



Situational Analyses of the Current State of Plant Genetic Resources Important for Food and Agriculture in Georgia (Caucasus Ecoregion)

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Abstract

Conservation of the genetic resources of ancient crops in Georgia are current landraces and primitive forms occurring in Georgia and to publish lists of indigenous landraces and CWRs of cereals, legumes, vegetables, vine and fruits representing direct ancestors, and endemic, rare or endangered species. National policies and comprehensive measures are urgently needed to address the problem of conserving the genetic resources of ancient crops in Georgia. It is necessary to establish a general overview of the types of crops that are current landraces and primitive forms occurring in Georgia. However, the introduction of new parasites has revealed that endemic forms of Georgian crop plants contain valuable selective disease-resistant material for genetic engineering. Establishment and maintenance of *ex situ* collections and databases should be considered just as a first step in the conservation process of ancient crop varieties. Storage of the *ex situ* collections should be improved through upgrading the present storage of the field crop genebank facilities.

Keywords: Crops; CWRs; Introduced cultivars; Landraces; Medicinal plant

Introduction

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. Food and, exceptional wine was exported from Georgia since ancient times to neighbour countries and represented main economic income for the country. The vineyards were cut off by the Muslim nations not for religious order but for reducing income by exporting the wine, which diminished economic status during the occupation of the country [1].

In the early 1990's, until Georgia get independence, it was one of the main producers and exporters of agricultural products throughout the Soviet Union. Its exports were 70% higher than its imports [2]. In 2009, the imported agricultural food amounted to 1 156 billion US\$ (82,5%) and the export was only 246 million US\$ (17,5%) [3]. This means that agricultural sector oriented in the past for export was destroyed. As a result, the active increase of import of agricultural food products caused almost complete collapse of agriculture in Georgia. In 2004 total agricultural production had fallen by more than half compared to the pre-independence period [2]. A severe impact on agricultural exports had as well the Russian Federation's embargo on Georgian

products, imposed early in 2006, affecting the livelihoods of rural people. Since 2010, the export has begun to increase, although, import still represents very significant amount and value. Therefore, nowadays, opportunity of significance for Georgian entrepreneurs and foreign investors in the food and agricultural sector might be presented by export opportunities either as part of an import substitution orientation.

Besides the diminishing of the amount of agricultural products, the main threat to agrobiodiversity in Georgia is the loss of landraces and ancient crop varieties. These process has started from 1950s when 'kolkhozis' reached extreme level of development in soviet republics and almost all the local varieties of cereals (wheat, barley, rye, oat, Italian millet and millet), legumes (peas, lentils, common vetch and faba bean), and landraces of grapes have been disappeared. Only the gene banks and living collections in Georgia and foreign countries hold germplasm of landraces extinct in the local farms. There are many threats to these oldest of crops in the modern period. 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. 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, vine 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.

Crops and Local Landraces

The loss of local and ancient crop varieties should be considered to be the main threat to agrobiodiversity in Georgia. These varieties reveal a high level of adaptation to local climatic conditions and often have high resistance to diseases. 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. There are several reasons for the genetic erosion of ancient cultivars and the wide distribution of new varieties of introduced crops. Intensive Genetic erosion of ancient crops started in Georgia since 1950s which was also a period of intense selection work in breeding stations in the whole of the Soviet Union. Recently new breeder's varieties of wheat and other cereals are introduced from different countries. First of all, new cultivars have higher yields and are therefore preferred both as a source of food for local people and as cash crops that determines local income. 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.

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.

Introduced Crops

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 [1]. Some introduced crops have become very popular and widespread: cucumber (*Cucumis sativus*), eggplant (*Solanum melongena*), marigold (*Tagetes patula*), and black pepper (*Piper nigrum*) were introduced from India; Watermelon (*Citrullus lanatus*) from South Africa; Maize (*Zea mays*), sunflower (*Helianthus annuus*), tomato (*Solanum lycopersicum*), bean (*Phaseolus vulgaris*), pepper (*Capsicum annum*), and potato (*Solanum tuberosum*) were introduced from the Americas at about the same time as in

Europe [1]. Tea (*Camellia sinensis*) and citrus fruits (*Citrus limon*, *Citrus reticulata*, *Citrus sinensis*) came from China in the 1830. *Nicotiana rustica*, (tutuni in Georgian) has been cultivated for a long time and *N. tabacum*, was introduced during the Soviet period and was cultivated in *kolkhozis* for commercial use.

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 listed 195 varieties of field and vegetable crops and 195 varieties of fruits [4]. 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.

Crop Wild Relatives (CWRs)

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 [5].

Flora of the Caucasus region is rich as there are high concentrations of economically important and edible plants, particularly CWRs 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 [6]. The list of CWRs in Georgia was published in Plant Genetic Resources (PGR) Forum- CWR Catalogue of Europe and the Mediterranean [7]. 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. There are only data on endemic species and species genetically closely related to crops [8].

CWRs of Local Cultivars

According to the recent evaluation of the diversity of CWRs of local cultivars in Georgia [8], the numbers of species of the genera that are traditional crops in Georgia were identified. A total of 20 plant families, 76 genera and 559 species were identified as

wild relatives of ancient crops in Georgia [9]. Most of these plant species are closely related genetically to landraces and might be their progenitor species. The combined use of the gene pool (GP) and taxon group (TG) concept [7] have revealed 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 [8]. 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 3 species belonging to the Taxon Group 5 are *Aegilops*, a wild relative of wheat. Barley is one of the oldest crops to be domesticated from its wild progenitor *Hordeum spontaneum*, which have been found in Georgia in three different places [9]. This species was not included in the list of "Flora of Georgia" and it is a new species for Georgia.

