

The USDA-ARS Sunflower Collection as a Source of Genetic Diversity for Sunflower

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Outline

- **Wild sunflower germplasm diversity**
- **Sunflower collection**
- **Importance and value**
- **Uses of wild species**
- **Future prospective and challenges**



Sunflower Production

- 22.9 million hectares
- Production in 60 countries
- Fifth largest edible oilseed crop
- Second largest hybrid seed crop
- 40 billion USD value
- 10% of the world's edible oil

FAO, 2008



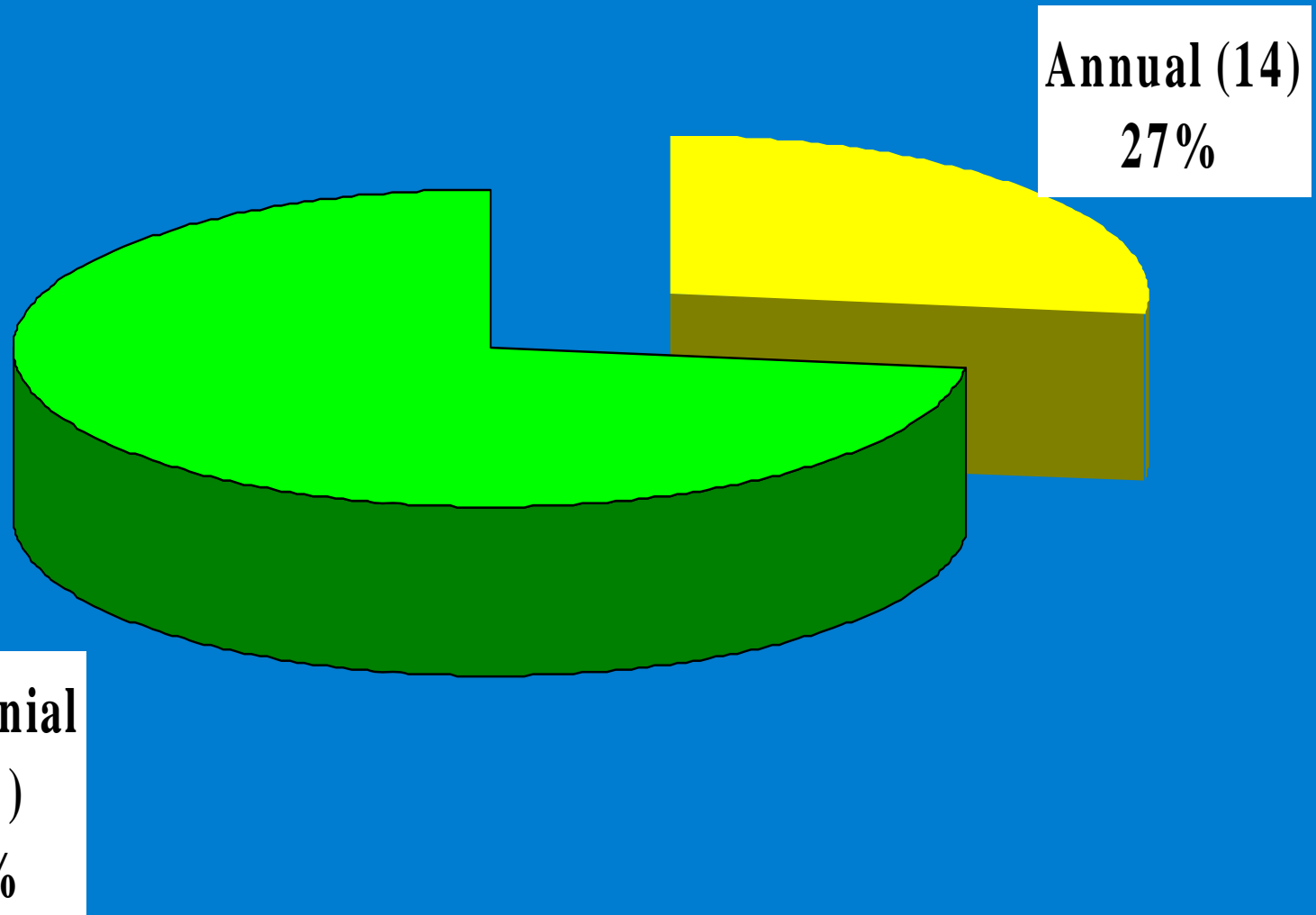
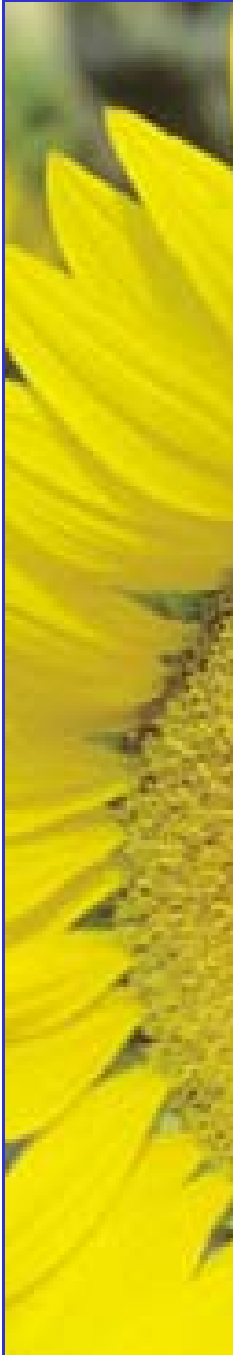
Sunflower Diversity

