Eggplant Wild Relatives Conservation and Use in Breeding

Divulgation Manual

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Project Title

Utilization of Crop Wild Relatives in Eggplant Pre- Breeding for Adaptation to Climate Change

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Part one

Crop wild relatives and their importance

Crop wild relatives and their importance

- Russian botanist Nikolai Vavilov was the first, in the early 20th century, in realizing the importance of crop wild relatives.
- Crop wild relatives (CWRs) are wild plant species that are genetically related to cultivated crops. Untended by humans, they continue to evolve in the wild.
- CWRs are essential components of natural and agricultural ecosystems and hence are indispensable for maintaining ecosystem health.
- Wild species and putative ancestral forms of crop plants contain valuable genes that are of immense genetic value in crop breeding programmes using conventional methods or modern biotechnology.
- Plant scientists and breeders haverecognized during the last few decades that the genetic variability of cultivated plants is rather limited. For future improvement of cultivated plants it is necessary to collect, maintain and preserve biological diversity of crop wild relatives for future utilization in plant breeding.
- Crop wild relatives play a significant role in securing 21st century food security. This is due to their potential uses in plant breeding to produce crop varieties which withstand adverse impact of climate change.

Nikolai Vavilov

Nikolai Ivanovich Vavilov was a prominent Russian and Soviet botanist and geneticist best known for having identified the centers of origin of cultivated plants. Nikolai Vavilov collected more seeds, tubers and fruits from around the world than any other person in History. Vavilov was an incredible explorer of crop diversity.

Part two

Threats to crop wild relatives

Threats to crop wild relatives

- CWR occur in a wide range of habitats around the world but are at great risk as habitats continue to be degraded worldwide due tourbanization, mining, the spread of invasive species, pollution, and climate change.
- Deforestation is leading to the loss of many populations of important wild relatives of fruit, nut, and industrial crops.
- Populations of wild relatives of cereal crops that occur in arid or semi-arid lands are being severely reduced by over grazing and resulting desertification.
- The growing industrialization of agriculture is drastically reducing the occurrence of CWRs within the traditional agro-ecosystems.
- In 2016, 29% of wild relative plant species were completely missing from the world's genebanks, 24% represented by fewer than 10 samples. Over 70% of all crop wild relative species worldwide need collecting to improve their representation in gene banks, and over 95% were insufficiently represented with regard to the full range of geographic and ecological variation in their native distributions (Castañeda-Álvarez *et al*., 2016).
- The Food and Agriculture Organization of the United Nations (FAO) estimates that about 75% of the genetic diversity of agricultural crops has been lost in the last century due to the widespread abandonment of genetically diverse traditional crops in favour of genetically uniform modern crop varieties.
- There is an urgent need to conserve CWR both in the wild (*in situ*) and in gene banks (*ex situ*) to ensure that genetic diversity remains available for future generations.

Part three

Conservation of Eggplant Wild relatives

Conservation of Eggplant wild relatives

- Agricultural scientists identified crop wild relatives (CWRs) as a target group for conservation over 30 years ago
- Therefore during the last few years CWR collecting, conservation and characterization has been in progress
- Numerous diverse approaches that result in CWR conserved genetic reserves.
  - In situ conservation[1]
  - Ex situ conservation[2]
- Effort and resources were made during the following decades to collect CWRs and maintain them in ex situ (off-site) conservation program.
- Ex situ conservation is usually carried out in gene banks and botanical gardens
- World's genebanks are currently thought to conserve only a small fraction of the total diversity of CWR.
- 5% of the accessions in global genebanks correspond to wild relatives of vegetable crops.

Why is *in situ* conservation of CWR important?

