Genet Resour Crop Evol (2019) 66:291–310
https://doi.org/10.1007/s10722-018-0715-5

REVIEW PAPER

Are the old International Board for Plant Genetic Resources (IBPGR) base collections available through the Plant Treaty's multilateral system of access and benefit sharing? A review

Imke Thormann · Johannes M. M. Engels · Michael Halewood

Received: 20 April 2018 / Accepted: 30 October 2018 / Published online: 13 November 2018

Abstract In 1975, the International Board for Plant Genetic Resources created the first internationally linked system of genebanks, known as the Registry of Base Collections (RBC), to conserve plant germplasm and make it available globally for agricultural research and development. Over time, international efforts shifted away from enhancing and building the RBC toward other means to promote the conservation and sustainable use of plant genetic resources. Perhaps the most important development in this regard was the negotiation of the International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty or ITPGRFA) and the development of its multilateral system for access and benefit sharing (multilateral system). Our study aimed to ascertain whether the RBC materials are still being conserved/curated in the original recipient organizations. We also sought to assess whether those materials have been included in, and are available through, the ITPGRFA's multilateral system. This outcome would be significant since, in many ways, the multilateral system reflects the spirit, commitment, and objectives of the RBC, with important additional components (e.g. obligations to share monetary benefits derived from the uses of plant genetic resources for food and agriculture). We identify four levels of probability that RBC materials are included in, and available through, the multilateral system. Ultimately, we find that there is a high level of probability that approximately 80% of the RBC materials are currently available through the multilateral system. We further identify a number of possible interventions that could be made to ensure that all RBC materials are conserved and made available through the multilateral system (or on similar terms and conditions of facilitated access and benefit sharing).

Keywords Access and benefit sharing · Global genebank system · International Treaty on Plant Genetic Resources for Food and Agriculture · Agricultural research and development · Network of base collections

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10722-018-0715-5) contains supplementary material, which is available to authorized users.

I. Thormann (✉) · J. M. M. Engels · M. Halewood
Bioversity International, Rome, Italy
e-mail: imke.thormann@gmail.com

Present Address:
I. Thormann
Federal Office for Agriculture and Food, Bonn, Germany

Introduction

The International Board for Plant Genetic Resources (IBPGR) was created in 1974 to respond to concerns

about the rapid loss of farmers' varieties and crop wild relatives, particularly in centres of crop diversity. This loss was mainly attributed to the introduction of improved high-yielding varieties (Frankel and Hawkes 1975; Harlan 1975). Between 1975 and 1995, the IBPGR supported the collecting of over 200,000 samples of threatened landraces, wild relatives and other materials in 136 countries. The IBPGR also coordinated the creation of an internationally linked system of genebanks known as the Registry of Base Collections (RBC) to conserve and make available a subset of those materials (Hansen et al. 1984).

The IBPGR started the development of the RBC at the end of 1975 and signed the first agreement with the International Center for Tropical Agriculture (CIAT) for the establishment and conservation of a regional collection of *Phaseolus* L. The IBPGR worked in close collaboration with the United Nations Food and Agriculture Organization (FAO), which was the administrative host of the IBPGR at the time, establishing the RBC. One of the guiding principles and architectural pillars of the RBC was that selected genebanks around the world would accept responsibility for managing a regional or global base collection of a given crop, under well-defined storage conditions and infrastructure that would ensure long-term conservation. They also were required to make the conserved germplasm available upon request to any bona fide user. At the end of the 1990s, the RBC included 52 selected genebanks (Table 1) spread across all continents, covering 80 genera and a total of approximately 250 species (IBPGR 1991; Thormann et al. 2015). In total, the RBC collections included 144,000 accessions.[1]

Over time, international efforts shifted away from enhancing and building the RBC toward a focus on other, additional means to promote the conservation and sustainable use of plant genetic resources, with considerable efforts put into developing equitable benefit-sharing mechanisms. Perhaps the most important development in this regard has been the negotiation of the International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty or ITPGRFA), which came into force in 2004 (FAO 2009). Among other things, the ITPGRFA creates the multilateral system of access and benefit sharing (multilateral system), which is meant to provide a sound legal basis for the Contracting Parties and their constituents and international organizations to virtually pool and exchange plant genetic resource for food and agriculture (PGRFA) and share benefits derived from their use. The multilateral system embraces a number of the core principles and basic architecture of the RBC but goes further in important ways—for example, legally requiring PGRFA users to share monetary benefits under certain circumstances.

Purpose of the study

Thormann et al. (2015) conducted a study to ascertain whether the RBC materials still existed and were being conserved/curated in the original recipient collections. We use information collected as part of that earlier study to make a preliminary assessment about which RBC materials have ultimately ended up in the ITPGRFA's multilateral system. The results of that latter assessment are reported in this article. Based on the results of this analysis, we were able to identify potential initiatives—involving cooperation between collection-hosting organizations, national governments, international agricultural research organizations, the Global Crop Diversity Trust, and the Secretariat of the ITPGRFA—to ensure that all of the RBC collections are ultimately available globally and publicly, as they were always meant to be, under the framework of the ITPGRFA.

International policy developments between the early days of the RBC and the ITPGRFA

In its earliest days of operation, the IBPGR, in close consultation with its Board of Trustees and FAO, invited and designated genebanks to become part of the RBC, beginning in 1975, in the absence of any other international mechanism. Not surprisingly, efforts to create the first ever internationally linked system of plant genetic resources collections in the form of the RBC attracted considerable critical attention, including questions about appropriate forms of governance of the network. For example, public controversy was generated when it was learned that RBC materials conserved at the National Seed Storage

[1] These 144,000 accessions derive from about 98,000 collected samples. As the samples were distributed to more than one genebank, the number of accessions generated is higher than the number of samples collected.

