The legacy of the Crop Wild Relatives (CWR) Project

Pre-breeding achievements

Benjamin Kilian, Crop Trust

March 1, 2022

Norad

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

Legacy video
celebrating the mission and major achievements
of the CWR Project

The CWR Project: *Adapting Agriculture to Climate Change: Collecting, Protecting and Preparing Crop Wild Relatives*

- Unique, global initiative to facilitate the use of CWR in breeding new, improved crop varieties
- Supported by the Norwegian Government
- USD 50 million
- 10 years (2011- Dec 2021)
- http://www.cwrdiversity.org/

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MILLENNIUM SEED BANK PARTNERSHIP Kew

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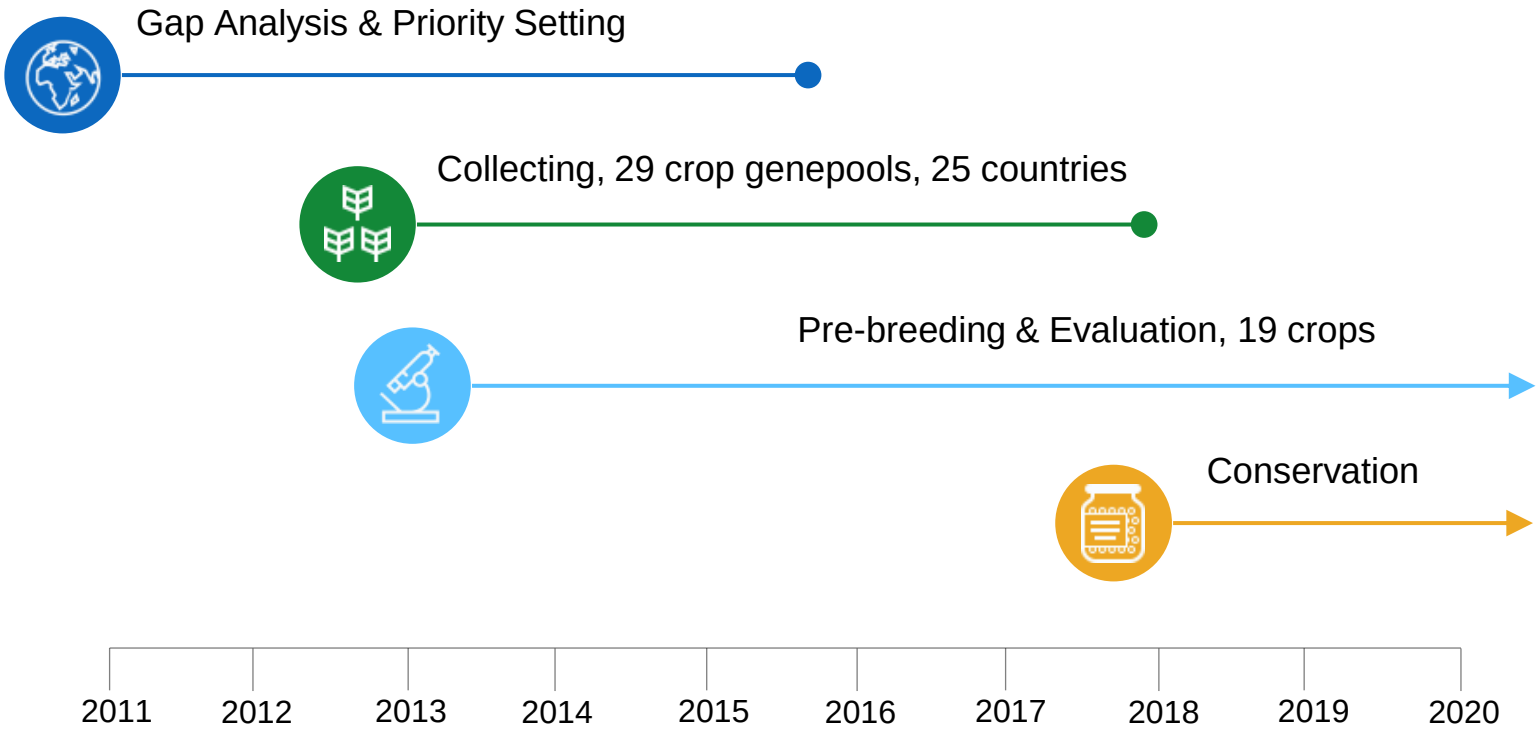
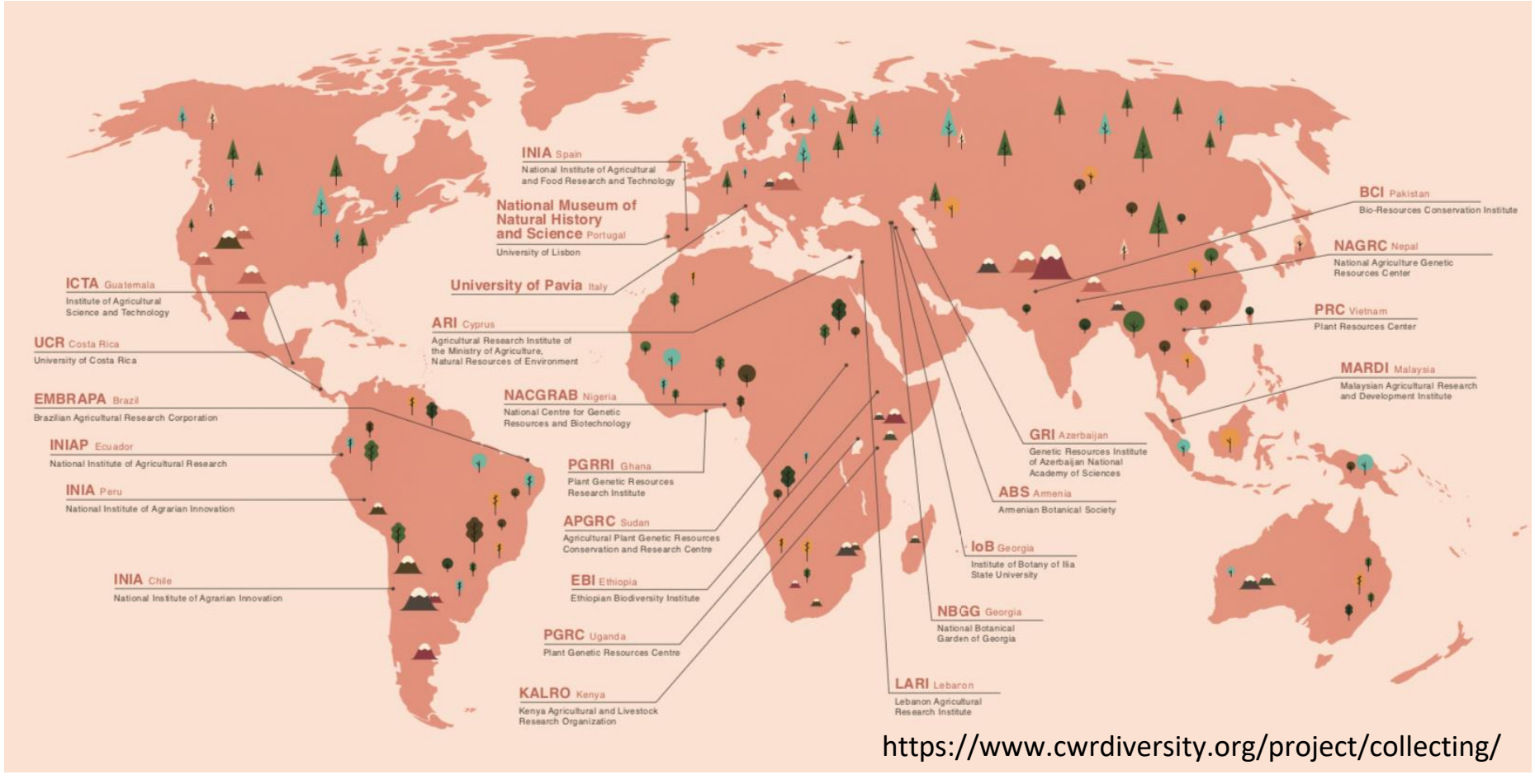
The CWR Project: four major components



