



The Plants That Feed the World:

baseline data and metrics to inform strategies for the conservation and use of plant genetic resources for food and agriculture

**Eleventh Meeting of the Ad Hoc Open-ended Working Group to
Enhance the Functioning of the Multilateral System
(IT/OWG-EFMLS-11)**

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**Colin Khoury
San Diego Botanic Garden**

The Plants that Feed the World - rationale

- It is important that the PGRFA community, including ITPGRFA Parties, is able to **access information** on the **current use of food and agricultural plants** as well as **interdependence regarding, demand for, supply of, and security of their genetic resources**
 - e.g. toward MLS implementation, BSF allocation, Global Biodiversity Framework, and SDGs 2.5 and 15.6
- **Pertinent information increasingly available but scattered**, e.g.:
 - FAO's Food and Agricultural Statistics Database (FAOSTAT)
 - FAO World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture (WIEWS)
 - Data Store of the International Treaty on Plant Genetic Resources for Food and Agriculture
 - International Union for the Protection of New Varieties of Plants (UPOV)'s PLUTO Plant Variety Database
 - Genesys Plant Genetic Resources portal (Genesys PGR)
 - Botanic Garden Conservation International's PlantSearch database
 - Global Biodiversity Information Facility (GBIF)
 - Svalbard Global Seed Vault's Seed Portal
 - National Center for Biotechnology Information (NCBI)'s Entrez database



USDA pomegranate collection, Davis, California. Photo: Colin Khoury

The Plants that Feed the World - aim

- A reproducible **set of metrics and associated baseline data** that provides an evidence base enabling the community to strategize and prioritize actions regarding the conservation and availability for use of PGRFA
- Measured periodically, these metrics can also provide insights on **change over time** in the use of crops and issues regarding interdependence on, demand for, supply of, and security of their genetic resources



Photo: World Vegetable Center

The Plants that Feed the World - aim

This work on PGRFA metrics:

- does not create new information systems, but, rather, **gathers and processes** in a standardized manner **data from several relevant systems**
- **does not substitute** PGRFA indicators (such as those for Sustainable Development Goal Targets 2.5 or 15.6) gathered through **country-driven efforts**
- Is most appropriately **complemented by other sources** of information and analysis that cannot be made available in the form of reproducible metrics, as evident in the development of the Global Crop Conservation Strategies



Photo: Manon Koningstein

The Plants that Feed the World – scope

5 Domains (98 metrics in total):

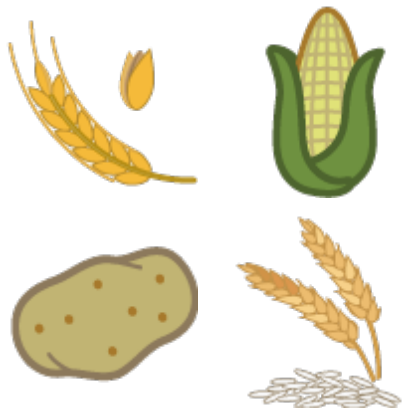
- **USE** - contribution of each crop to food supplies, agricultural production, trade, and other metrics (51 metrics)
- **INTERDEPENDENCE** among countries for each crop's genetic resources (22 metrics)
- **DEMAND** for each crop's genetic resources (7 metrics)
- **SUPPLY** of each crop's genetic resources (i.e. *ex situ* conservation) (16 metrics)
- **SECURITY** – safety backup of each crop's genetic resources (2 metrics)



Parque de la Papa. Photo: Colin Khoury

The Plants that Feed the World - scope

- Coverage: **355 food and agricultural crops**
 - Inclusive of all those covered in FAOSTAT, Annex I of the International Treaty, and CGIAR mandate major crops, as well as other crops deemed internationally significant
- Time point – **recent year** (generally between 2019 to 2022), with some metrics averaged across years, data dependent



A few crops – very large amount of information



Dozens of crops - medium amount of information



Hundreds of crops – only a small amount of information

FOOD

Beverage

- Agave
- Barley
- Grapes



Cereal

- Adlai
- Amaranth
- Barley
- Buckwheat
- Canary seed
- Finger millet
- Fonio
- Foxtail millet
- Japanese millet
- Kaniwa
- Kiwicha
- Kodo millet
- Little millet
- Maize
- Oats
- Pearl millet
- Proso millet
- Quinoa
- Rice (African)
- Rice (Asian)
- Rye
- Sorghum
- Teff
- Triticale
- Wheat
- Wildrice



Fruit

- Acerola
- Ackee
- Apple
- Apricot
- Atemoya
- Avocado
- Azarole
- Babaco
- Bananas
- Blueberry
- Breadfruit
- Cainito
- Carambola
- Cherimoya
- Cherries
- Chinotto
- Chontadura
- Citron
- Cranberries
- Currants
- Custard apple
- Dates
- Durian
- Elderberry
- Feijoa
- Figs
- Gooseberries
- Grapefruits
- Grapes
- Guavas
- Huckleberry



- Jackfruit
- Jujube
- Kiwi fruit
- Kumquat
- Lemons and limes
- Litchi
- Longan
- Loquat
- Mamey sapote
- Mammee
- Mandarines
- Mango
- Mangosteen
- Medlar
- Melons
- Mombin
- Mulberry
- Myrtle
- Naranjilla
- Oranges
- Papayas
- Passionfruit
- Pawpaw
- Peaches and nectarines
- Pears
- Pepino
- Persimmons
- Pineapples
- Plums
- Pomegranate
- Prickly pear
- Quinces
- Rambutan
- Raspberries
- Sapodilla
- Service tree
- Soursop
- Strawberries
- Strawberry tree
- Sugar apple
- Tamarind
- Tomatillo
- Tree tomato
- Watermelons



Herb and spice

- Allspice
- Anise
- Annato
- Badian
- Basil
- Bay leaf
- Caraway
- Cardamoms
- Chillies and peppers
- Cinnamon
- Cloves
- Coriander
- Cumin
- Dill
- Fennel
- Fenugreek
- Ginger
- Hops
- Lavender
- Licorice
- Marjoram
- Nutmeg
- Oregano
- Pepper
- Peppermint