Table 1 Country, name and institute code of the genebanks belonging to the Register of base collections. In addition we provide the level of collection and the date of the agreement, if known

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
Argentina	ARG1342	Institute Nacional de Tecnologia Agropecuaria (INTA)	Groundnut [*Arachis*]	Regional-South America	
Australia	AUS001	Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Plant Industry, Canberra	Wild perennial soybean [*Glycine*]	Global	Mar-84
Australia	AUS045	Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Tropical Crops & Pastures. Brisbane	*Cenchrus*	Global	May-86
			Centrosema	Global	May-86
			Desmanthus	Global	May-86
			Desmodium	Global	May-86
			Digitaria	Global	May-86
			Macroptilium	Global	May-86
			Stylosanthes	Global	May-86
			Urochloa	Global	May-86
Bangladesh	BGD001	Bangladesh Jute Research Institute (BJRI)	Jute [*Corchorus*]	Global	Apr-88
			Kenaf [*Hibiscus*]	Global	Apr-88
Belgium	BEL014	Jardin Botanique National de Belgique (JBNB)	Wild *Phaseolus*	Global	Dec-88
			Wild *Vigna*	Global	Dec-88
Brazil	BRA003	Centro Nac de Recursos Geneticos/Empresa Brasileira de Pesquisa Agropecuaria (CENARGEN/EMBRAPA)	Wild *Arachis*	Regional	Feb-84
			Macroptilium	Global	May-85
			Citrus	Regional	
Canada	CAN004	Plant Gene Resources of Canada (PGRC)	Oats [*Avena*]	Global	Aug-77
			Barley [*Hordeum*]	Global	May-81
			Pennisetum	Global	Dec-80
			Brassica campestris,	Global	May-81
			B. juncea,	Global	May-81
			B. napus,	Global	May-81
			Sinapis alba	Global	May-81
Taiwan	TWN001	The World Vegetables Center (AVRDC)	*Vigna radiata*	Global	Apr-84
			Capsicum	Global	
			Solanum melongena	Global	
			Allium	Global	
			Sweet potato) [*Ipomoea*]	Regional-Asia	Apr-84
Republic of China	CHN001	Chinese Academy of Agricultural Sciences (CAAS)	Wheat [*Triticum*]	Regional	Mar-87
			Brassica oleracea	Global	Mar-87
			Raphanus	Global	Mar-87

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
Colombia	COL003	Centro International de Agricultura Tropical (CIAT)	*Phaseolus vulgaris* wild & cult.	Regional-New World	Dec-75
			P. lunatus wild & cult.	Regional-New World	Dec-76
			P. coccineus wild & cult.	Regional-New World	Dec-76
			P. acutifolius wild & cult.	Regional-New World	Dec-76
			Cassava [*Manihot esculenta*]	Global	Dec-83
			Centrosema brasilianum	Global	Jul-86
			C. macrocarpum	Global	Jul-86
			C. pubescens	Global	Jul-86
			Desmodium ovalifolium	Global	Jul-86
			D. heterophyllum	Global	Jul-86
			Pueraria phaseoloides	Global	Jul-86
			Stylosanthes capitata	Global	Jul-86
			S. macrocephala	Global	Jul-86
			S. guianensis	Global	Jul-86
			Zornia glabra	Global	Jul-86
			Andropogon gayanus	Global	Jul-86
			Brachiaria brizantha	Global	Jul-86
			B. decumbens	Global	Jul-86
			B. dictyoneura	Global	Jul-86
			B. humidiocola	Global	Jul-86
			B. ruziziensis	Global	Jul-86
			Hyparrhenia ruffa	Global	Jul-86
			Panicum maximum	Global	Jul-86
Costa Rica	CRI001	Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE)	*Capsicum*	Global	Apr-81
			Lycopersicon	Global	
			Cocoa	Global	Sep-84
Czech Republic	CZE003	Research Institute for Plant Production	*Helianthus*	Regional-Europe + Mediterranean	Feb-89
			Allium	Global (field genebank)	Apr-85
Ethiopia	ETH085	Institute of Biodiversity Conservation (PGRC/E)	Indigenous Ethiopian millets	Regional	Dec-76
			Barley [*Hordeum*]	Regional	Dec-81
			Brassica carinata	Global	Dec-81
			Eleusine	Global	Dec-81
			Eragrostis	Global	Dec-81