The CWR Project: a global collecting effort



https://www.cwrdiversity.org/project/collecting/

Bean collecting projects

- 103 accessions of 10 species collected in 4 countries:
- El Salvador (2012)
- Costa Rica (2016-2018)
- Ecuador (2016-2018)
- Guatemala (2016-2018)

Species	Number of accessions
Phaseolus augustii	7
Phaseolus coccineus	16
Phaseolus costaricensis	4
Phaseolus leptostachyus	6
Phaseolus lunatus	42
Phaseolus microcarpus	6
Phaseolus oligospermus	1
Phaseolus talamancensis	1
Phaseolus vulgaris	15
Phaseolus xanthotrichus	5

CWR Project: Pre-breeding crops and target traits (simplified)

Alfalfa
Drought tolerance

Banana
Drought tolerance

Barley
Drought and heat tolerance, disease and pest resistance

Bean
Heat, drought, waterlogging and root rot resistance

Carrot
Heat, salt and drought tolerance

Chickpea
Drought tolerance

Cowpea
Drought and heat tolerance

Eggplant
Drought, waterlog-ging, bacterial wilt

Finger millet
Drought, blast, *Striga*

Grasspea
Heat, toxicity, *Orabanche*

Lentil
Drought, *Oraban-che*, *Stemphyllium*

Pearl millet
Heat tolerance and blast resistance

Pigeonpea
Salinity, pod borer, *Phytopthora*

Potato
Drought, heat, late blight, bacterial wilt

Rice
Drought tolerance

Sorghum
Heat tolerance, water-use efficiency, rust

Sunflower
Drought tolerance, early flowering

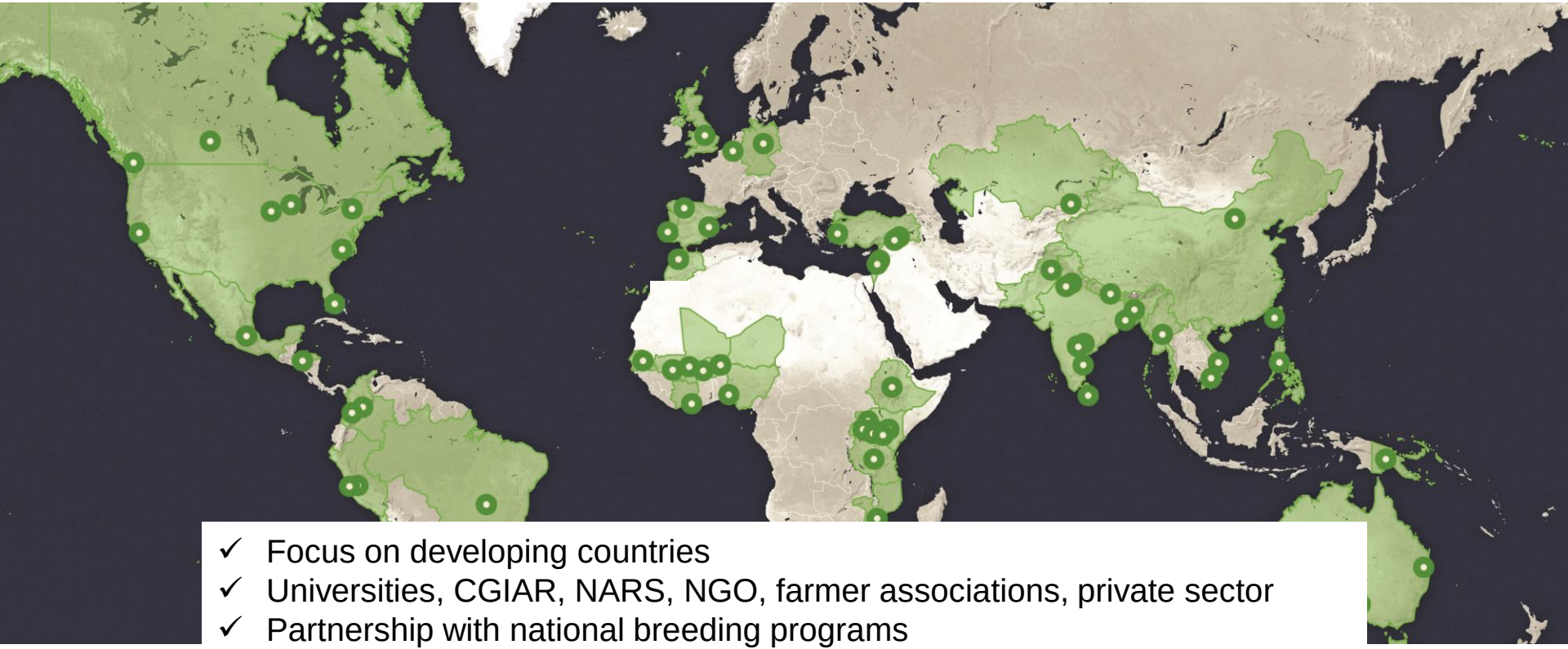
Sweetpotato
Heat tolerance

Wheat (durum)
Yield potential, heat and drought tolerance, disease resistance

✓ Focus on climate change related traits

CWR Project: Impact through partnerships

Pre-breeding partnerships: 100+ partners, 50 countries, 19 crops



- ✓ Focus on developing countries
- ✓ Universities, CGIAR, NARS, NGO, farmer associations, private sector
- ✓ Partnership with national breeding programs

