with the genetic engineering. The Tbilisi Botanical Garden and Institute of Botany has two collections of seeds. One is collection of rare endemic plant seeds, which is collected in the framework of the Millennium project managed by Kew Royal Botanical Garden, UK. The second is collection of aboriginal crop varieties collecting in different regions of Georgia. These program works together with IPK, Gatersleben Germany, where the analogy of the collected material is kept at the gene bank. The living collections of CWRs are very few. Botanical Gardens in Tbilisi and Batumi have some small collections of CWRs collected in the frameworks of international collaborative projects. However, maintenance of the collections after finishing the projects is impossible and they are cancelled in several years. The plant genetic resources documentation in Georgia is mostly computerized. There are several databases, which include all information and passport data for accessions of field crops, but so far they have no free access.

Most threats to biodiversity are the results of human actions, which are expressed in the overuse of natural resources for fuel, fodder, manure, grazing and collecting of ornamental and medicinal plants. This process leads to the loss of genetic diversity including crop wild relatives. The *in situ* protection measures are not easy to implement and, thus, the accent should be directed on *ex situ* conservation.

7. Conclusions

Very old archaeological 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 fact that large-scale genetic erosion of the ancient landraces in Georgia has reached extreme levels from 1950s and almost all the local varieties of cereals (wheat, barley and millet), legumes (peas, lentils, common vetch and faba bean), and grapes are now disappear from the farms requires special analyses and development of conservation measures. Only the gene banks and living collections hold germplasm of landraces extinct in the farms. An assessment of the effectiveness of current conservation strategies to protect the diversity of ancient crops in Georgia reveals a gap in the reintroduction of conserved germplasm to the fields of local farmers. In our opinion, the corresponding governmental institutions responsible for conservation of biodiversity should refocus the strategy to require complementary *in situ* and *ex situ* conservation actions to maintain maximum diversity of the target taxon's gene pool by supporting local farmers in reintroducing ancient crops on the market and thereby filling this gap. Moreover, at present, neither field crop genebank nor live collections of the permanent crops have sufficient land and equipment in Georgia, as well as funding to carry out *ex situ* conservation at the modern level. Storage of the *in situ* collections should be improved through upgrading the present storage of the field crop genebank facilities.

There is a need to improve public awareness of importance of e*x situ* conservation. Popularity of the data obtained by scientists should be distributed among the local population so that they themselves have contributed to the preservation of national heritages. The results of scientific investigations that some crops represent local cultivars and even domesticated landraces in this area means that this is connected with lifestyle of the local population. The fact that longevity of life in the Caucasus was very high and centenarians lived to 120 years and more should be understand that a healthy diet of mankind is not only amount of calorie but the combination of food of high quality. The modern alkaline diet almost completely coincides with the traditional Georgian cuisine. Therefore, we must appreciate the importance of conservation of local varieties to ensure the health of local people.

The data obtained in our investigations (Ekhvaia &Akhalkatsi, 2010; Ekhvaia et al., 2010, 2011; Asanidze et al., 2011) indicate importance of CWR species in Georgia as many of them represent direct ancestors of local cultivars. The fact that wild grape shows high genetic relation to local varieties of grape indicates that winemaking represents an ancient culture in Georgia, which is expressed even in religious rituals of the nation. Wild grapevine and pear representing the wild ancestors of local varieties are under threat because of wood cutting. Many other CWRs are in the same position. The legislation of species conservation is applied to rare and endemic species and *in situ* conservation is maintained only at protected areas. However there is no legislation that can protect CWRs growing in rural and urban areas and representing weed species. No actions of conservation are undertaken to protect these species. Many CWRs (wild wheat, rye, coriander, etc.) are grown in cultivated lands of local farmers. Many years, wild wheat species were mixed with local varieties of wheat and barley but now they are disappeared. The events which are protecting them are traditional cultivation technology of the landraces to which the local weeds are adapted by their life strategy and propagation character. The threats here will be change of traditional crops to the new varieties, which will need different cultivation events. This might lead to disappearance of the CWRs from the cultivated beds. At present, CWRs *ex situ* collections are almost absent in Georgia.

The problem of genetic erosion of landraces and their wild relatives needs active contributions by national policies and comprehensive measures are urgently needed to avoid the complete loss of ancient crop genetic resources in Georgia. International nature conservation institutions and Georgian scientific and nongovernmental organizations should show more activity to the restoration of ancient crops, which defined the healthy life of Georgians.

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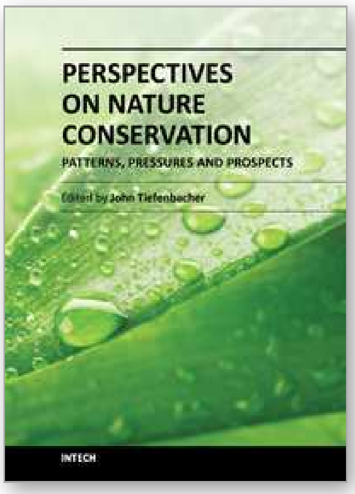

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