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* revealing the genetic and morphological relations with landraces, which confirmed the domestication of grape in Georgia [10]. 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. The fruit crops (GP1A) and ancestor species (GP-1B) are the following: Pome fruits - pear (*Pyrus communis*, *P. caucasica*), apple (*Malus domestica*, *M. orientalis*), 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*), and nuts - such as hazelnut (*Corylus avellana*), almond (*Amygdalus communis*), and walnut (*Juglans regia*), etc. The number of endemic species from the total 479 CWRs of agricultural cultivars for food is 114 (23.8%).

Wild Plants Harvested and Managed for Food

These are wild and naturalized fruits collected by local population in the natural habitats - walnut, pear, apple, quince, plum, sour plum, cornel cherry, medlar, mulberry, pomegranate, red raspberry, currant, fig, bladdernut, and nuts - such as hazelnut and walnut, etc. Green biomass of many herbs called *mkhali* in the eastern Georgia and *pkhali* in the western Georgia are used by peasants for food, especially in the spring when deficit of vitamins are substituted by them. The list of these edible herbs is not yet done.

Some spices are collected in the wild such as caraway, gitsruli in Svanetian (*Carum carvi*), creeping savory (Satureja

spicigera), Hyssop (*Hyssopus angustifolius*), wild thyme (*Thymus serpyllum*), Oregano (*Origanum vulgare*), etc. Collection of wild plants for food in the natural habitats does not represent threat for the species extinction as local populations in regions has very tolerant relation to nature and never harvest amount creating threats to the species. Only, in case, if some company will use the wild resources for a market and industry, it might represent the real threat as the amount will be more than it is acceptable for the maintenance of the population.

Medicinal Plants

Local population in Georgia has a great experience for traditional use of medicinal plants in folk medicine. Local people actively are using herbal medicine and have valuable indigenous knowledge from ancestors on preparation of remedies. Another type of persons are educated, who has ground knowledge on herbal medicine, has books on medicinal plants and often they serve as homeopaths in villages. Almost in all villages are persons, who are healing patients using herbal medicine. Such "public doctors" are much respected persons in villages and people trust them. As a total, 1200 vascular plant species are listed as medicinal plants in Georgia [8]. 418 vascular plant species have been determined only in one Samtskhe-Javakheti region of Georgia [11]. Among them are endangered, rare and endemic species needed both in situ and *ex situ* conservation.

It is concluded [11] that even if local population is collecting plants for own use, it does not threatens natural populations of species. However, when plant is collected for pharmaceutical industry to produce drugs in a big amount, it leads to extinction of populations in the region. In general, anthropogenic impacts such as heavy grazing and wood cutting are the cases threatening plant species. It is necessary to develop legislation to protect effectively economically important plant species. Collection in the wild should be strictly controlled by legislation.

Pasture and Rangeland Species

Pastures are of two types - summer and winter. Summer pastures are subalpine and alpine meadows mainly used for sheep and cattle. Winter pastures are in the arid zone and used mainly for sheeps. In alpine meadows grass, sedge and polydominant grass-forb meadows are characteristic. Grass-forbs and legume dominated meadow communities are characterized by high diversity, containing more than 30 species in one community [12]. There are several types of grass meadows where dominant species might be *Festuca ovina*, *Bromopsis variegata*, *Poa alpina*, *Koeleria caucasica*, *Nardus stricta* or *Festuca varia*. Dominated species in sedge meadows are *Carex humilis* or *Carex brevicollis*. Dominant species in legume meadows is *Trifolium ambiguum*. Polydominant grass-forb meadows are composed by *Sibbaldia procumbens*, *Alopecurus vaginatus*, *Bromopsis variegata*, *Phleum alpinum*, *Trifolium ambiguum*, *Festuca ovina*, *Galium verum*, *Stachys macrantha*, etc. Polydominant alpine meadows contain *Festuca ovina*, *Potentilla alpestris*, *Gentiana septemfida*, *Carum caucasicum*, *Trifolium repens*, *Aster alpinus*, *Luzula spicata*,

Campanula collina, *Potentilla gelida*, etc.

Rural vegetation is one of the most interesting in terms of CWRs. Especially, field CWRs occur in this biome. Roadsides are completely covered by *Aegilops cylindrica* and *Hordeum leporinum*. Agricultural land area is covered by CWRs of legumes, herbs and grasses. Many wild fruit trees and shrubs occur on roadsides and urban areas. Many invasive and adventive cosmopolitan plant species are used in traditional and scientific medicine. 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 field 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 leading to changing in technology of field cultivation methodology and leading to disturbances of wild weed species of high conservation value.

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 is 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.

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. *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. 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.

Conclusion

National policies and comprehensive measures on the conservation of agrobiodiversity in Georgia are still not being sufficiently implemented. There are several international projects realized by FAO, UNEP, ICARDA, IPGRI, USDA, etc. contributed in undertaking efforts in monitoring and conservation of agrobiodiversity in Georgia. 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. 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, 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 2016. 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.

The following actions should be considered as agenda for conservation of plant genetic resources in Georgia:

1. Conservation of the genetic resources of ancient crops in Georgia should be considered as priority action. 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.
2. At the first step 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, vine 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.

3. 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. 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 ex situ collections should be improved through upgrading the present storage of the field crop genebank facilities.
4. Establishment and maintenance of ex situ collections and databases should be considered just as 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. This data 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.
5. There is a need to improve public awareness of importance of ex 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.

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