CWR Project: Impact through capacity building

Carrot pre-breeding in Bangladesh

Farmers training at Ishurdi (heat stress)
December 2019

Farmers training at Lalmonirhat (drought stress)
January 2020

CWR Project: Impact through capacity building

Summary statistics

Summary of capacity-building activities as of December 2021

Details	Collecting	Pre-breeding and evaluation	Information systems
Number of trainees	174	12,369*	143
Number of countries	45	46	36
Women (%)	44	40	51

✓ 211 fellows & students trained in pre-breeding & evaluation

* includes more than 10,000 farmers

CWR Project: Impact through seeds

Most promising pre-bred lines conserved in genebanks

Crop	CWR-derived material (ILs/crosses) conserved in genebanks	Genebank details
Alfalfa	40	Australian Pastures Genebank (Australia)
Banana*	*In progress*	---
Barley	24	ICARDA (Morocco)
Carrot**	*In progress*	---
Chickpea	9,673	Aegean Agricultural Research Institute (Turkey); Australian Grains Genebank (Australia); ICARDA; USDA National Plant Germplasm System (USA)
Common bean	47	Alliance of Bioversity International and CIAT genebank (Colombia)
Cowpea	64	IITA (Nigeria)
Durum wheat	19	ICARDA (Morocco)
Eggplant	185	INRAE-PACA (France); Universitat Politècnica de València Genebank (Spain)
Finger millet	7	ICRISAT (India)
Grasspea***	*In progress*	---
Lentil	24	ICARDA (Morocco)
Pearl millet	17	ICRISAT (India)
Pigeonpea	4	ICRISAT (India)
Potato	29	CIP (Peru)
Rice	110; 1,497	Genebank of the Mekong Delta Development Research Institute (MDI), Can Tho University (Vietnam); IRRI (Philippines)
Sorghum	1,227	Australian Grains Genebank (Australia); Genetic Resources Research Institute (Kenya)
Sunflower	360	USDA North Central Regional Plant Introduction Station (USA)
Sweetpotato	868	CIP (Peru)
Total	**14,195**	