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
Ethiopia	ETH013	International Livestock Research Institute (ILRI)	*Neonotonia*	Regional-African	Apr-86
			Trifolium	Regional-African	Apr-86
			Cenchrus	Global	Apr-86
			Digitaria	Global	Apr-86
			Lotononis	Global	Apr-86
France	FRA006	Département des Productions Fruitières et Horticoles (INRA-CIRAD) (CIRAD-FLHOR)	*Citrus* and related species	Regional-Mediterranean + Africa field genebank	Jun-87
France	FRA002	Department des cultures annuelles (CIRAD-CA)	*Gossypium*	Global	
Germany	DEU146	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	*Lycopersicon*	Global	Jan-90
			Lupinus	Global	Jan-84
Germany[b]	DEU[b]	FAL Institute of Crop Science and Plant Breeding	*Avena*	Global	Oct-89
			Beta	Global	Mar-77
			Brassica carinata	Global	Apr-81
			B. campestris	Global	Apr-81
			B. juncea	Global	Apr-81
			B. napus	Global	Apr-81
			Sinapis	Global	Apr-81
			Phaseolus	Regional-Europe	Feb-85
Greece	GRC005	Greek Gene Bank	*Gossypium*	Regional-South Europe-Mediterranean	Apr-84
			Tobacco	Regional-South Europe-Mediterranean	Apr-84
			Beta	Regional-South Europe-Mediterranean	Apr-84
Hungary	HUN003	Research Centre for Agrobiodiversity (RCA)	*Allium ampeloprasum*	Regional-South + East Europe	Nov-84
			Allium cepa	Regional-South + East Europe	Nov-84
India	IND001	National Bureau of Plant Genetic Resources (NBPGR)	*Vigna mungo*	Global	Nov-87
			Vigna umbellata	Global	Nov-87
			Capsicum	Regional-Asian	Nov-87
			Brassica juncea	Regional-Asian	Nov-87
			B. campestris	Regional-Asian	Nov-87
			Raphanus	Regional	Nov-87
			Okra [*Abelsmoschus*]	Global	Nov-87
			Lablab purpureus	Global	Nov-87
			Cajanus cajan	Global	Nov-87
			Carthamus tinctorius	Global	Nov-87
			Solanum melongena	Global	Nov-87
			Amaranthus	Regional-Asian	Feb-81
			Minor Indian millets*	Regional-Asian	Aug-77

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
India	IND012	Sugarcane Breeding Institute	Sugarcane [*Saccharum*]	Global (field genebank)	Jan-88
India	IND002	International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)	*Pennisetum*	Global	
			Sorghum (cultivated and wild)	Global	Jul-84
			Eleusine	Global	Jul-84
			Setaria italica	Global	Jul-84
			Panicum milaceum	Global	Jul-84
			Chickpea	Global	Jul-84
			Pigeonpea	Global	Jul-84
			Groundnut [*Arachis*]	Global	Jul-84
Italy	ITA004	Istituto di Genetica Vegetale	*Triticum*	Global	May-77
Jamaica	JAM003	Banana Board Research Department	*Musa* (wild and cult., including banana, plantain + wild relatives)	Regional (field genebank)	Dec-86
Japan	JPN003	National Institute of Agrobiological Science (NIAS)	*Oryza sativa*	Global	Dec-76
			Maize [*Zea*]	Regional-Asian	Sep-85
			Wheat [*Triticum*]	Global	Sep-85
			Barley [*Hordeum*]	Regional-Asian	Sep-85
			Sweet potato seed [*Ipomoea*]	Global	Sep-85
			Cruciferous crops	Regional-East Asian	Sep-85
			Allium	Asian	Sep-85
			Sugarcane seed [*Ipomoea*]	Global	Sep-85
			Vigna angularis	Global	Sep-85
			Glycine max	Global	Sep-85
			Panicum	Global	Sep-85
			Chloris	Global	Sep-85
Japan	JPN059	Faculty of Agriculture, Tohoku University	Wild cruciferous crops	Global	Jul-81
Japan	JPN001	Plant Germplasm Institute, Faculty of Agriculture, Kyoto University	Wheat including *Triticum* and *Aegilops*	Global	Jan-77
Japan	JPN004	Fruit Tree Research Station	*Citrus* and relatives	Regional (field genebank)	Sep-85
Kenya	KEN007	Kenya Agricultural Research Institute (KARI)	Sesame [*Sesamum*]	Global	Jan-90
Republic of Korea	KOR010	Rural Development Administration (RDA)	Sesame [*Sesamum*]	Global	Mar-89
Malaysia	MYS030	University of Malaya	*Citrus*	Global (field genebank)	Dec-86
Mexico	MEX001	Estación de Iguala, Instituto Nacional de Investigaciones Agrícolas (INIA)	Cassava [*Manihot esculenta*] + wild relatives	Regional- Central America (field genebank)	Jun-84

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
Mexico	MEX002	Centro International de Mejoramento de Maiz y Trigo (CIMMYT)	Maize [*Zea*]	Global	Jun-90
			Wheat [*Triticum*]	Global	Jun-90
			Triticale [*Triticosecale*]	Global	Jun-90
The Netherlands	NLD037	Center for Genetic Resources (CGN)	Lettuce [*Lactuca*]	Global	Feb-89
			Allium cepa	Global	Mar-86
			Allium ampeloprasum	Global	Mar-86
			Wild *Allium* species	Global	Mar-86
			Capsicum	Global	Jul-81
			Brassica oleracea	Global	Jul-81
			Solanum melongena	Global	Jul-81
Nigeria	NGA039	International Institute of Tropival Agriculture (IITA)	Cowpea [*Vigna unguiculata*]	Global	Mar-77
			Cassava [*Manihot esculenta*] + wild spp.	Regional-African	Feb-84
			Rice [*Oryza*]	Regional-African	Jun-84
Peru	PER001	Centro Internacional de la Papa (CIP)	Potato [*Solanum tuberosum*]	Global	May-80
			Sweet potato [*Ipomoea*]	Global	No letter
Philippines	PHL130	Institute of Plant Breeding (IPB)	Winged bean [*Psophocarpus tetragonolobus*]	Global	Dec-80
			Lycopersicon	Regional-Asian	May-81
			Benicasa	Global	Dec-83
			Luffa	Global	Dec-83
			Momordica	Global	Dec-83
			Trichosanthes	Global	Dec-83
			Vigna radiata	Global	Dec-83
Philippines	PHL150	Philippine Council for Agricultural and Resources Research & Development (PCARRD)	Banana, plantain and wild relatives [*Musa*]	Regional-Asian (field genebank)	Jun-84
Philippines	PHL001	International Rice Research Institute (IRRI)	*Oryza sativa (indica & javanica)*	Global	Dec-76
			Wild *Oryza*	Global	
Poland	POL003	Polish Gene Bank	*Pisum*	Regional-Central + East Europe	Jan-84
			Rye [*Secale*]	Global	Feb-83
Portugal	PRT005	Portuguese Gene Bank	Maize [*Zea*]	Regional-South Europe	Jul-80

