



Inclusion of most appropriate crop wild relative populations and sites from Serbia in European *In situ* Network

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Summary: Crop wild relative (CWR) conservation planning has started in many European countries with some of them having developed national CWR conservation strategies. The development of the European PGRFA *In Situ* Conservation Network has been implemented through the H2020 “Farmer’s Pride” project but it did not have sufficient funds to include all European countries. Funding is required to ensure those countries currently uninvolved are able to identify populations and sites, and prepare applications to join the European *in situ* PGRFA conservation network. The project “Inclusion of CWR sites in European *in situ* network” was approved for financing under ECPGR Activity Grant Scheme (Phase X) First Call for proposals. The aim is to improve national capacities for *in situ* PGRFA management in Lithuania, Cyprus, Albania, Bulgaria, Slovenia, Slovakia, Latvia, Romania, Croatia and Serbia. The joint effort from the ECPGR Working Group “Wild Species Conservation in Genetic Reserves” and the “Farmer’s Pride” Project contributed to the development of European strategy for CWR conservation, National and European MAWP selection and thus biodiversity conservation. Mountain Fruška gora has been proposed for inclusion as the MAWP site, while wild garlic - *Allium ursinum* and a sunflower CWR - *Helianthus tuberosus* have been proposed as the MAWP populations from Serbia for the European CWR *in situ* Network.

Keywords: crop wild relatives, biodiversity, *in situ*, conservation

List of abbreviations:

MAWP Most Appropriate (crop) Wild (relative) Populations

PGRFA Plant Genetic Resources for Food and Agriculture

Background on PGRFA conservation in Serbia

Activities prior to 2000

Significant increase in activity on PGRFA marked the period between 1961 and mid- or late 1980s and coincided with the development of agriculture in Serbia and ex-Yugoslavia. During that time, intensive research in the fields of genetics and plant breeding made it possible to collect a lot of PGR and to start work on the national gene bank. The key project was "Construction of plant gene bank", with two subprojects "Construction of plant gene bank of Yugoslavia" and "Formation of gene pool for the needs of Plant Gene Bank of Yugoslavia". That gene bank was also meant to serve as the regional research center for PGRFA with professional and material assistance from the International Board for PGR (IBPGR). The creation of the gene pool for the needs of the gene bank began in 1989, with the participation of 26 research institutes and significant FAO support. Until the year 1992, 63 plant species

were studied and 5.228 samples were processed, all of them today at the National plant gene bank (NPBG). From the beginning of the nineties, crises and civil wars brought work on PGR activities down to minimum. The work continued in the late 2000's in several PGR groups of: cereals and maize, forage, industrial crops, medicinal and aromatic plants (MAP), fruit crops, vitis and vegetables (Marjanović et al. 2013).

PGR Conservation efforts through national projects

Up to 2009, collected samples were transferred to the agricultural research institutes or universities, depending on who organized the mission. Before the mentioned year, the national plant gene bank did not function, nor existed synchronized collection activities, centralized documentation and organized conservation of the most important accessions. Several projects were funded for wheat PGR research:

"Collection and evaluation of agronomically useful genetic variability of wild relatives, as donors of desirable genes." Short-term research project. Federal Secretariat for Labor, Health and Welfare. Federal Institute for Plant and Animal Genetic Resources, 2001-2002.

"Preservation and sustainable use of wheat crop collections". Short-term scientific research project. Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, 2005-2006.

Funding calls for support of work on PGR collection and conservation have been announced annually since 2000 mostly by the Ministry of Agriculture. Evaluation of PGR was usually funded by the Ministry of Science as subprojects of crop specific National projects focused on breeding. On farm PGR are evaluated only sporadically like old cultivars on mountain Fruška gora in the project of the Provincial Secretariat for Science (Milošević et al. 2012).

PGR Conservation efforts through international projects

The research on PGR also included joint missions with the USDA-ARS and support of the FAO for sunflower CWR collection in the USA, where five collecting trips were organized (1980-1991). After the year 2000, several notable projects related to PGR management and conservation have been launched and completed in Serbia with foreign support. The three most important were: Establishment of PGR information infrastructure system - EPGRIS (2000-2003), SEEDNet project (2004-2010) and the FAO Project "Support for Development of the National Program for PGRFA" (2011-2013), as the second part of the project started in 1990. The SEEDNet and the FAO projects significantly contributed to upgrading the equipment within the National Plant Gene Bank, as well as the development of the National PGR Programme (Marjanović et al. 2013). The National Program was issued in 2013, but has not been officially adopted yet.