CWR Project: Impact through seeds

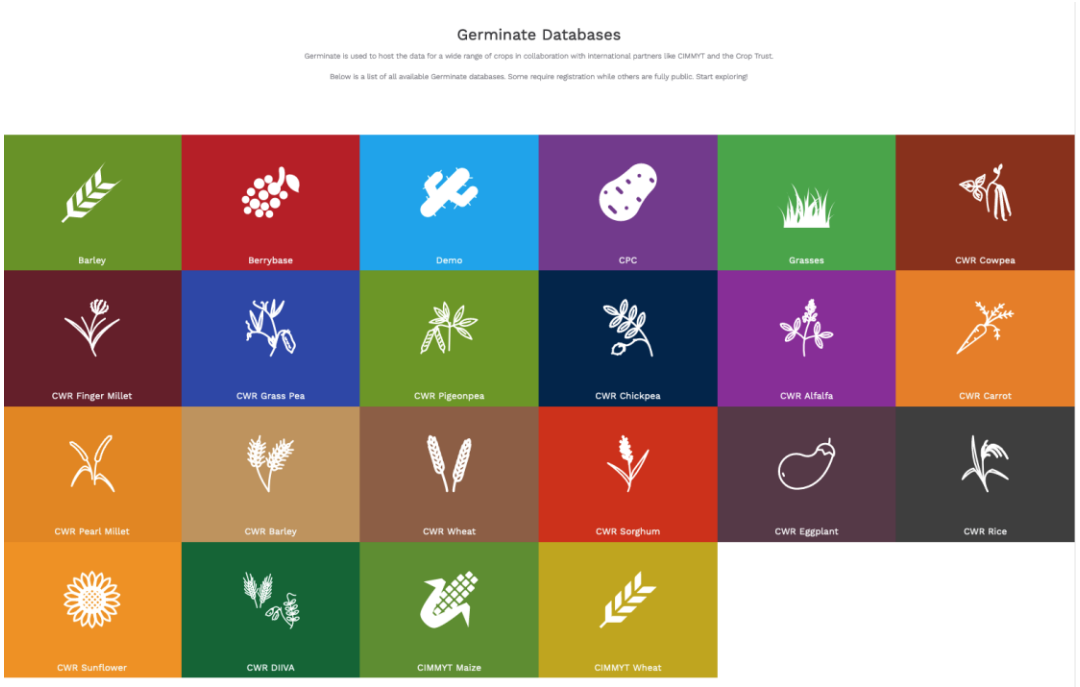
Improved varieties

First CWR-derived varieties released and most advanced lines

Crop	Country	Variety name	Lead partner institute	Release year	Key traits
Alfalfa	China and Kazakhstan	Zhongcao No. 3	Grasslands Research Institute, Chinese Academy of Agricultural Sciences, SARDI	2019	Cold tolerance, broadly adapted to continental environments, high yield
Durum wheat	Lebanon	Zagharin2	ICARDA	2020	Drought tolerance, high yield, good pasta-making quality
Durum wheat	Morocco	Jabal	ICARDA	2021	Strong farmer preference, high yield, large grains
Potato	Peru	CIP-Matilde	International Potato Center	2022	Late blight resistance
Rice	Vietnam	L102-5	Can Tho University, Vietnam	2022	Resistant to blast and brown planthopper, tolerant to salinity and acid sulfate soils, wide adaptation and high yield