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
Russia	RUS001	Vavilov Institute of Plant Industry	Maize [*Zea*]	Regional-European	Jun-88
			Cucurbita	Global	Jun-88
			Triticum	Global	Jun-88
			Cucumis	Global	Jun-88
			Citrullus	Global	Jun-88
Spain	ESP085	Universidad Politecnica de Madrid	Wild relatives of cruciferous crops	Global	Apr-81
Spain	ESP002	Instituto Nacional de Investigaciones Agrarias (INIA)	*Citrus* & wild species	Regional-Mediterranean (field genebank)	Aug-84
			Cucumis	Global	Jan-84
			Citrullus	Global	Jan-84
Sweden	SWE054	Nordic Genetic Resources Centre (NordGen)	*Pisum*	Global	1981
			Hordeum	Regional-European	1981
			Avena	Global	1981
			Secale	Global	1981
			Beta	Global	1981
Syria	SYR002	International Centre for Agricultural Research in the Dry Areas (ICARDA)	Kabuli chickpea [*Cicer arietinum*]	Global	Jan-89
			Faba bean [*Vicia*]	Global	Jan-89
			Lentil [*Lens*]	Global	Jan-89
			Barley [*Hordeum*]	Global	Jan-89
			Durum wheat [*Triticum*]	Global	Jan-89
			Wild progenitors of wheat	Global	Jan-89
			Medicago- annual	Global	Sep-90
Thailand	THA006	Thailand Institute of Scientific and Technological Research (TISTR)	Winged bean [*Psophocarpus tetragonolobus*]	Global	Jun-84
			Maize [*Zea*]	Regional-Asian	Jun-84
Trinidad and Tobago	TTO001	University of the West Indies	Cocoa and related species [*Herrania and Theobroma*]	Global (field genebank)	Aug-84
United Kingdom	GBR004	Royal Botanic Gardens Kew, Seed Bank	Woody species (of interest for fuel wood)	Global-(Arid zones)	Jan-83
			Neonotonia	Regional-African	Mar-85
			Trifolium	Regional-African	Mar-85
			Cenchrus	Global	Mar-85
			Digitaria	Global	Mar-85
			Lotononis	Global	Mar-85

Table 1 continued

Country	FAO institute code	Institute name	Genera/Species[a]	Type of collection	Date of agreement (if recorded)
United Kingdom	GBR006	Warwick Genetic Resources Unit	Carrot [*Daucus*]	Global	May-89
			Brassica oleracea	Global	Nov-81
			B. campestris	Global	Nov-81
			B. juncea	Global	Nov-81
			B. napus	Global	Nov-81
			Raphanus	Global	Nov-81
			Allium	Global	Nov-81
			Beta	Regional—European	Nov-81
USA	USA	USDA National Plant Germplasm System (NPGS)	Wheat [*Triticum*]	Global	Jan-77
			Sorghum	Global	Jan-77
			Pennisetum (crop)	Global	Jan-77
			Phaseolus	Global	Jan-79
			Amaranthus	Global	Jun-80
			Lycopersicon	Global	Apr-81
			Solanum melongena	Regional—New World	Apr-81
			Sugarcane [*Saccharum*]	Global (field genebank)	Jun-83
			Cucurbita	Global	Dec-83
			Cucumis	Global	Dec-83
			Citrullus	Global	Dec-83
			Glycine max	Global	Dec-83
			Citrus & relatives	Regional (field genebank)	Aug-84
			Leucaena	Global	Apr-85
			Zornia	Global	Apr-85
			Paspalum	Global	Apr-85
			Cynodon	Global	Apr-85
			Pennisetum (forage)	Global	Apr-85
			Rice [*Oryza*]	Regional- Mediterranean, USA, South America	Jan-83
			Maize [*Zea*]	Global	Jan-83
			Vigna unguiculata	Global	
			Allium cepa & wild spp.	Global	
			Sweet potato [*Ipomoea*]	Global (seeds)	
			Abelmoschus	Global	
			Sugarcane [*Saccharum*]	Global (seeds)	

Asterisk indicates Minor Indian millets include *Panicum, Eleusine, Setaria, Echinochloa* and *Paspalum*

[a]The genus name was added where only the common name was provided

[b]This genebank does not exist anymore. Collections have been transferred to DEU146

Laboratory in Fort Collins, United States, were considered to be the property of the United States and that the United States was not making RBC materials available to recipients in countries with whom it had poor relations (Kloppenburg and Kleinman 1987; Mooney 1983). This situation contributed to calls to 'replace the loose formality of IBPGR arrangements with legally binding agreements between FAO and participating institutions or preferably governments' (Frankel 1988).