- Rosemary
- Saffron
- Thyme
- Turmeric
- Vanilla



Nut

- Almonds
- Areca nuts
- Brazil nut
- Butter-nut
- Cashews
- Chestnuts
- Hazelnuts
- Kola nuts
- Macadamia nut
- Pecan
- Pili nut
- Pine nut
- Pistachios
- Walnuts



Oil

- Beech nut
- Candlenut
- Carapa
- Castor bean
- Chontadura
- Coconuts
- Cotton
- Crambe
- Flax
- Groundnuts
- Hemp
- Jojoba
- Kapok
- Karite nuts
- Mahuwa
- Maize
- Noog
- Oil palm
- Oiticica
- Olives
- Perilla
- Physic nut
- Pongamia oil
- Poppies
- Purging croton
- Rapeseed and mustards
- Safflower
- Sesame
- Shala tree
- Soybeans
- Sunflowers
- Tung nuts



Pulse

- Adzuki bean
- Ahipa
- Bambara bean
- Black gram
- Chickpeas
- Common bean
- Cowpeas
- Faba beans
- Grasspea
- Groundnuts
- Jack bean



- Jicama
- Lablab
- Lentils
- Lima bean
- Lupins
- Mat bean
- Mung bean
- Peas
- Pigeonpeas
- Rice bean
- Runner bean
- Soybeans
- Sword bean
- Tepary bean
- Velvet bean
- Winged bean
- Year bean



Root and Tuber

- Achira
- Arracacha
- Arrowroot
- Cassava
- Chufa
- Jerusalem artichoke
- Maca
- Mashua
- Mauka
- Oca
- Plantains
- Potatoes
- Sago palm
- Sweetpotatoes
- Taro
- Ulluco
- Yacon
- Yams
- Yautia, cocoyam



Stimulant

- Cocoa
- Coffee
- Mate
- Tea
- Tobacco



Sugar

- Maize
- Maple sugar
- Sugar beets
- Sugarcane



Vegetable

- African eggplant
- Artichokes
- Asparagus
- Bamboo shoot
- Beets
- Bitter gourd
- Black nightshade
- Black salsify
- Butternut squash
- Cabbages
- Cabbages and other brassicas



- Calabash
- Canola
- Capers
- Carobs
- Carrots
- Celery
- Ceylon-spinach
- Chayote
- Chervil
- Chicory
- Chillies and peppers
- Common bean
- Cress
- Cucumbers and gherkins
- Cushaw
- Eggplant
- Ethiopian rape
- Fig leaf gourd
- Garlic
- Horseradish
- Leeks and other alliaceous vegetables
- Lettuce
- Luffa
- Malabar spinach
- New Zealand spinach
- Okra
- Onions
- Orache
- Parsley
- Parsnip
- Pumpkin
- Radish
- Rhubarb
- Salsify
- Savory
- Slippery cabbage
- Snake gourd
- Sorrel
- Spider plant
- Spinach
- Tarragon
- Tomatoes
- Turnips
- Water dropwort
- Watercress
- Wax gourd
- West Indian Gherkin
- Zucchini



FIBRE

- Abaca
- Agave
- Albardine
- Caesarweed
- Carneros Yucca
- Caroa
- Cotton
- Devil's cotton
- Esparto
- Fique
- Flax
- Giant cabuya
- Jute
- Kenaf
- New Zealand flax
- Ramie
- Roselle
- Sisal
- Snake plant
- Sunn hemp
- Velvet leaf



FORAGE

- Aeschynomene
- Agropyron
- Agrostis
- Alfalfa
- Alopecurus
- Alysicarpus
- Andropogon
- Arrhenatherum
- Astragalus
- Atriplex
- Brachiaria
- Calopogonium
- Centrosema
- Clovers
- Coronilla
- Dactylis
- Desmodium
- Fescue
- Galactia
- Hedysarum
- Indigofera
- Lespedeza
- Leucaena
- Lolium
- Lotus
- Macroptilium
- Melilotus
- Neonotonia
- Onobrychis
- Ornithopus
- Phalaris
- Phleum
- Poa
- Prosopis
- Pueraria
- Rhynchosia
- Salsola
- Sesbania
- Stylosanthes
- Tripsacum
- Vetch
- Zornia



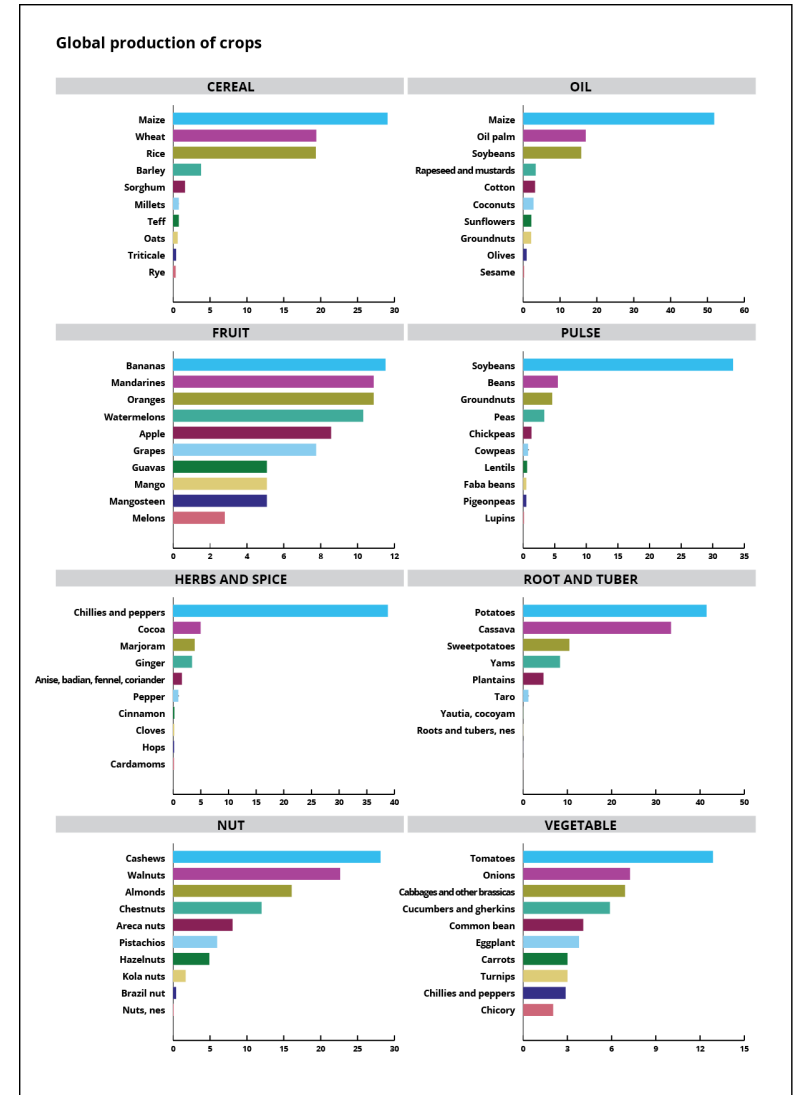
INDUSTRIAL

- Ceara
- Chicle
- Citronella
- Guayule
- Gutta-percha
- Hemp
- Jelutong
- Poppies
- Pyrethrum
- Rubber, natural
- Tallowtree