CWR Project: Impact through data & information

Managing and sharing data through Germinate



https://germinateplatform.github.io/get-germinate/

CWR Project: Impact through data and information

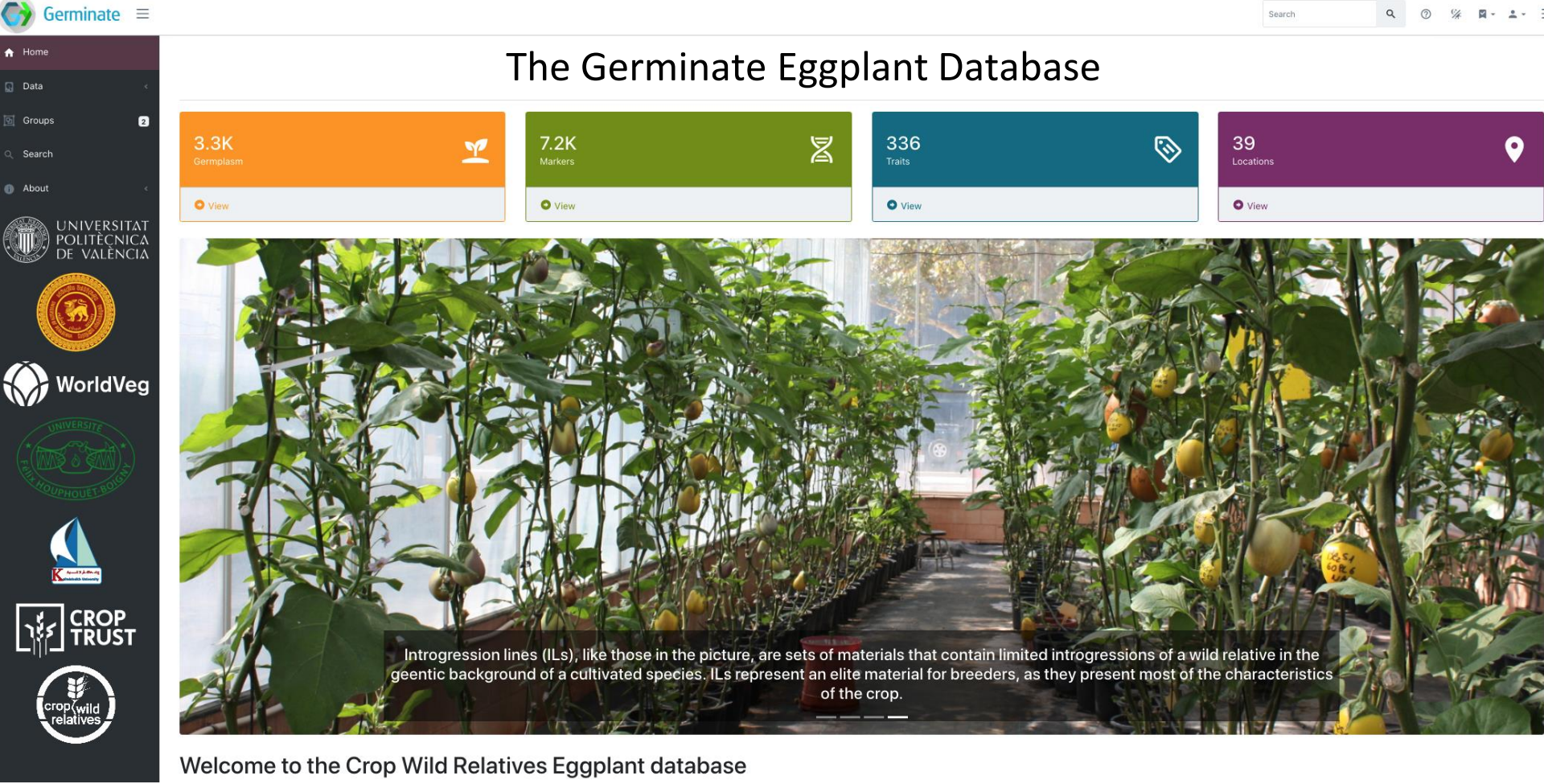
Germinate Crop databases

Summary statistics for 15 Germinate pre-breeding & evaluation databases

Project Crop	Germplasm	Trait datapoints	Markers
Eggplant	3,335	39,741	7,160
Sunflower	7,884	93,318	47,207
Chickpea	23,458	146,666	0
Finger millet	1,677	32,521	84,055
Pigeonpea	2,864	73,423	3,687
Rice	4,904	90,801	6,352
Sorghum	2,797	19,530	17,118
Alfalfa	2,687	61,551	0
Cowpea	13,114	157,680	0
Pearl millet	2,400	39,645	0
Barley	33,242	9,416	578,294
Grasspea	5,597	16,110	42,439
Wheat*	621	10,293	0
Carrot*	248	-	104,956