In situ conservation allows populations to continue to evolve and generate new variation, some of which might be valuable for use in future breeding efforts

Ways of *in situ* Conservation

- Inventory → International, National, Local levels
- Research → CWR mapping, Eco-geographic surveys, CWR policy study, Ethnobiological investigations, CWR monitoring

- Site selection and/ or management recommendations
- Establishment of protected area and or development of management plan

[1] ***Insitu conservation*** : The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings

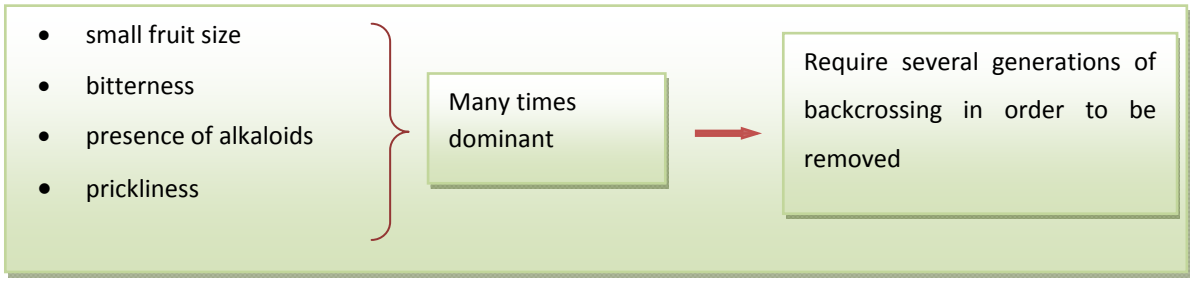
[2] ***Ex situ conservation*** : The conservation of plant genetic resources for food and agriculture outside their natural habitats

Part four

Characteristics of Eggplant Wild relatives

Characteristics of eggplant wild relatives

- Many of the eggplant CWR analyzed here could be classified as weeds: *Solanum campylacanthum*, *S. insanum*, and *S. anguivi* all have very large distributions in many different sorts of disturbed and semi disturbed habitats
- Weediness facilitates commensalism with humans, ease of establishment, and possibly also crossability with domesticates.
- Most of Eggplant wild relatives are only partially interfertile with *S. melongena* and require more advanced techniques (e.g., somatic hybrids and tissue culture) to interbreed.
- Utilization of eggplant wild relatives in eggplant breeding is hindered by the fact that these eggplant wild materials present many unfavourable traits