The Plants that Feed the World – results formats

- 3 calculation types:
 - **Average** (calculated data)
 - **Indicator**
 - **Normalized indicator** (0-1)
- 2 scales:
 - **All crops**
 - By **crop use type** - 11 food categories (beverage, cereal, fruit, herb and spice, nut, oil, pulse, root and tuber, stimulant, sugar, and vegetable crops) as well as fibre, forage, and industrial crops
- Available as:
 - **Text and figures** in main study
 - **Excel spreadsheets** – supplementary materials
 - **Online interactive figures** (coming!)
- **Vignettes** on: oil crops, plant-based protein, crops of the future, PGRFA and climate change, capacity building, biofuel crops, DSI, SGSV, and safety backup for vegetatively propagated crops

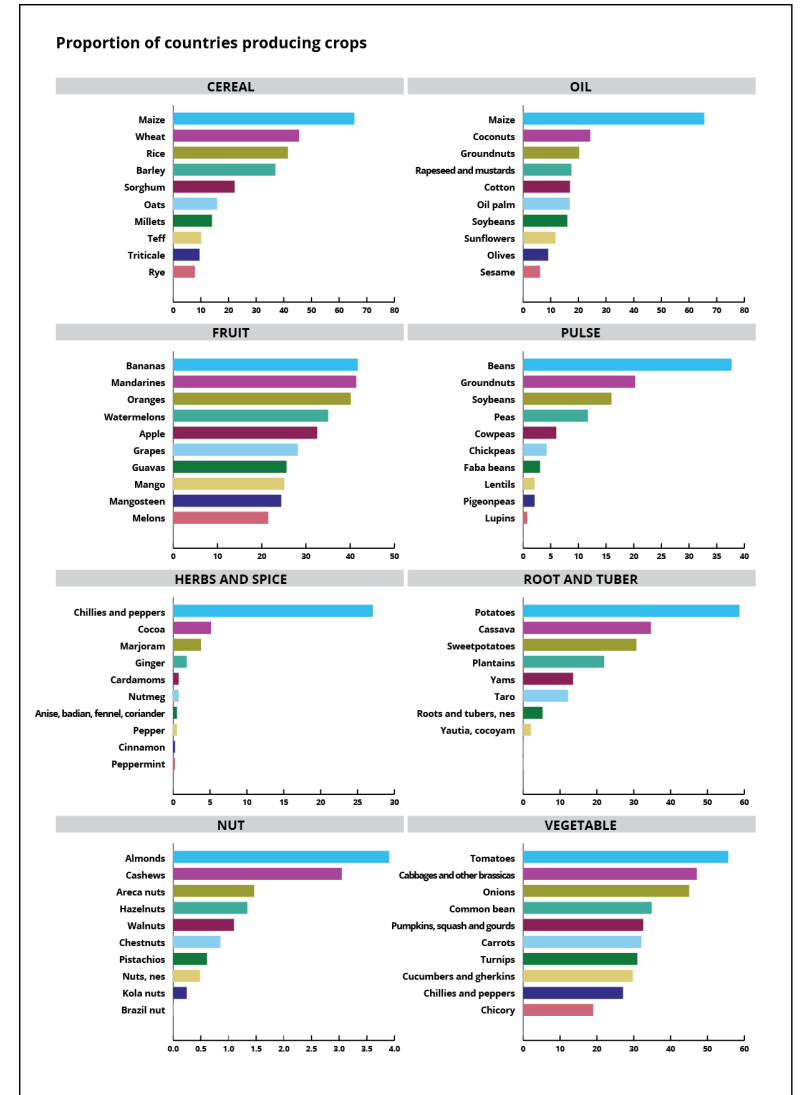


Use of crops in global agricultural production as measured in terms of production quantity (tonnes). The results are presented as the proportion of the value of the crop, compared with all crops per use type. Top 10 crops for the metric shown.