The most recent FAO supported activity is an ITPGRFA BSF (Benefit Sharing Fund) project "Redesigning the exploitation of small grains genetic resources towards increased sustainability of grain-value chain and improved farmers' livelihoods in Serbia and Bulgaria (GRAINEFIT)" 2020-2022.

Current status of PGR conservation

Conservation of plant genetic resources in the Republic of Serbia is implemented *in situ*, *ex situ* and on-farm. Measures of *in situ* protection are applied to protect indigenous flora (and PGR) in their natural habitats, usually in protected nature reserves. Valuable genetic resources of fruit and grape, old and local varieties, followed by vegetables and cereals are kept in 'on-farm' conditions with incentives available from the Ministry of Agriculture. According to the published agrobiodiversity report for Serbia, the highest number of accessions of cultivated plants is currently protected *ex situ* in collections of different national institutes and stakeholders (Dajić-Stevanović et al. 2018).

In situ conservation of crop wild relatives

The CWR are of particular importance as genetic resources and plants within this group exhibit particularly high presence and diversity in numerous protected areas. On the territory of Serbia protected areas occupy over half a million ha or about 6% of the total area. The protected areas in Serbia include 5 national parks (Fruška gora - 25,393 ha, Đerdap - 63,608 ha, Tara - 19,175 ha, Kopaonik - 11,810 ha, and Šar-planina - 39,000 ha), 16 nature parks, 16 landscapes of exceptional characteristics, 72 strict and special nature reserve, and 480 monuments of nature and historical sites (Marjanović et al. 2013).

Among CWR, there are several notable groups like the forage species, wild fruit species belonging mostly to the Rosaceae family and medicinal and aromatic plants. Several crop species in Serbia are autochthonous, including a few cereals, forage grasses, legumes, vegetable species, fruit crops, and vitis. The complete list of old and local varieties does not exist for Serbia (Dajić-Stevanović et al. 2018).

Work yet to be done for CWR:

- Review existing Nature conservation systems as to their suitability for PGR.
- Create a List of Wild Crop Relatives to provide the basis for further activities.
- Establish a mapping of PGR *in situ*.
- Identify regions with erosion of PGR diversity.

On farm conservation

Today, old/primitive varieties and local/autochthonous populations (landraces) of cereals and maize can only be found on the farmers' fields. According to recent estimates, no more than 130 of such landraces still exist, while no more than 2% of the entire agricultural land is currently occupied by local populations and varieties. The key reason for PGR endangerment and extinction is in general down to the: loss of traditional practices and knowledge, low concern on PGR by the government (the state), by society and by the farmers who still maintain the PGRFA (Dajić-Stevanović et al. 2018).

Work yet to be done for On farm conservation:

- Draw up a List of old cultivars and local populations.
- Determine PGR on-farm that are not yet collected and take samples of these PGR for *ex situ* conservation.
- Study of the vulnerability of PGR grown on-farm to influences of different factors (biological, climatic, agricultural and socio-economic)
- Support and promote on-farm conservation of PGR.

General and specific knowledge on socio economic, legal, geographical and crop specific context

Socio economic: Political changes in the region of former Yugoslavia during a long period started in 1991 and eventually also resulted with formation of multiple new, PGRFA National systems. The mentioned changes were accompanied with a significant decrease in economic activity that lasted even longer and therefore only minimal investments were made in PGRFA conservation.

Legal: After Serbia gained independence, the National legal framework was developed so that 12 laws (2005-2010) and 7 National strategies (2005-2013) were adopted affecting the work on PGRFA (Marjanović et al. 2013). Serbia participates in all important international documents concerning PGRFA and harmonizes its national legislation with them. Drafts of the Law on PGRFA management, the National PGRFA conservation program in Serbia and the Rulebook on incentives for PGR preservation have been prepared.