In 1983, the FAO Conference created the Commission on Plant Genetic Resources as the first intergovernmental organization to deal with PGRFA.[2] At the same conference, the International Undertaking (IU) was adopted as an instrument to 'ensure that plant genetic resources of economic and/or social interest, particularly for agriculture, will be explored, preserved and made available for plant breeding and scientific purposes' (FAO 1983).[3] The principle on which the IU was originally based was that plant genetic resources were 'heritage of mankind' and should be freely available without restrictions for the benefit of present and future generations. In the years that followed, this concept was weakened through successive reinterpretations in the form of FAO Conference resolutions that recognized the primacy of plant breeders' rights in 1989 and national sovereignty in 1991.[4] The Convention on Biological Diversity (CBD), which came into force in 1993, underscores the sovereign rights of countries over their own genetic resources. In 1994, the FAO initiated renegotiations of the IU to bring it into harmony with the CBD, reflecting much more fully the concept of state sovereignty over PGRFA.

Article 7 of the IU provides for the development of a global PGRFA system that should include 'an international network of base collections in genebanks, under the auspices or the jurisdiction of FAO'. In 1989, the Commission on Genetic Resources for Food and Agriculture (CGRFA) called for the development of the International Network of Ex Situ Collections as part of this global system. During the administrative separation of the IBPGR from the FAO and the establishment of the IPGRI as its successor, a Memorandum of Understanding on Programme Cooperation was concluded in September 1990 between the IBPGR and the FAO. It included an article on the intention to merge the IBPGR's RBC with the FAO's International Network of Ex Situ Collections. It was thought that overseeing a global network of ex situ collections would be much more in line with the responsibilities of an intergovernmental organization such as the FAO rather than an international organization such as the newly reconstituted IBPGR, which was then renamed the IPGRI.

Eventually, the International Network of Ex Situ Collections became a reality in October 1994, when 12 CGIAR centres signed agreements with the FAO, placing most of their collections (approximately 450,000 accessions) under the auspices of the FAO as part of this international network. In this way, the RBC collections maintained at the CGIAR genebanks—approximately 38% of the RBC materials distributed by IBPGR—became 'automatically' part of the FAO's International Network of Ex Situ Collections. A survey of national RBC genebanks in Europe in 1995 investigated their preparedness to place their RBC base collections under the auspices of the FAO as part of the International Network as in trust germplasm (Thormann and Engels 2001). The outcome of this inventory was inconclusive. Efforts to encourage countries to change the status of the RBC collections held in national genebanks were weak and countries did not evince much desire to do so on their own (personal communication of J.M.M. Engels, 2017). Efforts under the auspices of the CGRFA to develop model agreements under the IU for national collections were similarly not concluded, with the result that none of the collections in the national RBC genebanks were formally included in the International Network. Ultimately, efforts to develop these agreements were eclipsed by the renegotiations of the IU, leading to the adoption of the ITPGRFA in 2001 (Halewood 2010, 2015).

The ITPGRFA came into force in June 2004. As of November 2017, there are 144 Contracting Parties, including the European Union. There are also 17 Article 15 agreements between the ITPGRFA's Governing Body and international institutes placing

[2] In 1995, when its mandate was expanded to include PGRFA beyond plants, including, for example livestock genetic resources, the Commission on Plant Genetic Resources was renamed the Commission on Genetic Resources for Food and Agriculture to reflect its broader mandate.

[3] International Undertaking on Plant Genetic Resources for Food and Agriculture, 1983, http://www.fao.org/waicent/faoinfo/agricult/cgrfa/IU.htm (accessed 5 January 2018).

[4] See Resolution 4/89, 5/89 and 3/91.

their ex situ collections under the ITPGRFA framework. It is estimated that 2 million accessions of ex situ materials are available worldwide through the multilateral system. In the multilateral system's first 10 years of operation from 2007 to 2016, over 4 million PGRFA samples were distributed, using almost 60,000 Standard Material Transfer Agreements (SMTA) (ITPGRFA 2017). In total, 93% of those transfers were from the CGIAR centres, of which approximately 85% were to recipients in developing countries and countries with economies in transition. The overwhelming majority of these recipients were public sector research and development organizations. All of the materials in the multilateral system are transferred under the SMTA. Requestors in Contracting Parties have the right of facilitated access to materials in the multilateral system to use them for 'utilization and conservation for research, breeding and training for food and agriculture provided that such purpose does not include chemical, pharmaceutical and/or other non-food/feed industrial uses' [Article 12.3(a) of the ITPGRFA]. Providers are required to distribute the materials for free or for minimum administrative costs.

Materials and methods

First, we analysed whether the materials originally distributed to the 52 genebanks as part of the RBC would currently be included in the multilateral system, assuming they have continued to be conserved by those genebanks. We used the IBPGR publications and organizational records to ascertain the scope of the materials included in the RBC as well as the conditions under which the organizations agreed to host and distribute those materials, and we compared those to the conditions and scope of the multilateral system. As part of the exercise of trying to verify whether the RBC materials were included in the multilateral system, we accessed the ITPGRFA website to verify which countries have ratified the Treaty and to access lists of ITPGRFA Annex 1 crop and forage collections that, based on information from countries and international organizations, are available according to the terms and conditions of the multilateral system.[5] We also looked for information about non-Annex 1 materials that are being made available under the same terms and conditions as the multilateral system (that is, using the SMTA) by either international institutions or other providers in the Contracting Parties. To ascertain whether or not other RBC materials have been made available (and, if so, under what conditions), we surveyed secondary literature, organizational websites, and accession-level databases; we also surveyed the organizations to whom the RBC materials were originally sent, as discussed in the following paragraph.