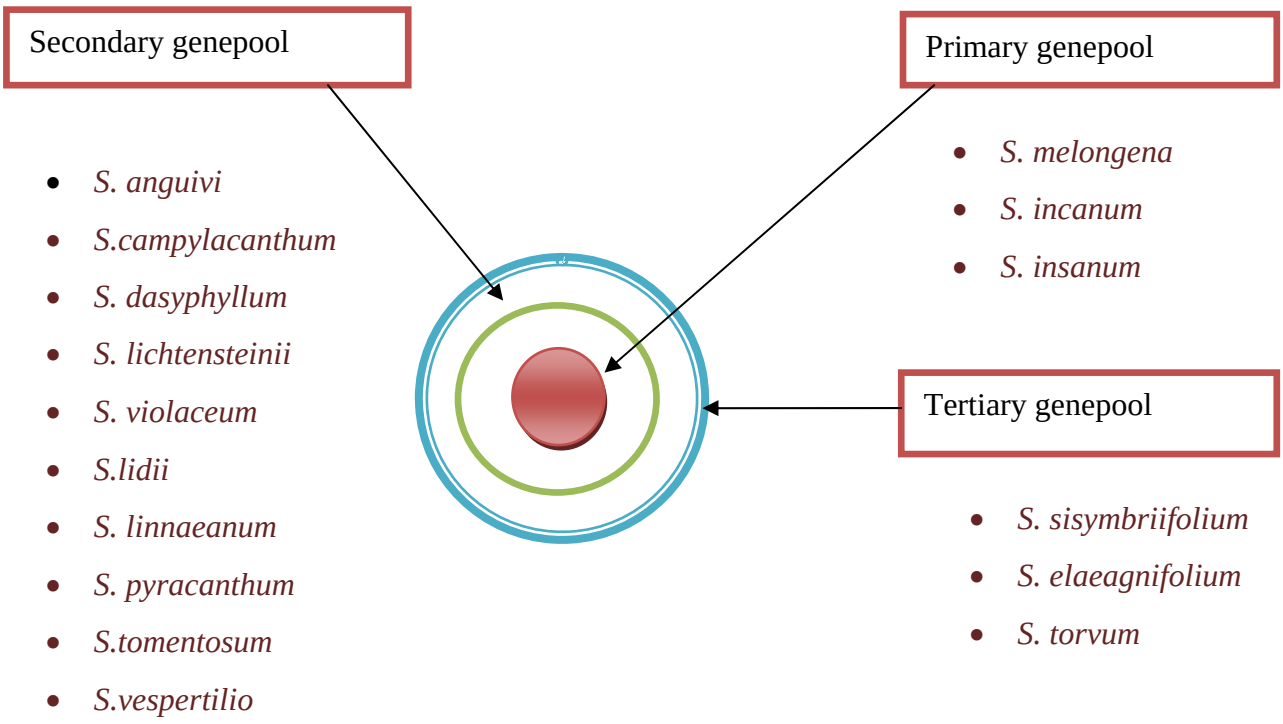
Part five

Gene pool concept & eggplant wild relatives

Gene pool concept & eggplant wild relatives

- Eggplant has multiple centers of domestication. It could have two centers of domestication in China and/or India with an additional and independent center of domestication in the Philippines.
- All three cultivated eggplant varieties are members of the diverse genus *Solanum* L., which is one of the largest genera of flowering plants and has more than 1500 species distributed worldwide
- The progenitor of *Solanum melongena* is *S. insanum* L., a species widespread in tropical Asia from Madagascar to the Philippines. The rest of the close wild-relative species of eggplant occur outside the main centers of eggplant domestication, mostly in tropical eastern Africa and the Middle East
- Taxonomic studies have clarified the species identities and distributions of this complex set of taxa, and phylogenetic analyses have clarified their relationships.
- Gene pool concept of eggplant
- CWR species are classified into groups based on how easy it can exchange genes with the cultivated species to which they are related.
- In this system, wild relatives are divided to be in the crop's primary, secondary or tertiary gene pools.
- ***Primary gene pool (GP-1):*** Members of this gene pool can intermate freely. Among forms of this gene pool, crossing is easy; hybrids are generally fertile with good chromosome pairing; gene segregation is approximately normal and gene transfer is generally easy. Primary genepool of the eggplant consists of both cultivated and wild varieties of *S.melongena* and the close relatives *S. insanum and S. incanum*

- ***Secondary genepool (GP-2):*** Is composed of crop wild relatives that are distinct from the cultivated species, but which are still so closely related that they can cross with the crop to at least some extent to produce some fertile offspring. It is more difficult to use species from the secondary genepool, because reproductive barriers of different kinds are present between it and the crop. Some hybrids resulting from crosses with secondary genepool species are partly sterile or weak.
- ***Tertiary genepool (GP-3):*** Is made up of even more distantly related crop wild relative species. To get this type of wild relatives in the plant breeding, specific breeding techniques must be used, such as embryo rescue, or biotechnological approaches to transfer genes. Even when the cross succeeds, the resulting progeny are often sterile.



Floral variation among genepools

Primary genepool

S.melongena

S.insanum

S.incanum

Secondary genepool

S. pyracanthum

S. anguivi

S. dasyphyllum

Tertiary genepool

S. torvum

S. elaeagnifolium

S. sisymbriifolium

Part six

Breeding values of selected Eggplant wild relatives

Breeding values of selected Eggplant wild relatives

- There are many traits of an individual eggplant wild relative as a (genetic) parent that have been identified as having an economic value, and these breeding values are combined with the relevant economic values to produce Breeding Value.