The Plants that Feed the World – crop use

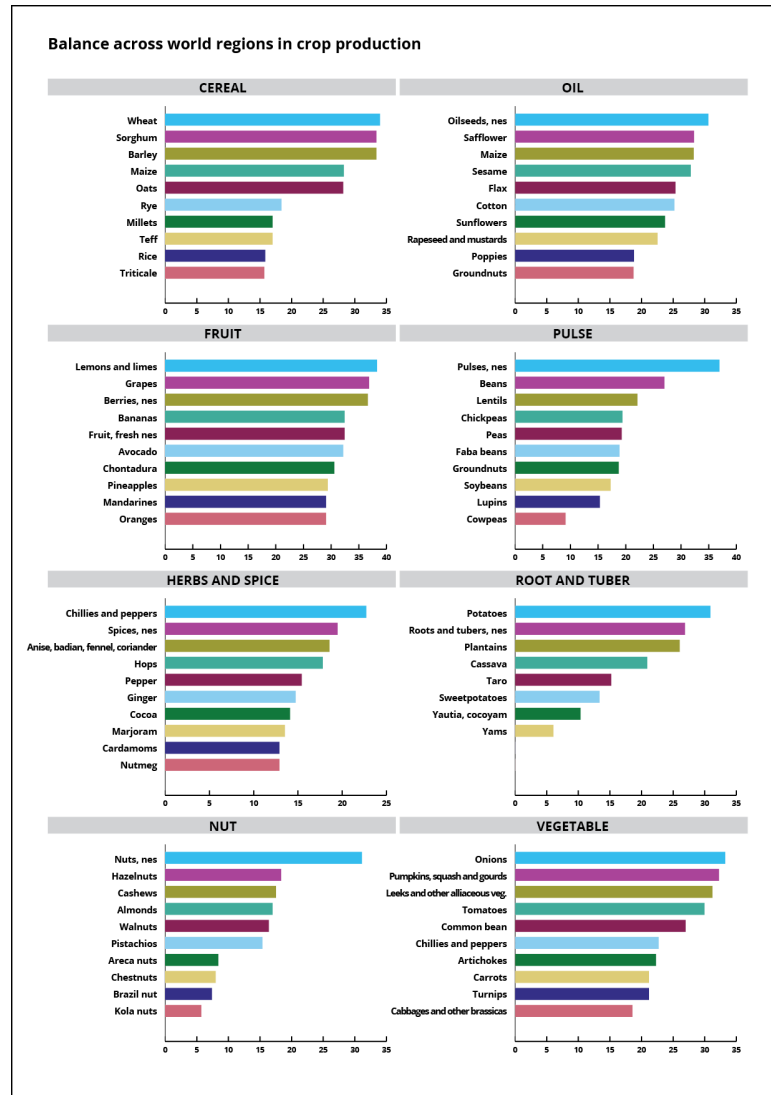
Crop use

- 11 metrics - Crop use data from FAOSTAT
- 11 metrics - Crop use data from FAOSTAT - Count of countries
- 11 metrics - Crop use data from FAOSTAT - Equality of use (GINI)
- 11 metrics - Crop use data from FAOSTAT - Change over time
- 4 metrics - Crop research investigation - Google Scholar and PubMed Central
- 3 metrics - Crop public interest/awareness - Wikipedia pageviews

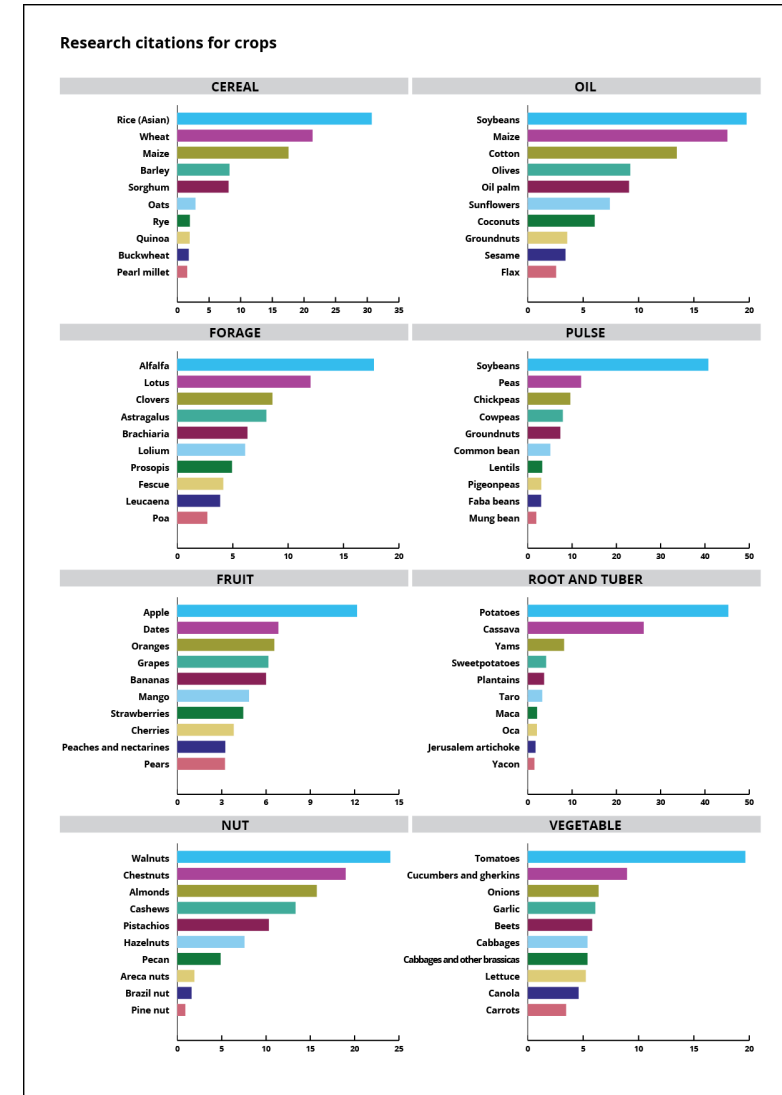


Geographic spread of crops in global agricultural production as measured in terms of the proportion of countries in which the crop is significant compared with the total number of countries reported in FAOSTAT (205).

The Plants that Feed the World – crop use



Geographic evenness of crops in terms of agricultural production in different world regions. The results are presented based on a mathematical metric of evenness called the Gini coefficient, in this case with values close to 100 representing high evenness in use across regions, and those close to 0 representing unevenness.

