IMPORTANCE OF AGROBIODIVERSITY CONSERVATION

A.L. Tsivelikas and GRS team
A. Ensure access to enough and nutritious food

➢ 15th November 2022
✓ The day of 8 billion people

➢ By 2050...
✓ World population will grow to 9.2 billions (annual growth rate 0.7%)

World population estimates and projections with prediction intervals and high/low scenarios, 2020 - 2100 (UN, 2019)
Critical Challenges in Agriculture

- Living under extreme poverty (<$2.15 per person per day at 2017 purchasing power parity):
  - The share of people is declining for three decades, falling at 8.4% in 2019, but reaching at 9.3% in 2020 due to covid-19 crisis (The World Bank, 2022).

Two targets...

- Increasing production and energy content (carbohydrates, protein, fat) of staple foods
- Moving from “green revolution” to “revolution with greens”
B. Adaptation to climate change

Global Climate Models all converge with regard to projections of:

✓ Increased frequency of drought, and
✓ high temperatures

In:
✓ central North America,
✓ northern Africa,
✓ central Asia, and
✓ western Australia

(Girvetz et al. 2009, Elert & Lemonick 2011)
B. Adaptation to climate change (continue…)

Heat stress will increase vulnerability of crops more than drought. (Semenov & Shewry 2011)

✓ The years 2013-2021 all ranked among the ten-warmest years on record (https://www.noaa.gov/)

✓ The year 2020 tied with 2016 for the hottest year on record since recordkeeping began in 1880 (source: NASA/GISS)

This will require to aim for yield and environmental adaptation in unprecedented/different circumstances!
“...the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”

(CBD, 1992)
Levels of Biological Diversity

- **Ecosystem diversity**
  - the variety of habitats, biological communities and ecological processes affecting the adaptation of performance of a species
  - Deforestation
  - Population growth
  - Urbanization

- **Species diversity**
  - the numbers of species existing in one site, country or region (qualitative richness)
  - Alien species
  - Changes in agriculture

- **Genetic diversity**
  - the genetic variation (alleles/genes) existing within all individuals of a species, between populations of a species as well as between species
  - GMOs
  - Narrow of genetic base
Agricultural Biodiversity (Agrobiodiversity)

The variable forms and functions of all living organisms that are useful in agriculture today or have potential usefulness in the future.

✓ It includes all crop plants, domestic animals, yeasts and other useful food processing organisms, N and P-fixing soil bacteria, etc., as well as their ancestral or related wild species at the genetic, species and ecosystem levels, which are necessary to sustain the key functions of the agro-ecosystem.

It is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers and represents the basic element for safeguarding national and global food security.
Agricultural Biodiversity (Agrobiodiversity)

Components of Agrobiodiversity (CBD, 2011):

- Plant, animals, fish (cultivated and domesticated and WR)
- Microbes
- Rainfall variation
- Climate change
- Soil moisture

Genetic resources for food and agriculture

Ecosystem services

- Water and nutrient cycling
- Pollination

Abiotic factors

Socio-economic and cultural dimensions

- Local knowledge
- Participatory processes
- Agric. landscape
Three major crops: maize, rice and wheat are holding >40% of total crop production (FAOStats, 2021)
The overall genetic diversity of cultivated species and their wild relatives, which have the potential to contribute in crop breeding (Hawkes, 1983).

Phylogenetic distribution of edible plants: Adapted from Ulian et al. (2020); Rectangles at the tips of the phylogeny denote the presence of human food plants (orange) and major food crops (brown) in each family.
Centers of Origin of Crops

De Candolle (1882) and Vavilov (1926) first realized that crop diversity is not evenly distributed over the globe:

I. China (crops: soybean, buckwheat, rice)
II. a. India, b. Indochina (crops: banana, sugarcane, yam, rice)
III. Central Asia (N. India, Afghanistan, Turkmenistan) (crops: wheat)
IV. Near East (fertile crescent) (crops: wheat, barley, rye, chickpea, lentils, figs)
V. Mediterranean (crops: oat, rapeseed)
VI. Abyssinia (crops: barley, sorghum, millet)
VII. Southern Mexico and middle America (crops: maize, common bean, sweet potato)
VIII. North-eastern south America (Bolivia, Ecuador, Peru) (crops: potato, lima bean, groundnut, cassava)
Examination of relationships among plant species and of their prospects for exploitation in crops genetic improvement, proposed based on the "biological species concept" (Harlan and de Wet, 1971) the following three categories:

- **Primary gene pool (GP1):** Types and forms in this category easily cross each other and the offspring are fertile (cultivated species and wild relatives).
- **Secondary gene pool (GP2):** Species that lead to partial fertility on crossing with GP1.
- **Tertiary gene pool (GP3):** Species that lead to sterile hybrids on crossing with GP1 (special techniques are required).
The Wheat Genepool

- **GP1**: All diploid and tetraploid *Triticum* and *Aegilops* species with A, B and D genomes
- **GP2**: Landraces, early domesticates
- **GP3**: All non-progenitor diploid and tetraploid species (e.g. *Thinopyrum*, *Secale*, etc.)
  - Tetraploid species with one genome common with wheat
  - Diploid *Aegilops* S-genome species from section *Sitopsis*
The overall genetic diversity of cultivated species and their wild relatives, which have the potential to contribute in crop breeding (Hawkes, 1983).