Primary genepool

1. *S. incanum*

- Native to northern Africa and the Middle East to Pakistan
- Cross-compatible with *S. melongena* with regular meiosis
- Interspecific hybrids as rootstock
- Backcross introgression of high content in bioactive phenolic acids
- Resistance to *Fusarium* wilts

2. *S. insanum*

- Closest wild relative of eggplant and gives fertile hybrids with *S. melongena*

Secondary genepool

1. *S. anguivi*

- Can be found in many places throughout non arid part of Africa
- *Solanum anguivi* is of potential use as genitor in breeding programmes aimed at improvement for disease resistance, e.g. to bacterial wilt (*Ralstonia solanacearum*), and to increase the number of fruits per infructescence
- Can be used to obtain cytoplasm substitution male-sterile lines by backcrossing

2. *S. dasyphyllum*

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- Certain materials are resistant to *Cercospora solani*, *Thielaviopsis basicola* (damping-off disease, *Leucinoides orbonalis (shoot & pod borer)*, *Trialeurodes vaporariorum* (whitefly), *Amrasca biguttula* (leaf hopper) and highly tolerant to *Tetranychus urticae* (spider mite) and *Fusarium* wilting.
- High phenolic content and more resistant to fruit borers

3. *S. violaceum*

- A wild eggplant species tolerant to bacterial wilt
- Selection of selfings of interspecific hybrids resistant to *Fusarium* wilt
- Can be used to obtain cytoplasm substitution male-sterile lines by backcrossing

4. S. pyracanthum

- Native to tropical Madagascar and the islands of the western Indian Ocean
- The plant is not cold resistant and will die if exposed to temperatures below freezing for more than a week

5. S. linnaeanum

- Native to southern Africa
- Backcross introgression of resistance to *Verticillium dahliae*

Tertiary genepool

1. S. sisymbriifolium

- Crossed with eggplant in an attempt to incorporate genes for resistance to *Verticillium* wilt.
- Sexual and somatic hybridization for resistance to *Ralstonia solanacearum*
- Root-knot nematode-resistant wild species
- Resistance to fruit and shoot borers (*Leucinodes orbonalis*)
- Resistance to spider mite

2. S. elaeagnifolium

- The plants have very extensive, spreading root systems
- *S. elaeagnifolium*, an invasive weed with high tolerance to drought

3. S. torvum

- *Solanum torvum* is known for its resistance against soil borne pests and diseases, including *Ralstonia solanacearum* (the resistance, however, may break down at high

temperatures), *Verticillium dahliae*, *Thielaviopsis basicola*, *Phytophthora parasitica* and *Fusarium solani.*

- It also appears to be resistant to flea beetles and *Meloidogyne incognita.*

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Part seven

Introduction to the project

Introduction to the project

- "Utilization of crop wild relatives in eggplant pre-breeding for adaptation to climate change" Project (EGGPLANT PRE-BREEDING PROJECT) is aimed at using wild relatives for increasing the diversity available for eggplant (*Solanum melongena*) breeding, in particular focusing on traits related to adaptation to climate change. As a result of the Eggplant Pre-breeding Project**,** plant material with introgressions of wild relatives selected for adaptation to climate change in Southeast Asian and West African conditions will be obtained, adequately conserved in gene banks and made available for breeding. The goal of the eggplant pre-breeding work is to broaden the genetic diversity available for eggplant breeding, focusing specifically on traits related to climate change adaptation.

- The project is jointly led and managed by the Global Crop Diversity Trust and the Millennium Seed Bank of the Royal Botanic Gardens Kew, UK, and is being implemented by numerous partners all over the world. The Project's eggplant pre-breeding work is coordinated by a Spanish team from the Universitat Politècnica de Valencia in Spain along with partners from the University of Peradeniya and the Horticultural Crop Research and Development Institute in Sri Lanka and the Laboratory of Genetics of the Félix Houphouët-Boigny University in the Ivory Coast, all of which are specialized in eggplant breeding.

Main activities of the project →

- Collecting germplasm
- Conserving
- Evaluation
- Pre-breeding

Part eight

Importance of the project

Importance of the project

- Eggplant one of the three most important cultivated crops in the family Solanaceae.It is mostly grown in tropical areas, with China being the main producer. India and countries in Southeast Asia, as well as Turkey and some areas in North and West Africa are also very important eggplant producers in the world.
- Drought or moisture stress is one of the significant environment stresses causing huge loss to the agriculture worldwide. Drought has been occurring more frequently because of global warming. The eggplant is a crop that is related to many wild species that grow in very diverse environments, and wild populations in general harbor higher levels of genetic diversity. Solanaceae family consists of about 1500 morphologically diverse species. Many of these can be crossed with domesticated eggplants. It is possible to widen the genetic base of eggplant production, and improve its adaptation to climate change by introgression traits such as resistance to drought, higher temperatures, and salinity that are present in these wild species.