Access and use of the material: Currently, it is not determined by law who and under what conditions may perform collecting of PGR in Serbia. Access to genetic resources from Serbian research institutions is regulated by specific regulations of these institutes. Foreign exchange develops mostly between plant breeding institutions on a bilateral basis. Such an exchange lacks centralized record keeping and control. Access to genetic resources from the National collection is still not defined by special regulation. After adoption of Law on Seeds it is expected that access to genetic resources and propositions of benefit sharing will be precisely defined by the currently developed Law on PGRFA Management.

Geographical: Serbia is characterized by a huge geographic and biological diversity reflected in the richness of indigenous flora. According to the estimates from 2011, the flora of Serbia contains around 4,000 species out of total of 11,000 plant species in Europe (Dajić-Stevanović et al. 2018). Land and climate conditions in Serbia are highly conducive to the development of agriculture. Agricultural land in Serbia amounts to 5,051,000 ha, including 3,295,000 ha of arable land (Statistical Yearbook, 2011).

Crop specific context: Serbian PGRFA represents a part of the diversity of the national flora. In Serbia, about 200 plant species are used for food and commercial agriculture production, which are therefore referred as the mandate species (Table 1). In addition, about 200 species of medicinal and aromatic plants (MAP) are grown in Serbia, out of which about 50 in large areas.

Cultivated plants in all groups of PGR have wild relatives (Annex 1). It is estimated that there are over 1,000 species of wild relatives, which represent a secondary genetic pool of commercially grown plants (FAO report Serbia, 2009). The broadest genetic diversity and the highest number of species are present in wild relatives of: fruits and grape, cereals, vegetable and forage crops and in medicinal and aromatic plants (Marjanović et al. 2013).

Table 1. Number of cultivars and landraces in National variety list

PGRFA Group	Species in group	Registered			Total
		Cultivars		Landraces	
		Domestic	Foreign		
Cereals and Maize	12	839	403	7	1249
Industrial crops	19	286	366	36	688
Forage crops	43	100	34	39	173
Vegetables	71	280	961	352	1593
Fruits and grape	48	117	383	767	1267
Total	193	1622	2147	1201	4970

Nomination of national CWR *in situ* rich sites to join the European Network

There have been no known attempts to develop an inventory and characterize wild relatives of domesticated crops in the Republic of Serbia, except for wild relatives of fruit species. Limited explorations on *in situ* wild relatives in Serbia have been done in all groups of PGR (Marjanović et al. 2013).

The most important viticulture regions of Serbia are: Subotica - Palić, Čoka and Novi Bečej, *Fruška gora*, Vršac, Šumadija. Expeditions on forage crops that have been carried out to the mountain *Fruška gora* (Ćupina et al., 2006) and the mountains such as Rtanj, Kopaonik and Goč indicate that there are important genetic resources in natural and artificial populations of meadows and forests. A survey of old cultivars and landraces maintained on-farm on Mountain *Fruška gora* confirmed that there are mostly vegetable species and cereals maintained in the gardens but also some medicinal and aromatic plants

(Vasić et al. 2013). Based on several expeditions, wild relatives of cereals have been found on different localities in Serbia including surroundings of cities like Čačak, Valjevo, Majdanpek, Kruševac and Smederevo usually in uncultivated land, mountain pastures, sandy and stony localities (Dimitrijević et al. 2011).

Based on the Minimum quality standards proposed for CWR population management, adapted from Iriondo et al. (2012) and presented in the Proposal for the establishment of a European network for *in situ* conservation and sustainable use of PGR (Farmers pride workshop, 2019), the current status of CWR management in Serbia does not provide sufficient data to reliably nominate the correct site. Even the first step of determining CWR and LR diversity on the national level has not been taken.

Nonetheless, based on the existing literature data, Fruška gora is proposed as the first site in Serbia to be nominated for Inclusion in the European *In situ* Network, as a pilot site to promote the work on *in situ* conservation. The National Park status will facilitate work on the protection of the nominated species and populations, while Fruška gora is also included in the Natura 2000 network currently developed for Serbia within a project funded by the EU Instrument for Pre-Accession Assistance (IPA).