- Currently grown commercial cultivars
- Obsolete cultivars (expired legal protection)
- Breeding lines and stocks
- Local cultivars/landraces
- Primitive forms of crop plants collected from the centres of origin and diversity of the species.
- Crop wild relative species

Most of the times...

The term is restricted in the categories of plant germplasm which is not protected by special legislation.
Ex situ Germplasm Collections (Genebanks)

- Increased enormously in number and size over the last decades
  - Global efforts to conserve plant genetic resources for food and agriculture (PGRFA) ... sometimes with support from international community

- Worldwide...
  - 1,750 genebanks are registered and conserve over 7.5 million accessions, including major crops, minor or neglected crop species, together with trees and wild plants (Hay, 2019).
At the crossroad of the origin of the species...

- Crossroad between Near East and Mediterranean Centers of Origin.
- More than 65% of the global human calories consumption is “originated” from the CWANA Mega Center of crop origin

ICARDA’s Genebank Collection

At the heart that first crop domestication occurred (Fertile Crescent)...

a) Mortar and pestle from Wadi Hammeh in the southern Levant, 14,000 years ago. b) Bases querns in a room at Jerf el Ahmar, northern Syria and c) Quern from Tell ’Abr, northern Syria, all dated to 11,300 years ago. From Wilcox (Science 341, 39 (2013)).
ICARDA's Collection in Numbers

(1) Based on GENESYS information; Total accessions: 3,882,828 in 458 Institutes

Composition by population type

<table>
<thead>
<tr>
<th>Crop genepool</th>
<th>Global Ranking</th>
<th>% acc. globally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>2nd</td>
<td>19.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>4th</td>
<td>14.6</td>
</tr>
<tr>
<td>Chickpea</td>
<td>2nd</td>
<td>23.2</td>
</tr>
<tr>
<td>Faba bean</td>
<td>1st</td>
<td>89.1</td>
</tr>
<tr>
<td>Lentil</td>
<td>1st</td>
<td>43.5</td>
</tr>
<tr>
<td>Lathyrus</td>
<td>1st</td>
<td>63.6</td>
</tr>
<tr>
<td>Medicago</td>
<td>2nd</td>
<td>15.0</td>
</tr>
<tr>
<td>Pisum</td>
<td>3rd</td>
<td>12.1</td>
</tr>
<tr>
<td>Trifolium</td>
<td>3rd</td>
<td>9.0</td>
</tr>
<tr>
<td>Vicia</td>
<td>1st</td>
<td>23.7</td>
</tr>
<tr>
<td>Overall</td>
<td>4th</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Barley 30,242
Pisum spp. 4,596
Bread wheat 15,088
Trifolium spp. 5,519
Durum wheat 20,353
Vicia spp. 6,452
Primitive wheat 1,390
Faba bean 9,654
Aegilops spp. 5,183
Chickpea 14,833
Wild Triticum 2,160
Lentil 13,732
Wild Hordeum 2,240
Wild Cicer 552
Not mandate cereals 285
Wild Lens 645
Lathyrus spp. 4,412
Range & Pasture 5,828
Medicago annual 9,068
Others 48
Total 152,280

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Out of whole ICARDA's holdings ~45% are unique accessions and 78% phenotypically characterized

Composition by population type

≈58% landraces and wild relatives

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Conservation Plant Genetic Resources and Agrobiodiversity

A wealth of novel genes at the fields...

- Tackle epidemics of pests and diseases, owing to resistance genes (e.g. Hessian fly in wheat crop)
- Improve adaptation to climate change and related environmental adversities, due to the development of their specific adaptive traits under extreme/marginal environments
- Meet consumers preferences for specific quality/culinary traits or even cultural traits (link to specific traditions)
- Surpass performance plateaus (e.g., Norin-10 changing the whole “architecture structure” of the wheat plant)

Ensure a better quality of life and they compose the raw material for global food security against any unprecedented adversity.
THANK YOU FOR YOUR KIND ATTENTION!
Proportional global species richness change ($\Delta S_g$) relative to 1900 from land-use change only (Pereira et al., 2020).

Our results reveal that local trends of abundance, richness and diversity differ among biogeoregions, realms and taxonomic groups, demonstrating that biodiversity changes at local scale are often complex and cannot be easily generalized (Pilotto et al., 2020).
Fortunately, existing varieties of most crops have quite a broad genetic base. Farmer-accepted, adapted varieties will continue to provide most of the genes that breeders need. Indications are that after the 1960s and 1970s breeders have been able to again increase the diversity in released varieties. Thus, a gradual narrowing of the genetic base of the varieties released by breeders could not be observed.