Genetic resources are the biological basis of global food security. Preservation of cultivars, landraces, and wild relatives of important plant species provides the basic foundation to promote and sustain agriculture.

Campbell et al., 2010

Helianthus Species

(52 species, 69 taxa)



Perennial
(38)
73%

Annual (14)
27%

GENETIC DIVERSITY

52 *Helianthus* species

- 14 Diploid annuals ($2n=2x=34$)
- 27 Diploid perennials ($2n=2x=34$)
- 4 Tetraploid perennials ($2n=4x=68$)
- 7 Hexaploid perennials ($2n=6x=102$)
- 2 Mixaploid perennials ($2n=2x=34, 4x=68$)
- 2 Mixaploid perennials ($2n=4x=68, 6x=102$)





Wild Species- Center of Origin

- Co-evolution of crop, ancestors, and pests
- Genetic diversity-Habitat diversity



Wild Species Diversity

- Genetic diversity across cultivated sunflower was 0.47, as compared with 0.70 in the wilds, indicating a higher level of genetic diversity in a select group of wild *H. annuus* populations based on SSR markers

Mandel et al., 2011



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National Plant Germplasm System

<http://www.ars-grin.gov>



Accessions	543,203
Species	13,852

[List of Germplasm Repositories](#)

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Accessions in the USDA-ARS Sunflower Collection



H. debilis, Florida



Seed increase, Ames, IA



H. niveus, California

Type	Number	Available %
Cultivated	1816	92
Wild species	2201	87
Annual	1358	95
Perennial	831	70
Total	4031	88



Distributions of Accessions in the USDA-ARS Sunflower Collection 2001-2011

Sunflower collection	Cultivated	Wild	Total
Requests	650	520	1,170
Recipients	514	430	944
Accessions sent	7,303	7,707	15,010
Items sent	11,831	10,683	22,514

Wild Species Explorations

- 30 explorations in USA, Canada, and Australia over 35 years; 15 in the last 10 years
- Covered over 175,000 km
- 2,100 accessions added to the genebank collection
- USDA-ARS, Plant Exchange Office, National Germplasm Resources Laboratory provided the major funding for the wild sunflower explorations



Wild Species Traits of Value

Downy mildew resistance

Broomrape resistance

Rust resistance

Alternaria leaf spot resistance

Powdery mildew resistance

Cytoplasmic male sterility

Phomopsis tolerance

Insect resistance

Verticillium wilt resistance

Herbicide resistance

Sclerotinia resistance

Salt tolerance





Wild Species Value \$\$\$

- **393.4 million dollars in USA**
(Prescott-Allen and Prescott-Allen, 1986)
- **269.5 million dollars in USA**
(Phillips and Meilleur, 1998)