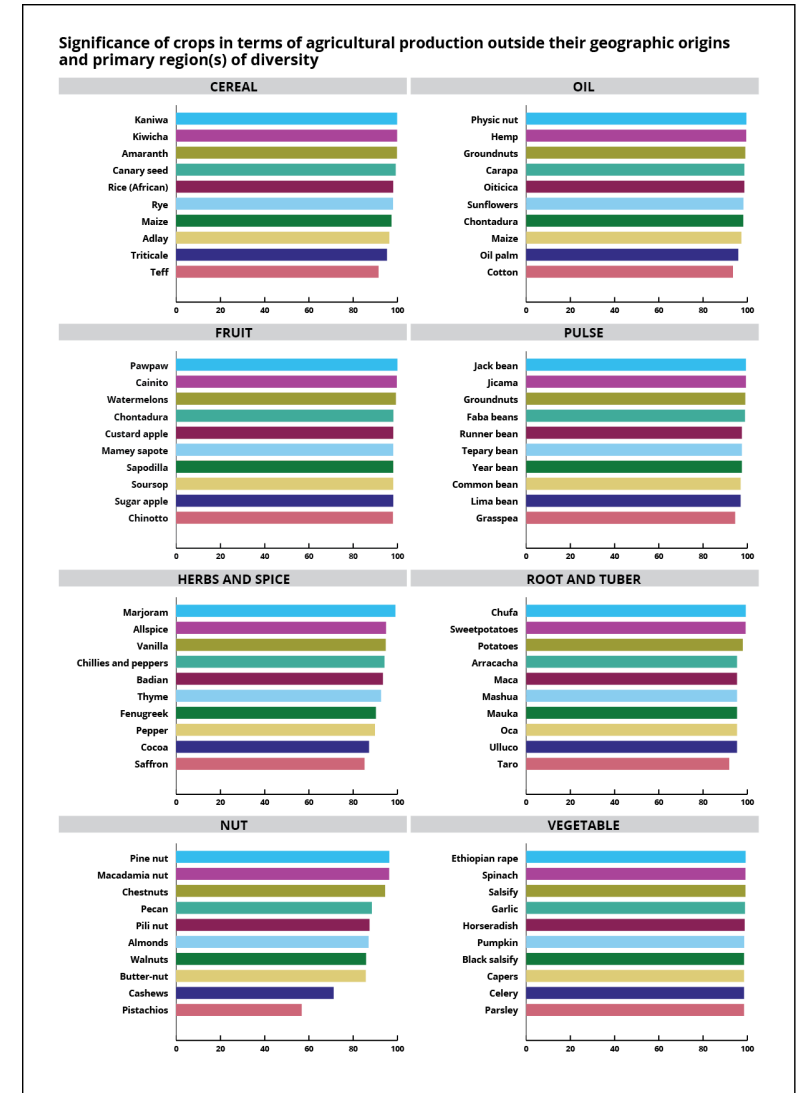


Research significance of crops as measured in terms of Google Scholar citations based on appearance of the common name of the crop in the article title. The results are presented as the proportion of the number of publications of the crop, compared with all crops in the crop use type.

The Plants that Feed the World – interdependence

Interdependence regarding crop genetic resources

- 11 metrics - Crop plant genetic resource interdependence
- 11 metrics - Crop plant genetic resource interdependence - Change over time

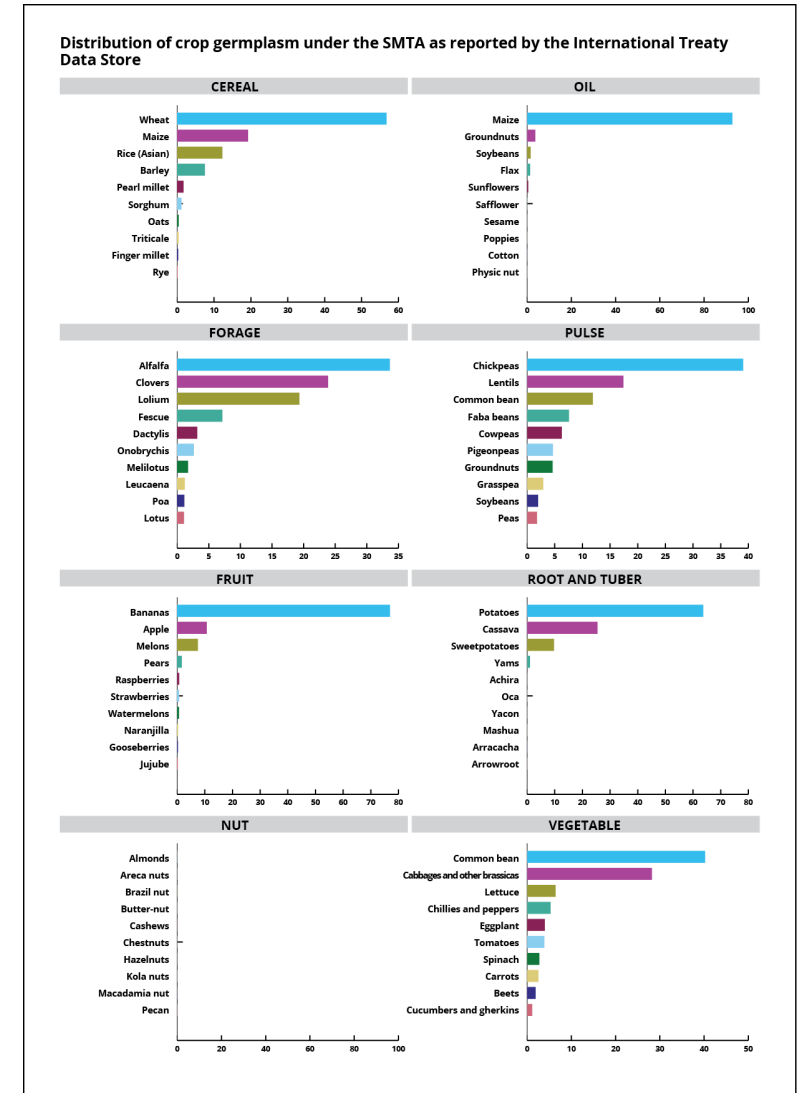


Significance of each crop in terms of agricultural production outside its geographic origins and primary region(s) of diversity. The results are presented as the proportion of the production of each crop outside its origins and primary region(s) of diversity, compared with total production of the crop worldwide.

The Plants that Feed the World – demand

Demand for crop genetic resources

- 1 metric - Germplasm distributions - Plant Treaty
- 1 metric - Germplasm distributions - Plant Treaty - Count of countries
- 1 metric - Germplasm distributions - Plant Treaty - Equality of distributions (GINI)
- 2 metrics - Genebank distributions - FAO WIEWS
- 1 metric - Varietal registrations - UPOV
- 1 metric - Varietal releases - FAO WIEWS