DIIVA (Barley, Lentil & Wheat)	2,878	47,402	0

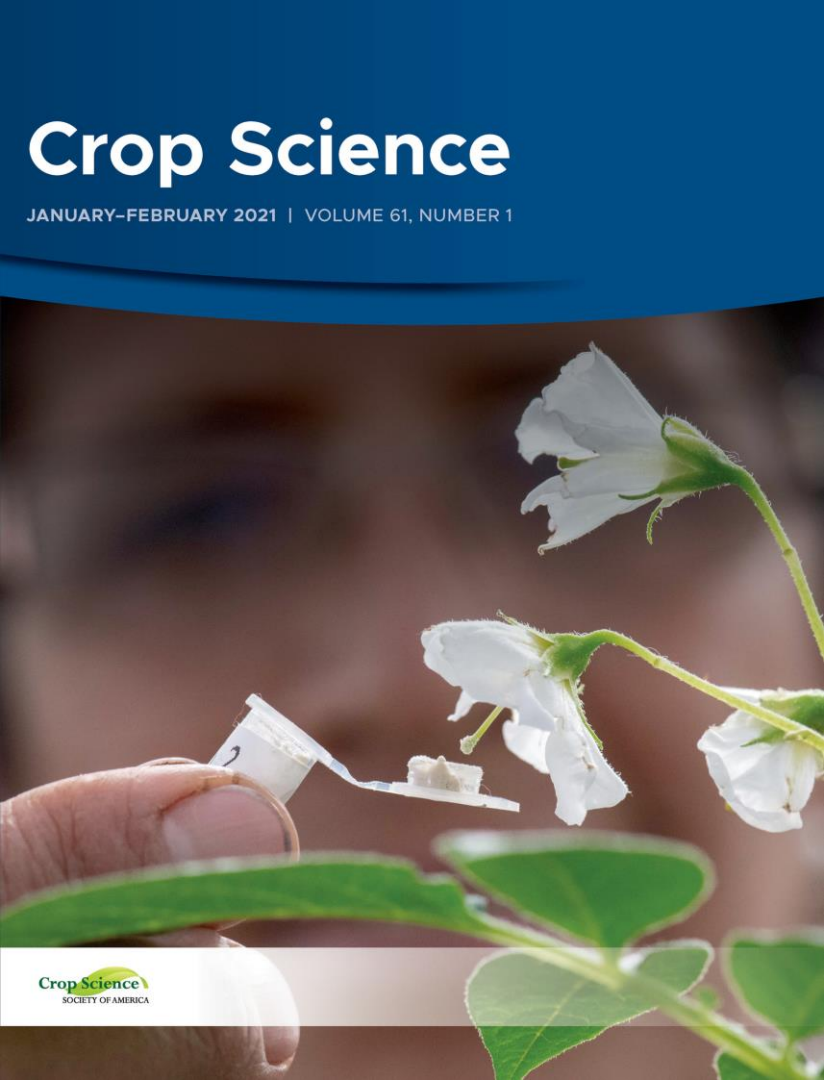
The James Hutton Institute

The Germinate Eggplant Database



https://ics.hutton.ac.uk/cwr/eggplant/#/home

https://vimeo.com/507909059



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Crop Science

SPECIAL ISSUE: ADAPTING AGRICULTURE TO CLIMATE CHANGE: A WALK ON THE WILD SIDE

Crop Science special issue: Adapting agriculture to climate change: A walk on the wild side

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Crop Science 2021 61(1)

- 19 papers on 13 crops
- from the pre-breeding & evaluation partners of the CWR Project

✓ As of 1 March 2022, 146 journal articles, 12 theses, one book, 13 book chapters had been published.