Use of Crop Wild Relatives in the Past 20 Years for 13 Important International Food Crops

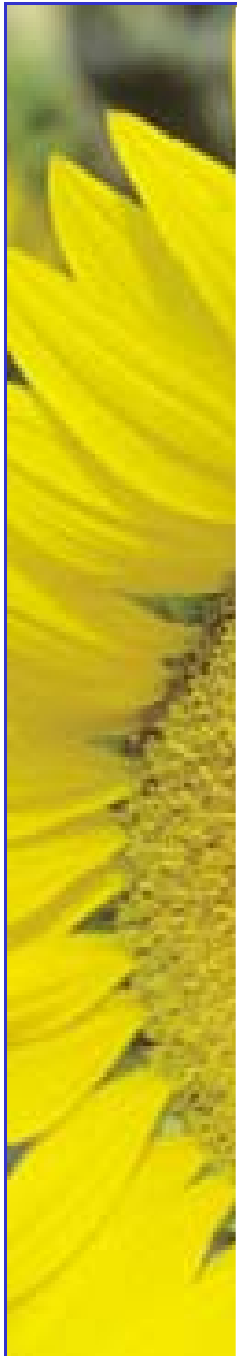
Crop	Diseases/ insects	Abiotic stress	Male sterility	Total traits contributed
	Number of species			
Tomato	10	2	0	55
Rice	7	3	1	12
Potato	6	0	0	12
Wheat	11	0	0	9
Sunflower	3	1	1	7



Wild *Helianthus* sources of resistance for sunflower diseases

Disease	Wild species	
	Annual	Perennial
Rust	3	5
Downy mildew	10	15
Sclerotinia	7	18
Phomopsis	7	18
Alternaria	3	9
Powdery mildew	3	9
Rhizopus	0	4
Phoma	2	8
Charcoal rot	0	5
Broomrape	5	25
Verticillium	4	3

Downy Mildew Resistance



Luka Cuk
IFVC, Novi Sad, 1980

H. argophyllus, Texas



Downy Mildew (New virulent races)

Species

Germplasm

H. argophyllus- TX

RHA 340

H. argophyllus- FL

HA 419/420

H. annuus- NM

HA 428

H. annuus- ID

HA 458

H. annuus- TX

TX-16



Rust resistance (Races 336 and 777)

Population

Germplasm

PI 413038 (*annuus*-SD)

PH3

PI 413048 (*annuus*-CA)

PH4

PI 413118 (*annuus*-CA)

PH5

PI 642072 (*annuus*-TX)

TX16R

PI 413047 (*annuus*- CA)

RHA 464

PI 596746 (*annuus*- OK)

Rf-ANN-1742

Broomrape

25 species of **perennial** sunflower have resistance

Only *H. nuttallii* had 33% incidence



Broomrape

<u>Species</u>	<u>Source</u>	<u>Germplasm</u>
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RACE F

<i>H. grosseserratus</i>	PI 617026	BR1
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<i>H. maximiliani</i>	PI 617027	BR2
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<i>H. divaricatus</i>	PI 617028	BR3
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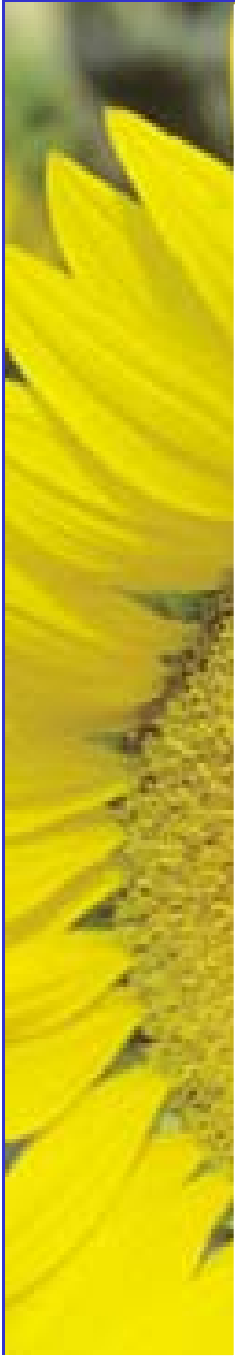
<i>H. divaricatus</i>	PI 617029	BR4
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RACE G