Breeding objectives for Eggplant varieties

- High-yielding
- Consumer preference
- Early maturing
- High fruit-quality
- Stress resistance/ tolerance
- High antioxidants
- Pest & Disease resistance/Tolerance
- High nutritional content

Part nine

Task performed in Sri Lanka

Task performed in Sri Lanka

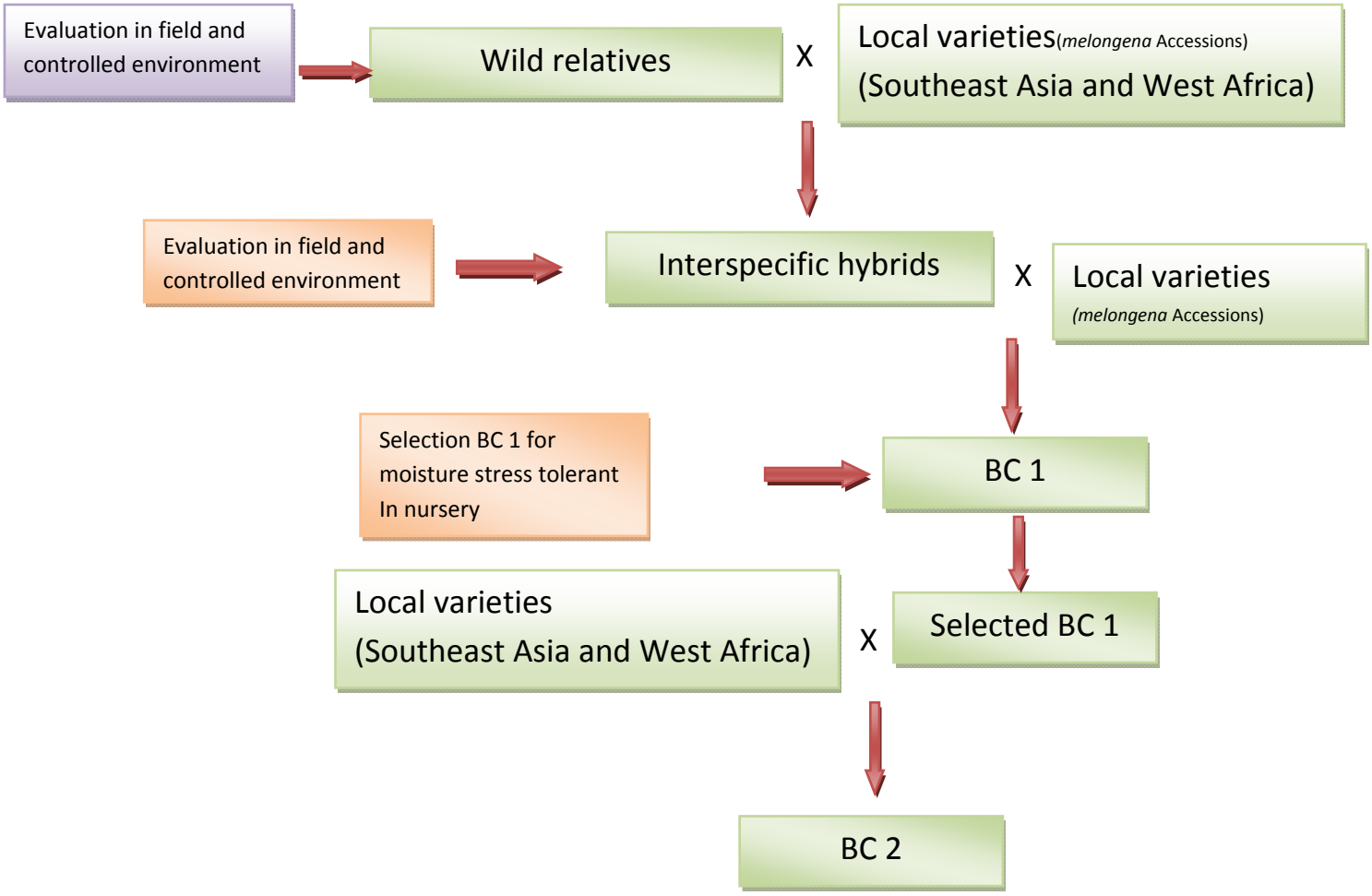

Figure 1: Graphical representation of tasks performed in short- medium term sub programme