CWR Project: The bean pre-breeding project (2016-2019)

Project partners:

- Alliance of Bioversity International and CIAT (Colombia)
- Universidad Zamorano (Honduras)
- Corporación Colombiana de Investigación Agropecuaria (Colombia)

Its objectives were:

✓ to establish a reliable methodology for screening *Phaseolus* against waterlogging

✓ to evaluate bean wild relatives for tolerance to heat and waterlogging and resistance to the root rot pathogen, *Pythium myriotylum*.

CWR Project: Highlights of the bean pre-breeding project (2016-2019)

- ✓ Numerous wild *Phaseolus* accessions showed tolerance to waterlogging and resistance to root rot.
- ✓ **Two wild *P. acutifolius* accessions tolerant to heat stress** and *P. vulgaris* (cultivated) accessions tolerant to waterlogging at the seedling stage were identified.
- ✓ These accessions were crossed to develop new populations using a foundational breeding strategy entailing a **bridging genotype (VAP1)** compatible with common bean and *P. acutifolius*.
- ✓ The resulting **interspecific hybrid bean populations** were evaluated under controlled conditions at CIAT and under field conditions.
- ✓ **Infrastructure was established for evaluating tolerance of beans** to waterlogging at the seedling stage under greenhouse conditions.

CWR Project: The bean evaluation project (2019-2021)

Project partners:

- Alliance of Bioversity International and CIAT (Colombia)
- Instituto de Investigação Agrária de Moçambique (IIAM, Mozambique)
- Escuela Agricola Panamerica Zamorano and Zamorano University (Honduras)
- AGROSAVIA (Colombia)

Interspecific populations generated during the pre-breeding project were shared with breeding partners, who received appropriate training to evaluate this material under heat stress under field conditions.

CWR Project: Highlights of the bean evaluation project (2019-2021)

- ✓ In Honduras, 51 CWR-derived lines were considered promising in terms of drought tolerance.
- ✓ Preliminary results indicate that 128 CWR-derived lines were able to grow and produce pollen under heat stress in southern Mozambique.
- ✓ At CIAT, the structure of the genetic mapping population was identified, and **wild *P. acutifolius* genomic segments were successfully introgressed** into a *P. vulgaris* background.
- ✓ Studies on genetic associations using yield, seed weight, pod wall dry weight, stem dry weight and pod harvest index revealed **significant associations for heat stress**.
- ✓ Data has been deposited in the Dataverse repository.
- ✓ 47 pre-bred lines derived from *P. acutifolius* have been deposited in the CIAT genebank and are accessible through an SMTA.

Conclusion & Future directions

- Despite the COVID-19 challenges faced by everybody, CWR Project partners found creative ways to continue their work.
- Impressive progress has been made in introgressing beneficial traits from CWR.
- Promising CWR-derived lines have been identified that justify the expense and effort.
- Farmer involvement from the beginning: often possible and very advantageous.
- The BOLD Project takes up where the CWR Project left off, building on and strengthening its legacy and delivering practical outcomes in farmers' fields.


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https://www.cwrdiversity.org/