Second, we sought to verify whether the originally distributed RBC materials were actually still being conserved by those recipient genebanks and the conditions under which they were being made available. To do this, the authors sent questionnaires (provided in Online Resource 1) to the 52 genebanks as presented in Table 1 that had signed RBC agreements with the IBPGR. The authors also sent each genebank all of the available passport data on the RBC materials extracted from the Bioversity Collecting Database (BCD) of the IBPGR-coordinated collecting missions (Thormann et al. 2012; Gaisberger et al. 2013). This information served to support the genebanks identifying which materials in their genebanks were received from the IBPGR and subject to the RBC agreements. The genebanks were also asked to share, with the authors, their own passport information about the relevant materials. The surveyed genebanks and the research team used this shared data to identify and 'link' 25% of the materials originally collected under the auspices of the IBPGR as part of the RBC with the accessions currently included in the collections maintained by the genebanks surveyed. Further details about this linking exercise, as well as the potential uses of the linked materials, are described by Thormann and colleagues (2015). We then analysed whether these materials were available through the multilateral system.

Given existing gaps in the information records—particularly, the fact that, to date, only 25% of RBC materials have been linked to existing collections—it was not possible to establish with certainty what proportion of RBC materials are currently included in the multilateral system. Instead, we were limited to analysing levels of probability. The levels of probability that an RBC sample would be included in the

[5] ITPGRFA, http://www.planttreaty.org/ (accessed July 2017).

multilateral system increase from 0 upwards if/when the sample is held by a genebank:

Level 0	In a country that has not ratified the ITPGRFA
Level 1	In a country that has ratified the ITPGRFA, but the materials are non-Annex 1
Level 2	In a country that has ratified the ITPGRFA, the material is Annex 1, but the country has not notified the ITPGRFA Secretary about inclusion of materials that are of the same genera as those included in the RBC
Level 3	In a country that has ratified the ITPGRFA, the material is Annex 1, and the country has notified the ITPGRFA Secretary about inclusion of materials that are of the same genera as those included in the RBC and by the same organization as received the RBC materials
Level 4	That belongs to a CGIAR centre or another international institution that has placed its collections in the multilateral system as per Article 15 of the ITPGRFA, or makes its collections available under the same conditions

Levels 3 and 4 are roughly equivalent in providing high levels of certainty that the materials concerned, assuming they still exist, will be available through the multilateral system. However, we are keeping them separate since the kinds of organizations holding the materials are different, as are their positions in the overall governance system of the ITPGRFA.

Our findings can therefore be presented at two levels: first, with respect to the likelihood of inclusion of all of the original RBC materials, assuming they still exist, and, second, with respect to the subset of 'linked' materials that we were able to confirm, with the limited resources at our disposal. (Note that, with more resources, it is highly likely that a much higher number of confirmed links could be made between the originally distributed RBC materials and the materials currently held in genebanks around the world. Indeed, further work on tracking down and linking RBC materials is one of the recommendations at the end of this article.)

Results

The scope of genera included in the RBC was broader

A major difference between the RBC and the multilateral system lies in the coverage of crop genera. The RBC had a much broader focus on crops, including industrial crops and neglected and underutilized crops. While a large part (77%) of the Annex 1 crops was also included in the RBC, the RBC included an additional 31 crops (see Table 2 and Online Resources 2 and 3).

The scope of the RBC was extremely broad and potentially unlimited with respect to all cultivated species. It initially included seed propagated cereals, food legumes, vegetables, forages, fibre crops (for example, jute, kenaf), industrial crops (for example, sugarcane, cacao), and, in many cases, some of their wild relatives. In the later 1980s, the RBC's scope was expanded to also include field genebanks for *Allium*, banana, cacao, cassava, citrus, and sugarcane. Crop expert committees were involved in the selection of crops and genebanks. For the most part, practical and scientific considerations took precedence in deciding what genera should be included in the RBC.

The multilateral system includes a finite list of 64 crops and forage genera that are identified in Annex 1 of the ITPGRFA, including wild relatives if they are of the same genus/crop gene pool (unless they are explicitly excluded from the Annex 1 list). The criteria for including crops or forages in the multilateral system are 'food security and interdependence' (Article 11.1 of the ITPGRFA).[6] Thus, crops that are not used for human food or animal feed were not included, ab initio. In addition, crops that may be important locally, but that are not widely used around the

[6] The criteria of interdependency reflects international recognition of the fact that no country is self-sufficient in terms of the genetic resources it needs to fulfill its food requirements, and countries have over time become more and more dependent on germplasm originally collected from other countries for their food and agricultural development (Flores-Palacios 1998; Ghimiray and Vernooy 2017; Khoury et al. 2015, 2016). All countries are dependent on plant genetic resources for food and agriculture (PGRFA) located or collected and conserved outside their own territory. It was shown that when provided with the opportunity of facilitated access, countries use a wide diversity of germplasm from many other countries, sub-regions and continents as inputs into their agricultural research and development programs (Galluzzi et al. 2016).

Table 2 Number of crop and forage genera included in the RBC and in Annex 1 of the ITPGRFA

	Included in both the RBC and Annex 1	Included in the RBC only	Included in Annex 1 only	Total number included in the RBC	Total number included in Annex 1
Crops	27	31	8	58	35
Forages	4	19	25	23	29

world—so-called neglected and underutilized species—were also not included.[7]

While the multilateral system, sensu *strictu*, is limited to 64 crops and forages, it is important to note that the Governing Body of the ITPGRFA confirmed in 2009 that those international organizations that signed Article 15 agreements (placing their collections under the ITPGRFA's framework) should also distribute non-Annex 1 'in trust' materials using the same SMTA, thus de facto expanding the multilateral system to include distinct ex situ materials of non-Annex 1 crops, held by international institutions. Furthermore, a number of countries—mainly in North America and Europe—have voluntarily adopted the policy to make a range of non-Annex 1 materials available using the SMTA, thereby exceeding their commitments under the ITPGRFA and de facto increasing the scope of crops and forages that can be accessed on the same terms and conditions as the multilateral system.