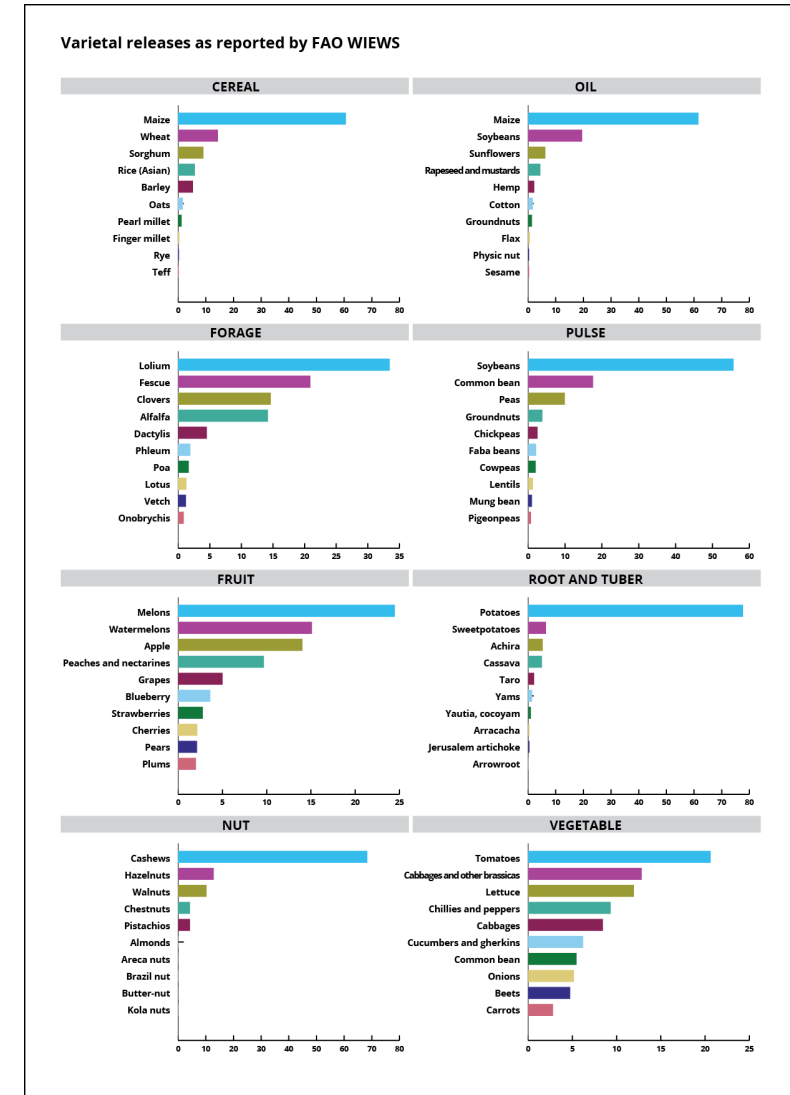


Demand for crop genetic resources as measured in terms of germplasm distributions under the SMTA of the International Treaty. The results are presented as the proportion of distributions of the crop, compared with total distributions of all crops per crop use type.

The Plants that Feed the World – demand



Varietal registrations as reported by UPOV. The results are presented as the proportion of registrations of the crop, compared with total registrations of all crops per crop use type.

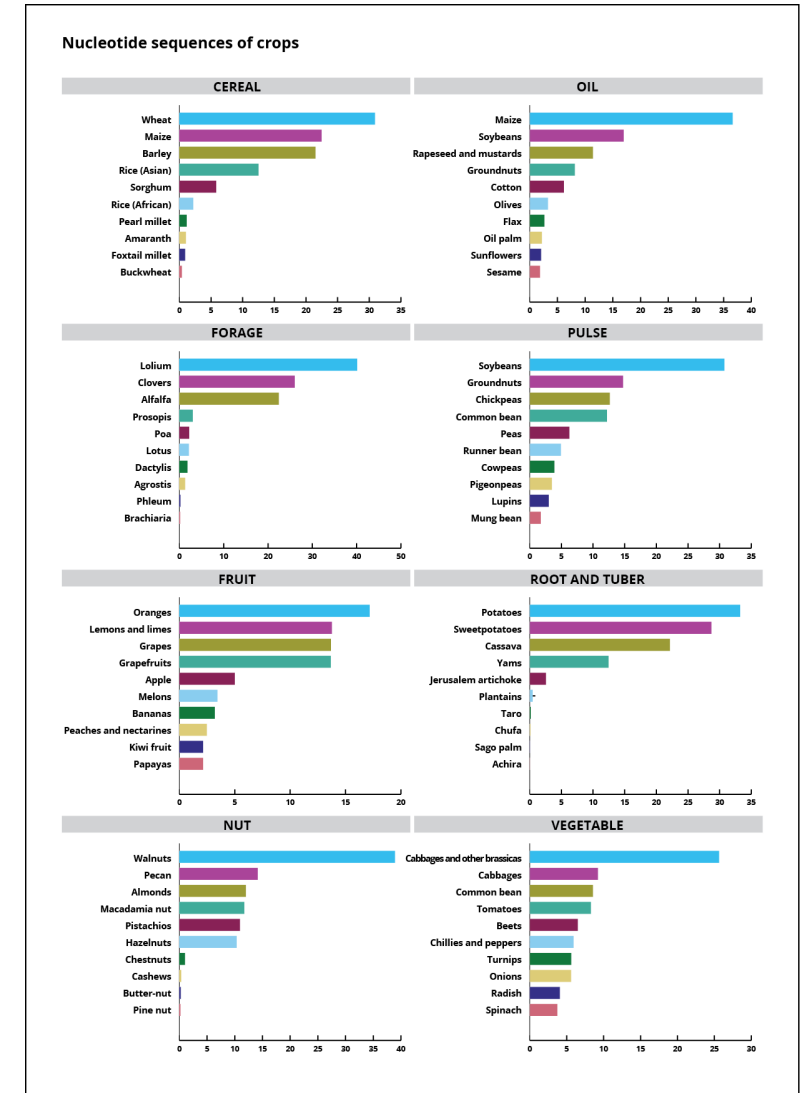


Varietal releases as reported by WIEWS. The results are presented as the proportion of releases of the crop globally, compared with total releases of all crops per crop use type.