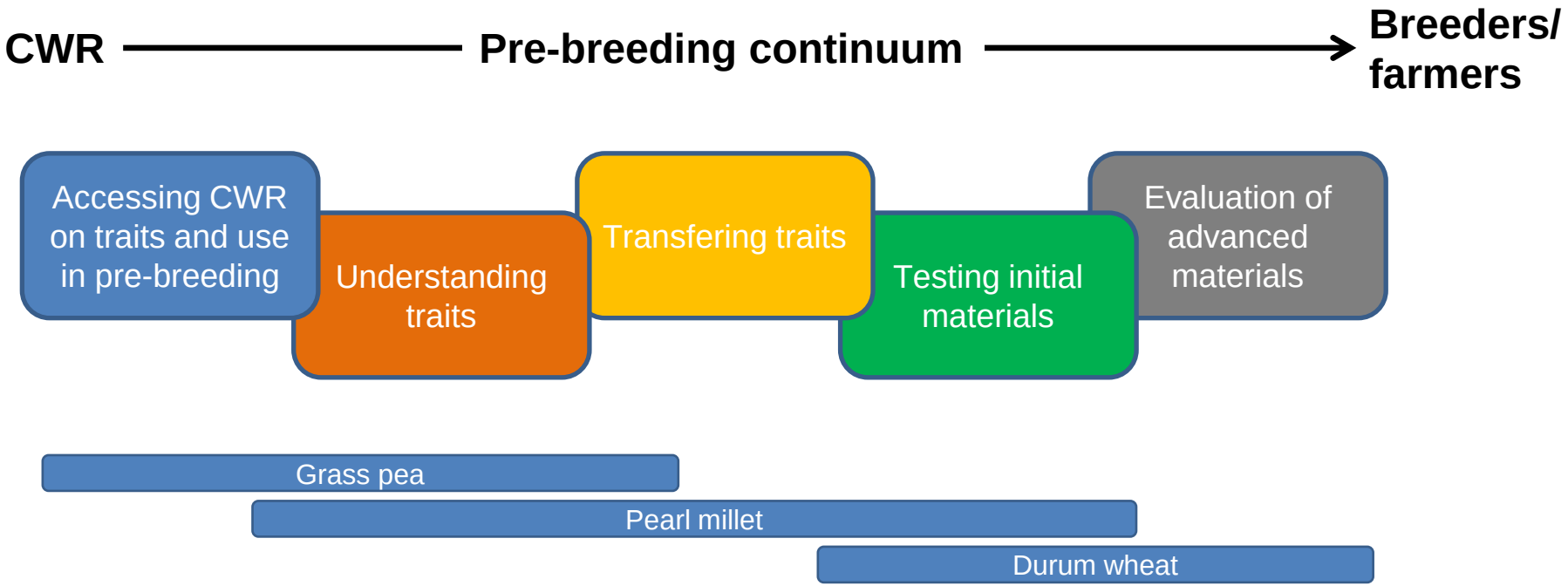
Calling all citizen scientists – grow old bean varieties to promote agrobiodiversity

Outline

- The legacy of the CWR Project
- Pre-breeding achievements of the CWR Project
- The Bean projects
- Outlook

Adam Bolton
University of Wisconsin-Madison

CWR Project: pre-breeding continuum



CWR Project: Impact through capacity building

211 fellows & students have been trained in pre-breeding and evaluation projects

Crop	Post-doctoral fellows	PhD students	MSc students	Undergraduate students
Alfalfa	2	3	2	2
Banana			2	1
Barley	1	4	4	
Carrot		7	18	18
Common bean			1	1
Chickpea		2		1
Cowpea	1	3	2	1
Durum wheat	2	1		
Eggplant	2	6	19	4
Finger millet		2	1	
Grasspea		1		1
Lentil	5	3	4	1
Pearl millet				
Pigeonpea		1		
Potato		3	1	2
Rice		1	4	51
Sorghum	1	2	1	
Sunflower	2	3	3	4
Sweetpotato		2		2
TOTAL	**16**	**44**	**62**	**89**

CWR Project: Impact through publications

Debouck, D. G., Araya-Villalobos, R., & Chaves-Barrantes, N. (2018). *Phaseolus angucianae* (Leguminosae: Phaseoleae), a new bean species from Fila Cruces of southeastern Costa Rica. *Journal of the Botanical Research Institute of Texas*, *12*(2), 507–520.

Porch, T. G., Beaver, J. S., Debouck, D. G., Jackson, S. A., Kelly, J. D., & Dempewolf, H. (2013). Use of Wild Relatives and Closely Related Species to Adapt Common Bean to Climate Change. *Agronomy*, *3*(2), 433–461. https://doi.org/10.3390/agronomy3020433

Biodiversity for Opportunities, Livelihoods and Development (BOLD-CWR)

January 2022

Think BOLD: A Global Project for Our Future

BOLD will build on the success of the Crop Wild Relatives Project and expand its work to help ensure **food security** in the face of **climate change**.

BOLD at a Glance

Origin: CWR Project

Duration: 10 years (2021-2030)

Value: USD 58 million

Donor: Norwegian Government

Work Packages

1. Capacity and resource development
2. Making new diversity available
3. Genebanks and seed systems
4. Safety duplication at Seed Vault
5. Communications, engagement and outreach
6. Project management