Identification of MAW Populations for *in situ* conservation

Currently, crop wild relatives in Serbia are only protected on the species level if they are critically endangered and as such included in the Red Data Book of Flora of Serbia, (Stevanović, 1999). This list contains 171 plant taxa (species and subspecies), which comprise approximately 5% of the total flora in the Republic of Serbia that are under protection according to the data in Biodiversity strategy of Serbia for 2011-2018 (Radović and Kozomara, 2011).

Old cultivars, landraces and local populations are on the other hand more closely monitored and usually conserved on farm. Some of the populations also have backup samples in *ex situ* conditions.

Based on the preliminary research on CWR, the species list of CWR in Serbia (Annex 1) and according to the established on-farm PGR management in Serbia, several candidate species and appropriate populations could be nominated for inclusion in the European network for *in situ* conservation and sustainable use of PGRFA. All of them are located on the Fruška gora mountain.

Wild garlic - *Allium ursinum* L.

The wild or broad-leaved garlic is a perennial herbaceous monocot. It reproduces primarily by seed, while the narrow bulbs are formed from a single leaf base. Wild garlic has been used in traditional medicine for centuries and it is still a popular non-wood forest product collected as a form of recreation but also for additional income (Sendl et al., 1992). The healing properties of wild garlic result from the activity of its secondary metabolites, which accumulate mainly in the leaves and roots of this species (Yoo and Pike 1998). Two subspecies exist, out of which subsp. *ursinum* was found on the mountain Fruška gora near monastery Petkovica.

The variability in morphological traits between wild garlic populations depend mostly on altitude and climatic features of their natural stands. The wild populations found in the western part of the Republic of Serbia are equally distributed at altitudes ranging from 80 to 1120 m above sea level (Gordanić et al. 2021).

The population occurrence has been mapped but no specific management plan is developed. Wild garlic is valuable as a wild edible plant useful in nutrition, medicine and for agronomic research. The plants will be accessible at the defined location according to the regulations of the Serbian Law on PGRFA management currently being drafted and the authority of the Institute for nature conservation of Serbia.

Sunflower CWR: Jerusalem artichoke - *Helianthus tuberosus* L.

It is considered that a perennial New World species *Helianthus tuberosus* L. definitely became native in the Balkan Peninsula during the 19th century. Although usually preferring the coastal regions with milder climates, it is found elsewhere, mainly due to its high competing ability in local wild floras and powerful propagation ability.

The vernacular names denoting *H. tuberosus* in the languages of the Balkan Peninsula are extremely abundant and reflect countless associations relating to the species. For instance, there are numerous borrowings of the French topinambour, while those in Hungarian or Serbian were derived from the Ottoman Turkish çiçek, meaning simply flower. Ethnobotanical accounts on *H. tuberosus* refer to its beneficial health effects, such as preventing diabetes, healing wounds and burned skin. Throughout the Balkan Peninsula, *H. tuberosus* is, if not for anything else, appreciated as an ornamental plant (Terzić et al. 2019).

The populations from Serbia have been found to differ from the populations originating from the USA as the center of origin according to multiple morphological traits, mineral content of tubers and leaves, but also the duration of vegetation phases (Terzić, 2010).

The species has been mapped as a weed and an increase in occurrence has been documented. No specific management plan is developed. Vegetative propagation is dominant although it does also produce seeds as a cross pollinated species. It is considered as an invasive species and as such it is on the quarantine species list in Serbia.

It has been used in breeding of cultivated sunflower to transfer disease resistance traits. In the 1980s, *H. tuberosus* was used as a donor of resistance genes for Phomopsis black stem disease. It is also popular for cultivation as it produces large biomass used as a forage species or for tuber production containing inulin or processing for bioethanol.

Two populations are sampled and accessible as accessions conserved *ex situ* at the Institute of Field and Vegetable Crops in Novi Sad. The material can be issued according to the ITPGRFA with a standard MTA.

Conclusion

The coordinated work and cooperation with international organizations for the conservation of biodiversity is of high value to all the stakeholders in agriculture and food production. The crop wild relatives are the first and most significant source of desirable traits if the cultivated gene pool fails to provide a genotype that can overcome a new biotic or abiotic stress. Selection and inclusion of most appropriate CWR populations and sites from Serbia in the European *In situ* Network is a promising step in securing biodiversity and thus food production security.