<i>H. debilis</i> ssp. <i>tardiflorus</i>	PI 468691	----
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Salt Tolerance



H. paradoxus, New Mexico



Salt Tolerance

Wild population

Germplasm

H. paradoxus-1671 (NM)

HA 429

(PI 468801)

(PI 632388)

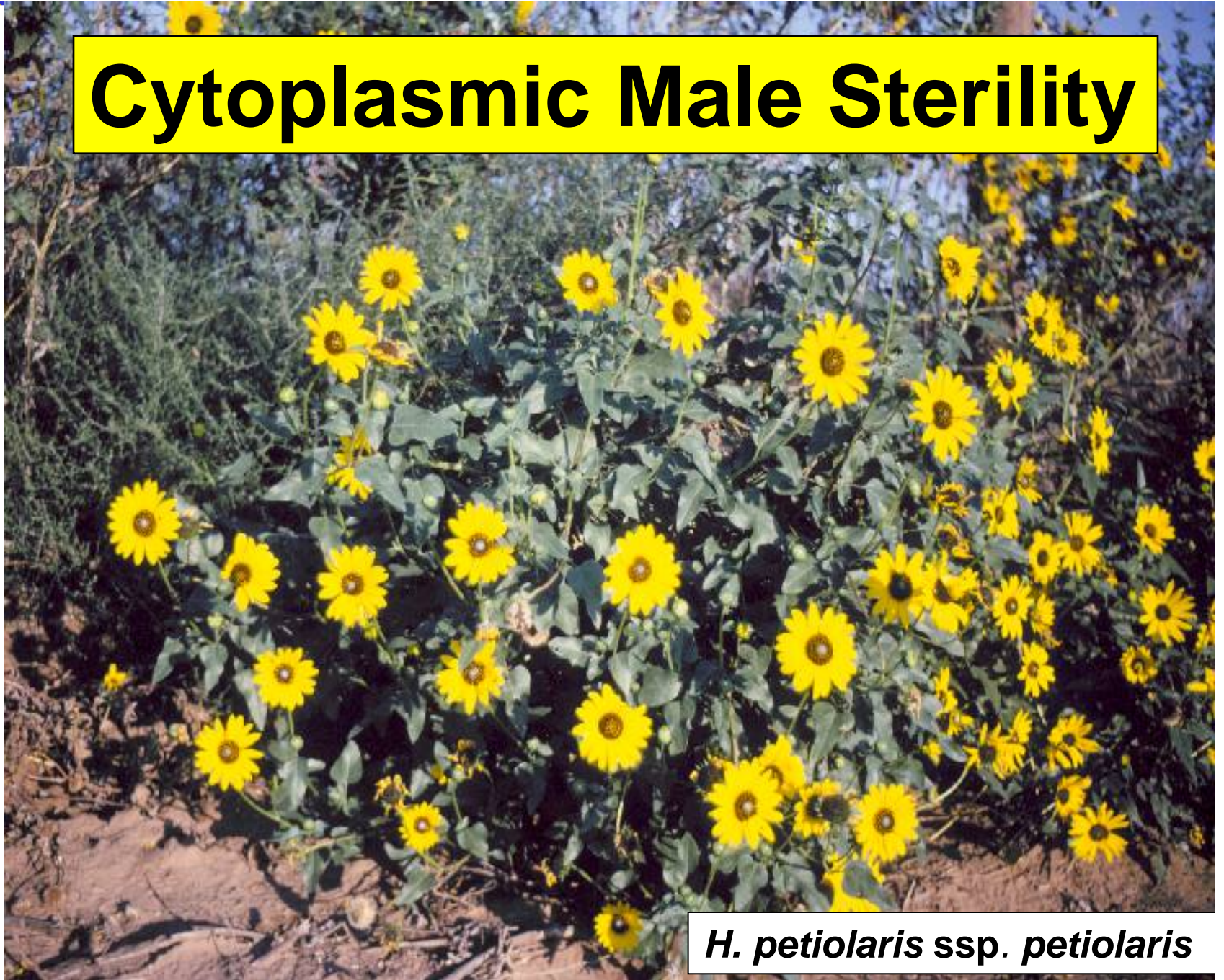
H. paradoxus-1673 (TX)