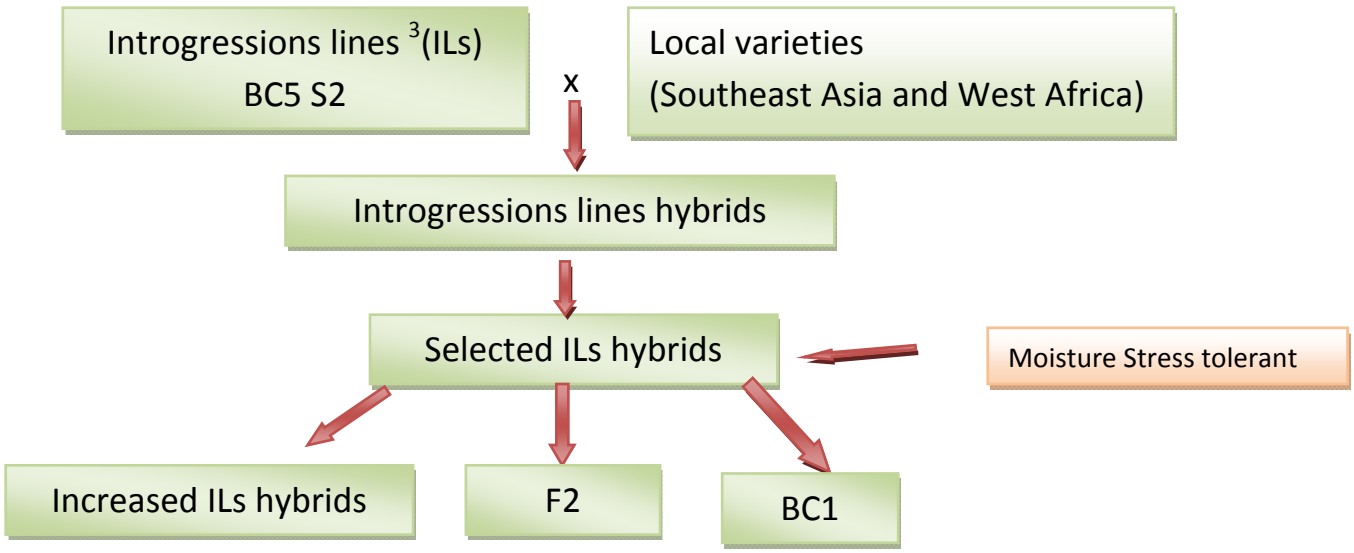

Figure 2: Graphical representation of tasks performed in short- medium term sub programme

[3] The term 'Introgressions lines' (ILs) refers to– 1st selfing of BC5 obtained from the selected individuals.These families used to develop ILs of eggplant.

Project team

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Summary

Application of breeding methods

Improved eggplant varieties

- Improved agronomic traits
- Drought tolerant
- Improved flavor

Pre breeding materials

- ILs
- ILs hybrids
- BC 1 of ILs
- Interspecific hybrids between eggplant and wild relatives
- Back cross generations of Interspecific hybrids between eggplant and wild relatives

Stored in germplasm bank

Acknowledgement

This work was undertaken as part of the initiative "Adapting Agriculture to Climate Change: Collecting, Protecting and Preparing Crop Wild Relatives" which is supported by the Government of Norway. The project is managed by the Global Crop Diversity Trust with the Millennium Seed Bank of the Royal Botanic Gardens, Kew and implemented in partnership with national and international gene banks and plant breeding institutes around the world. For further information see the project website: http://www.cwrdiversity.org/

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