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Annex 1. Crops wild relatives in Serbia (Marjanović et al. 2013)

Table 1. Wild relatives of cereals

Family	Genus	Species
<i>Poaceae</i>	<i>Aegilops</i>	<i>A. biuncialis</i>
		<i>A. cylindrica</i>
		<i>A. columnaris</i>
		<i>A. kotschy</i>
		<i>A. ovata</i>
		<i>A. tauschii</i>
		<i>A. triaristata</i>
		<i>A. triuncialis</i>
		<i>A. umbellulata</i>
	<i>Elymus</i>	
	<i>Hynaldia</i>	
	<i>Secale</i>	
	<i>Triticum</i>	

Table 2. Wild relatives of forage crops

Family	Genus	Species
<i>Poaceae</i>	<i>Agrostis</i> (6 species)	
	<i>Bromus</i> (14)	
	<i>Dactylis</i> (3)	
	<i>Festuca</i> (21)	
	<i>Lolium</i> (5)	
	<i>Poa</i> (17)	
	<i>Phleum</i> (8)	
<i>Fabaceae</i>	<i>Lathyrus</i> (30)	
	<i>Trifolium</i> (68 species)	<i>T. alpestre</i>
		<i>T. arvense</i>
		<i>T. hybridum</i>
		<i>T. medium</i>
		<i>T. montanum</i>
		<i>T. pannonicum</i>
	<i>Vicia</i> (35)	

Table 3. Wild relatives of vegetable crops

Family	Genus	Species
<i>Alliaceae</i>	<i>Allium</i>	<i>A. fistulosum</i>
		<i>A. ursinum</i>
		<i>A. schoenoprasum</i>
<i>Amaranthaceae</i>	<i>Amaranthus</i>	<i>A. retroflexus</i>
<i>Apiaceae</i>	<i>Daucus</i>	<i>D. carota occidentalis</i>
<i>Asteraceae</i>	<i>Arctium</i>	<i>A. lappa</i>
	<i>Bellis</i>	<i>B. perennis</i>
	<i>Carlina</i>	<i>C. acaulis</i>
	<i>Cichorium</i>	<i>C. intybus</i>
	<i>Helianthus</i>	<i>H. tuberosus</i>
	<i>Lactuca</i>	<i>L. scariola</i>
	<i>Taraxacum</i>	<i>T. officinale</i>
<i>Asparagaceae</i>	<i>Asparagus</i>	<i>A. officinalis</i>
<i>Brassicaceae</i>	<i>Brassica</i>	<i>B. napus</i>
		<i>B. oleracea</i>
	<i>Eruca</i>	<i>E. sativa</i>
	<i>Nasturtium</i>	<i>N. officinale</i>
<i>Caryophyllaceae</i>	<i>Stellaria</i>	<i>S. media</i>
<i>Chenopodiaceae</i>	<i>Atriplex</i>	<i>A. spp.</i>
<i>Chenopodiaceae</i>	<i>Chenopodium</i>	<i>Ch. album</i>
<i>Fabaceae</i>	<i>Lupinus</i>	<i>L. spp.</i>
<i>Lamiaceae</i>	<i>Glechoma</i>	<i>G. hederacea</i>
	<i>Lamium</i>	<i>L. album</i>
<i>Oxalidaceae</i>	<i>Oxalis</i>	<i>O. acetosella</i>
<i>Plantaginaceae</i>	<i>Plantago</i>	<i>P. major</i>
<i>Poaceae</i>	<i>Glyceria</i>	<i>G. maxima</i>
<i>Polygonaceae</i>	<i>Rumex</i>	<i>R. acetosa</i>

		<i>R. acetosella</i>
		<i>R. alpinus</i>
		<i>R. crispus</i>
		<i>R. obtusifolius</i>
<i>Rosaceae</i>	<i>Alchemilla</i>	<i>A. vulgaris</i>
<i>Urticaceae</i>	<i>Urtica</i>	<i>U. dioica</i>
	<i>Urtica</i>	<i>U. urens</i>
<i>Valerianaceae</i>	<i>Valerianella</i>	<i>V. locusta</i>