The Plants that Feed the World – supply

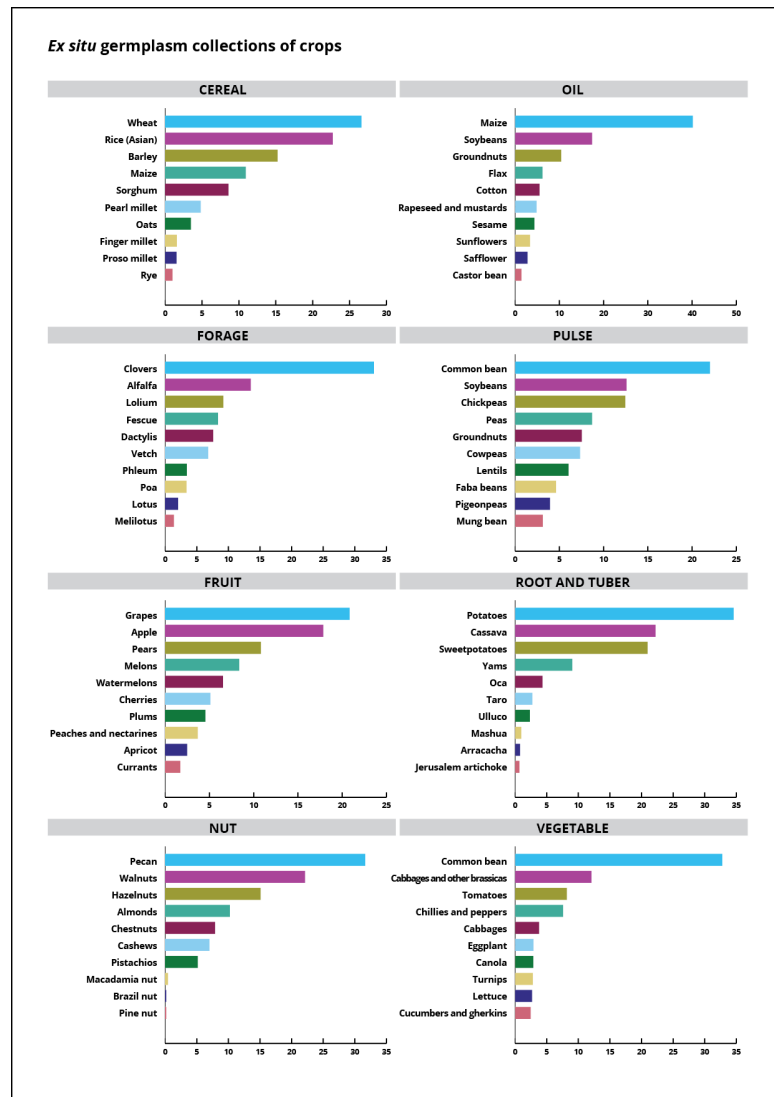
Supply of crop genetic resources

- 2 metrics - Ex situ collections - FAO WIEWS, Genesys PGR, and GBIF
- 4 metrics - Ex situ collections - FAO WIEWS, Genesys PGR, and GBIF - MLS status
- 2 metrics - Ex situ collections - FAO WIEWS, Genesys PGR, and GBIF - primary region coverage
- 2 metrics - Ex situ collections - Botanic Gardens
- 2 metrics - Research supply - GBIF
- 4 metrics - Research supply - NCBI

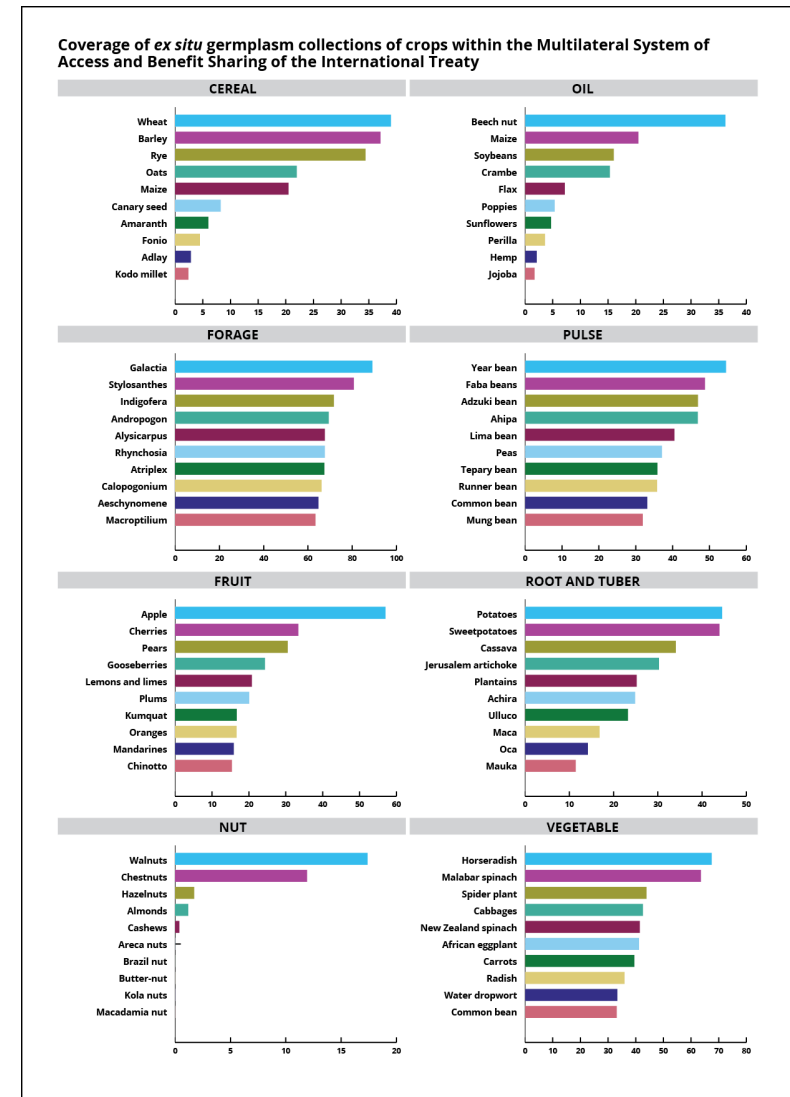


Supply of genetic sequence and other related data on crops. The results are presented as the proportion of nucleotide resources of the crop, compared with total nucleotide resources of all crops per crop use type.

The Plants that Feed the World – supply



Supply of crop genetic resources as measured in terms of *ex situ* germplasm collections. The results are presented as the proportion of accessions of the crop, compared with total accessions of all crops per crop use type.