While the RBC was limited to ex situ collections, the multilateral system extends, at least in theory, to in situ PGRFA that are 'under the management and control of Contracting Parties and in the public domain' (Article 11.2 of the ITPGRFA). However, to date, there is very little information about how countries are interpreting and implementing the relevant sections of the ITPGRFA in this regard.

The hosts/managers of materials included in the RBC and the multilateral system are similar

The kinds of organizations playing key roles in the conservation, use and sharing of genetic resources under both the RBC and the multilateral system are quite similar. All of the 52 genebanks hosting RBC collections were operated by national public or by international agricultural research and development organizations. The multilateral system automatically includes PGRFA of the Annex 1 crops and forages that are 'under the management and control of Contracting Parties and in the public domain' (Article 11.2 of the ITPGRFA) as well as those crops and forages managed by the international centres and available in the multilateral system through Article 15. For the most part, this formula will be interpreted in most countries to *not* automatically include materials controlled and managed by private companies, non-governmental organizations, farmers' organizations, farmers, and provincial or municipal governments (Halewood et al. 2013; ITPGRFA 2015). In contrast, the formula will be interpreted to include materials controlled and managed *de jure* by national public organizations (Moore and Tymowski 2005).The ITPGRFA also recognizes the importance of additional materials being included in the multilateral system by natural and legal persons (including companies, non-governmental organizations, private universities, and so on), but recognizes such inclusion will need to be voluntary. Whether PGRFA may be automatically included in the multilateral system by virtue of being 'under the management and control' of national governments and 'in the public domain,' or voluntarily included by natural and legal persons, they are not practically available to anyone if information about their existence, and characteristics, is not

[7] However, within these parameters, the actual composition of Annex 1 was subject to a highly politicized decision-making process, involving more than 150 countries negotiating the text of the ITPGRFA. This process has been described in length elsewhere (Khoury et al. 2015; Lim and Halewood 2008; Visser 2013). For now, it is perhaps enough to point out that the scope of crops and forages included in Annex 1 was motivated by concerns about food security but also highly influenced by political considerations that played out during the negotiations of the benefit-sharing provisions under the ITPGRFA. The potential scope of the list expanded and contracted dramatically over the course of the negotiations, with a number of crops being removed from the list in the final hours of negotiations. Notably, groundnut, tomato, sugar cane and oil palm are not included in Annex 1, despite their importance for food security.

published. The ITPGRFA does not explicitly require Contracting Parties to publish this information. However, in light of this important gap, the Treaty's Secretariat has circulated a request to all Contracting Parties to notify the Governing Body (through the Secretariat) about what collections are in the multilateral system. Interestingly, the model letter does not extend to information about in situ materials; perhaps that was considered too complex, given the long delays in getting responses from Contracting Parties about ex situ materials. To date, little information about the origin of the additional materials being voluntarily included in the multilateral system by natural and legal persons has been included in country reports to the Governing Body. The Governing Body of the ITPGRFA has repeatedly encouraged Contracting Parties to provide information about PGRFA that is available through the multilateral system.

Furthermore, the ITPGRFA also invites international institutions to sign agreements with the Governing Body of the Treaty, placing their materials under the ITPGRFA's framework (Article 15 of the ITPGRFA). To date, 17 international organizations have signed these agreements, 10 of which also previously received RBC materials. Thus, almost all of the material currently explicitly recognized and listed as being in the multilateral system is ex situ and in collections hosted by national and international public agricultural research and development organizations.

New legally enforceable, reporting and benefit-sharing conditions under the ITPGRFA/multilateral system

The main commitment on the part of the collection holders is similar under the RBC and multilateral system—namely, to make the material available to anyone for agricultural research. The responsibilities under which material was supposed to be conserved and distributed were, however, much less concretely defined under the RBC. Each organization holding RBC material agreed, through an exchange of letters with the IBPGR, to the following conditions. Genebanks holding base collections had to guarantee the availability of the material to the international scientific community and store the materials under appropriate conditions to preserve viability for long periods. All of the materials in the base collections were duplicated for safety, using appropriate monitoring and regeneration regimes to safeguard the long-term maintenance of the collection. The genebanks were required to continue to provide adequate operating funds and personnel to maintain the collections, and if this would not be possible at some future point, the FAO/IBPGR would be alerted.

Very little else in terms of the definition of the rights or responsibilities of the collection hosts/holders under the RBC can be verified from the available records. It is important to note that no common instruments (for example, material transfer agreements) were developed for use by the collection holders in execution of their undertakings as part of the RBC. No benefit-sharing conditions were required for users, and there were no obligations to report on the status of the materials in the collections or on the transfers of samples of those materials to others.

Under the ITPGRFA, the terms and conditions are much more exhaustively defined and 'legalized' under the multilateral system, including mandatory benefit sharing and an international infrastructure for documenting of the collections and the distributions of materials. The Contracting Parties of the ITPGRFA have undertaken to provide facilitated access, 'for the purpose of utilization and conservation for research, breeding and training for food and agriculture, provided that such purpose does not include chemical, pharmaceutical and/or other non-food/feed industrial uses' (Article 12.3.a of the ITPGRFA). They agree that the transfer of all materials in the multilateral system will be subject to the SMTA that was adopted by the ITPGRFA's Governing Body in 2006. Among other things, the SMTA includes obligations for recipients to share monetary benefits derived from the commercialization of new 'PGRFA products' that incorporate materials accessed from the multilateral system (Article 6.7 of the SMTA).