Table 4. Wild relatives of fruits and grape

Family	Genus	Species
<i>Adoxaceae</i>	<i>Sambucus</i> (3)	<i>S. ebulus...</i>
	<i>Viburnum</i> (2)	<i>V. lantana</i>
<i>Berberidaceae</i>	<i>Berberis</i>	<i>B. vulgaris</i>
<i>Betulaceae</i>	<i>Corylus</i>	<i>C. colurna</i>
<i>Caprifoliaceae</i>	<i>Lonicera</i> (4)	<i>L. alpigena...</i>
<i>Cornaceae</i>	<i>Cornus</i> (3)	<i>Cornus australis...</i>
<i>Cupressaceae</i>	<i>Juniperus</i> (3)	<i>Juniperus communis...</i>
<i>Ericaceae</i>	<i>Vaccinium</i> (3)	<i>V. myrtillus...</i>
<i>Grossulariaceae</i>	<i>Ribes</i> (4)	<i>R. alpinum...</i>
<i>Rhamnaceae</i>	<i>Frangula</i>	<i>F. alnus</i>
	<i>Rhamnus</i> (2)	<i>Rh. catharticus...</i>
<i>Rosaceae</i>	<i>Amelanchier</i>	<i>A. ovalis</i>
	<i>Cotoneaster</i> (2)	<i>C. integerrimus...</i>
	<i>Crataegus</i> (3)	<i>Crataegus monogyna...</i>
	<i>Fragaria</i> (2)	<i>Fragaria elatior...</i>
	<i>Malus</i>	<i>Malus silvestris</i>
	<i>Pyrus</i> (2)	<i>P. amygdaliformis...</i>
	<i>Prunus</i> (8)	<i>P. cerasifera...</i>
	<i>Rosa</i> (19)	<i>R. agrestis...</i>
	<i>Rubus</i> (8)	<i>R. caesius...</i>
	<i>Sorbus</i> (8)	<i>S. aria...</i>
<i>Taxaceae</i>	<i>Taxus</i>	<i>T. baccata</i>
<i>Vitaceae</i>	<i>Vitis</i>	<i>V. silvestris</i>

Uključivanje najprikladnijih populacija divljih srodnika i lokaliteta iz Srbije u Evropsku *in situ* mrežu

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Sažetak: Organizacija očuvanja divljih srodnika gajenih biljnih vrsta je započeta u mnogim evropskim zemljama, od kojih su neke do sada razvile i nacionalne strategije za tu oblast. Razvoj Evropske mreže za *in situ* očuvanje biljnih genetičkih resursa je sproveden kroz H2020 Farmer's Pride" projekat, ali on nije imao dovoljno sredstava da uključi sve evropske zemlje. Finansiranje je bilo potrebno da bi se osiguralo da i zemlje van Farmer's Pride projekta budu u mogućnosti da identifikuju populacije i lokacije, kao i da pripreme aplikacije za pristup u Evropskoj *in situ* mreži za očuvanje biljnih genetičkih resursa za hranu i poljoprivredu BGRHP. Projekat "Inclusion of CWR sites in European *in situ* network" je odobren za

finansiranje u okviru ECPGR aktivnosti za fazu 10. Cilj je da se unaprede nacionalni kapaciteti za *in situ* upravljanje BGRHP u Litvaniji, Kipru, Albaniji, Bugarskoj, Sloveniji, Slovačkoj, Letoniji, Rumuniji, Hrvatskoj i Srbiji. Zajedničko delovanje ECPGR radne grupe “Wild Species Conservation in Genetic Reserves“ i “Farmer’s Pride” projekta je doprinelo razvoju Evropske strategije za očuvanje divljih srodnika, odabiru najpogodnijih vrsta i lokacija za zaštitu na nacionalnom i evropskom nivou, a samim tim i očuvanju biodiverziteta. Planina Fruška gora je predložena za uključivanje kao najprikladnija lokacija, dok su divlji luk - *Allium ursinum* i divlji srodnik gajenog suncokreta - *Helianthus tuberosus* predloženi kao potencijalne populacije iz Srbije za Evropsku mrežu *in situ* zaštite divljih srodnika.

Ključne reči: biodiverzitet, divlji srodnici, *in situ*, očuvanje