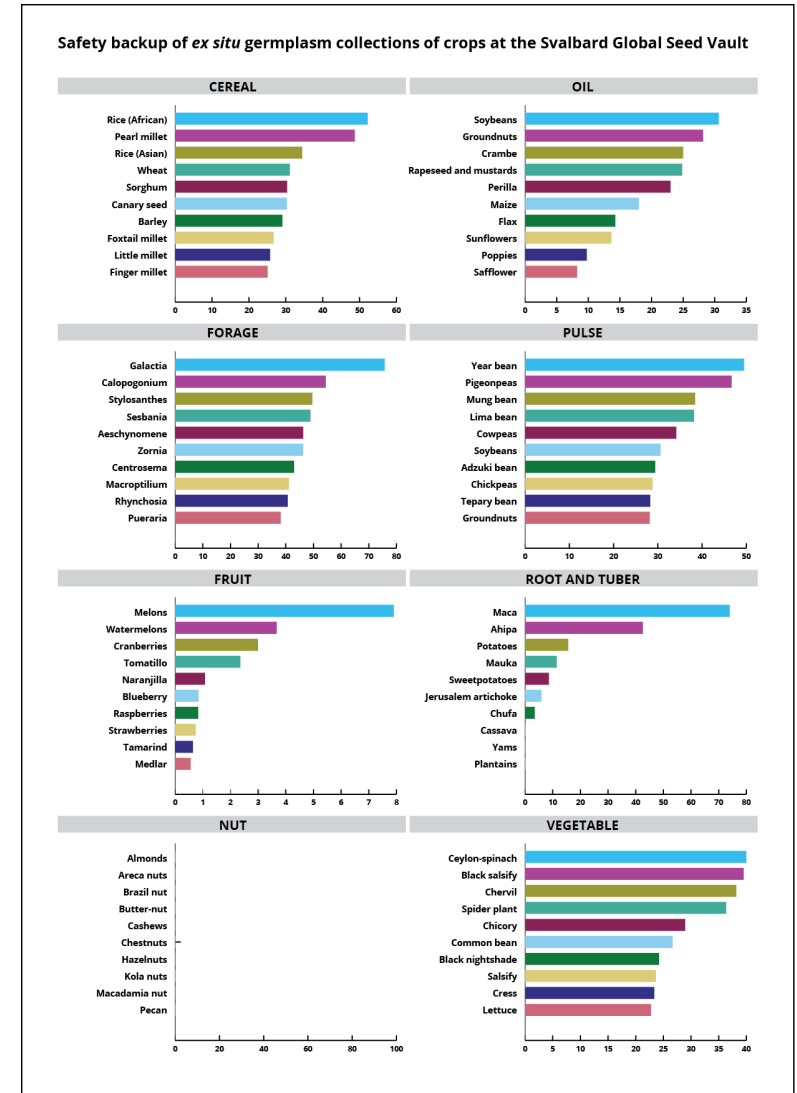


Coverage of crop genetic resources within the International Treaty's Multilateral System as measured by direct notation in global *ex situ* collections databases. The results are presented as the proportion of accessions of the crop included in the Multilateral System, compared with total global accessions of the same crop.

The Plants that Feed the World – security

Security of crop genetic resources

- 2 metrics - Ex situ backup - Svalbard Global Seed Vault



Safety backup of crop genetic resources at the Svalbard Global Seed Vault. The results are presented as the proportion of records of the crop in the SGSV, compared with total records of the crop in all *ex situ* collections.

The Plants that Feed the World – main findings

- **Hundreds of different crops are widely grown**, traded, present in food supplies, and researched around the world.
- **Crop use is not static** and a plant's utilization can vary widely both spatially and temporally. Crops that were not considered important on a global or regional scale a few decades ago have become widely utilized today. Likewise, plants that are currently grown only on a small scale could become major crops of the future.
- There is a **high level of interdependence among countries** with respect to PGRFA of most crops. Many of the crops studied also show **large directly quantified germplasm distributions** to recipients in many different countries and regions.
- There is **wide variation among crops in terms of the amount of PGRFA held *ex situ***. Genebanks and botanic gardens appear to **complement** one another with different crops.
- The availability of **botanical research specimens** and **digital sequence information** (DSI) are likewise **highly variable** among crops.
- While much has already been duplicated in the Svalbard Global Seed Vault, particularly for major cereals, pulses, and a few other crop types, **many of the world's *ex situ* accessions are not documented as safety duplicated**.
- **In short, there is tremendous use of crops and large interdependence regarding, demand for, supply of, and security of PGRFA globally. These vary substantially among crops.**
- Important to improving the assessment:
 - Broaden the scope of crops reported in FAOSTAT
 - More comprehensively report genetic resource distributions data in FAO WIEWS and the ITPGRFA Data Store
 - Enhance the completeness and accuracy of PGRFA supply data in FAO WIEWS, Genesys PGR, and PlantSearch, including more comprehensive notation of whether accessions are covered in the MLS, and enhance other data sources such as GBIF
 - Encourage accessibility to other pertinent databases such as UPOV's PLUTO.
 - Encourage alignment and standardization of data among data sources



Food and Agriculture
Organization of the
United Nations



The International Treaty
ON PLANT GENETIC RESOURCES
FOR FOOD AND AGRICULTURE



SAN DIEGO
BOTANIC
GARDEN



CROP
TRUST

Resources - The Plants That Feed the World:

Main product:

Khoury CK, Sotelo S, Amariles D, and Hawtin G (2023) *The Plants That Feed the World: baseline data and metrics to inform strategies for the conservation and use of plant genetic resources for food and agriculture*. International Treaty on Plant Genetic Resources for Food and Agriculture Rome: Food and Agricultural Organization of the United Nations. doi: 10.4060/cc6876en. <https://doi.org/10.4060/cc6876en>

Associated information, including links to data, codes, and associated products:

https://www.fao.org/plant-treaty/areas-of-work/the-multilateral-system/plant_genetic_metrics

Earlier version, for GB9:

Khoury CK, Sotelo S, Hawtin G, Wibisono J, Amariles D, Guarino L, Kiene T, and Toledo A (2022) *The Plants That Feed the World: baseline data and metrics to inform strategies for the conservation and use of plant genetic resources for food and agriculture*. International Treaty on Plant Genetic Resources for Food and Agriculture Information Document IT/GB-9/22/16.2/Inf.1. Rome: Food and Agricultural Organization of the United Nations. <https://www.fao.org/3/cc1988en/cc1988en.pdf>

Colin Khoury – ckhoury@sdbgarden.org **Alvaro Toledo** – alvaro.toledo@fao.org