HA 430

(PI 468802)

(PI 632339)

Cytoplasmic Male Sterility



H. petiolaris ssp. *petiolaris*



Cytoplasmic Male Sterility

- PET1- French cytoplasm
- 62 sources from wild species
- 15 different species
- 56 annual populations
- 6 perennial populations

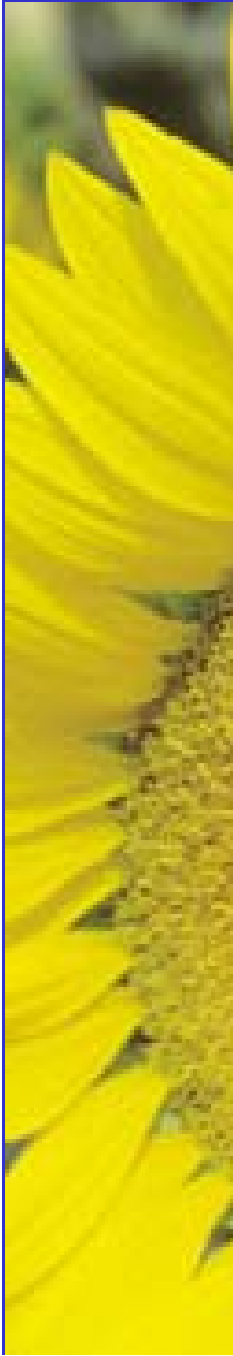
Herbicide Resistance



Wild *H. annuus*, Kansas soybean field

Helia 21: 45-54, 1998

Herbicide Resistance



<u>Species</u>	<u>Chemistry</u>	<u>Germplasm</u>
<i>H. annuus</i>	IMI	HA 425
<i>H. annuus</i>	IMI	RHA 426
<i>H. annuus</i>	IMI	RHA 427
<i>H. annuus</i>	IMI	HA 442
<i>H. annuus</i>	IMI	RHA 443
<i>H. annuus</i>	SU	SURES-1
<i>H. annuus</i>	SU	SURES-2

****Imazethapyr shown to control Broomrape****



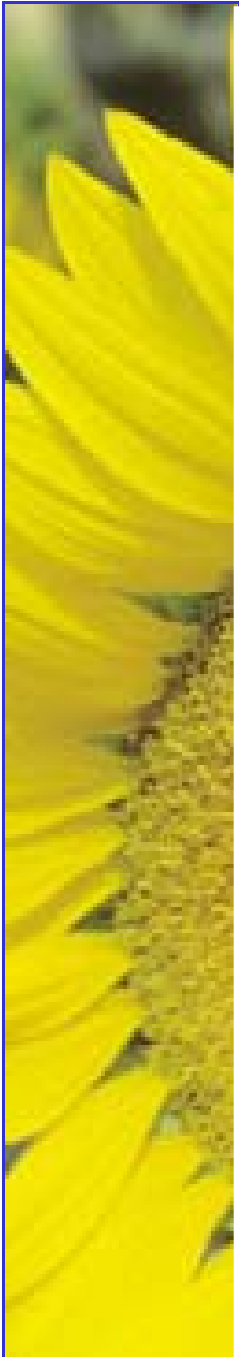
Future Opportunities

- Addition of molecular tools to mine the available genetic diversity
- Opportunity to move exotic genes with more precision and efficiency
- Currently bioinformatics is the bottleneck for complete exploitation of genetic resources information



Future Challenges

- **Genetic resources--Global political restructuring**
- **Decreased opportunity for germplasm exchange**
- **Decline in the funding and lack of commitment by countries for genetic resources**



Thank you!