Status of RBC materials *vis-à-vis* the multilateral system

The RBC includes 41 national genebanks, of which 38 are located in countries that have ratified the ITPGRFA (see Table 3 and Online Resource 4). Of these 38 genebanks, 17 have been the subject of member states' notification to the Secretariat/Governing Body, confirming they are included in the multilateral system. Furthermore, the RBC includes 11

Table 3 Distribution of samples to RBC genebanks and their status *vis-à-vis* the multilateral system

	Number of genebanks	Number of RBC accessions that belong to Annex 1 genera	Number of RBC accessions that belong to non-Annex 1 genera	Number of RBC accessions, included as part of Article 15 (that is, Annex 1 and non-Annex 1 genera)
International agricultural research centres (8 CGIAR centres, CATIE, CRU, AVRDC)	11			54,702
RBC genebanks in ITPGRFA member states that have provided the ITPGRFA Secretariat with information regarding collections of the respective RBC genera received from IBPGR that are in the multilateral system	18	63,179	14,111	
RBC genebanks in the ITPGRFA member states that have not provided the ITPGRFA Secretariat with information on any collections that are in the multilateral system or whose notification of information to the ITPGRFA Secretariat does not include the RBC genera	20	3,428	6219	
RBC genebanks in non-ITPGRFA member state	3	1450	1067	
Total	52	68,057	21,397	54,702

genebanks hosted by 11 different international institutions. Ten of those institutions have signed Article 15 agreements with the ITPGRFA's Governing Body to place their ex situ collections under the ITPGRFA's framework. Eight of the 10 are CGIAR centres; the other two are the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) and the Cocoa collection in Trinidad and Tobago (CRU). The eleventh organization is the Asian Vegetable Research and Development Center (AVRDC, also known today as the World Vegetable Center) located in Taiwan, which cannot sign an Article 15 agreement given the political status of its hosting government. However, the AVRDC has adopted the policy followed by the CGIAR centres of making materials available using the SMTA (as though it had signed an Article 15 agreement).

Ultimately, assuming all of the materials distributed to the RBC genebanks still exist, our findings, in accordance with the probability levels mentioned earlier, are that:

Level 0 2517 accessions (1.75%) are conserved in genebanks located in countries that are not member states to the ITPGRFA

Level 1 20,330 accessions (14.1%) are non-Annex 1 materials conserved in genebanks in countries that have ratified the ITPGRFA

Level 2 3428 accessions (2.4%) are Annex 1 materials conserved in countries that have ratified the ITPGRFA but have not provided any notification to the Treaty Secretariat, confirming the materials are available in the multilateral system

Level 3 63,179 accessions (43.8%) are Annex 1 materials conserved in countries that have ratified the ITPGRFA, and the Contracting Parties have published notification that PGRFA of the same crops or forages held by the same RBC-recipient organizations are available in the multilateral system

Level 4 54,702 accessions (37.95%) are conserved in genebanks maintained by international institutions that have signed Article 15 agreements with the Governing Body of the ITPGRFA

For the 45,101 'linked' samples/accessions that we were able to confirm are still being conserved (through the identification of accession numbers), most of them

(82%) correspond to a probability Level 3 and 4. In total, 16% are non-Annex 1 material corresponding to Level 1.

Discussion

The RBC materials

All materials collected by the IBPGR were distributed and conserved through the RBC with the aim of being freely available for research and breeding. If those materials are now included in the multilateral system, we can say that the basic commitments and objectives of the RBCs have been successfully carried forward under the ITPGRFA framework (subject also to additional desirable reporting and benefit-sharing conditions). Assuming they still exist, there is a high level of probability that approximately 82% of the RBC materials are currently available through the multilateral system (falling as they do within probability Levels 3 and 4, as reported above). The number of materials that fall under probability Level 3 has recently increased threefold reaching the amount indicated above due to the United States acceding to the ITPGRFA in 2017. As a result, over 500,000 accessions, which are under the management and control of the US Department of Agriculture/Agricultural Research Service's National Plant Germplasm System (NPGS), the organization that holds the RBC collections, are now available in the multilateral system. Samples of accessions from the US genebank system were made available to users worldwide, although without being subject to internationally agreed benefit-sharing conditions, prior to the United States joining the ITPGRFA (Bretting 2007; Heisey and Day Rubenstein 2015).

An additional 2.4% of the RBC materials, i.e. those accessions included in the aforementioned level 2, are probably already de jure in the multilateral system, but since no information about them has been published, interested recipients may not know that the materials are available with the SMTA. This outcome is due to the fact that Annex 1 PGRFA 'under the management and control of Contracting Parties and in the public domain' are automatically included in the multilateral system, regardless of whether information about them is published anywhere. These 2.4% of the RBC materials were distributed to national public organizations that comprise part of the centralized national public administrations of the countries concerned. It therefore seems likely that these collections would be considered to be 'under the management and control' of the Contracting Party and 'in the public domain'.

That said, the countries concerned have not yet responded to an invitation from the Treaty's Secretariat (and endorsed by the Governing Body) to inform the Governing Body about the materials in their country that are available in the multilateral system. Many countries worldwide are working extremely slowly through the process of confirming what materials fit this description, and it is possible that the key operative terms 'management and control', 'contracting party', and 'public domain' could be interpreted differently within various countries, leading to uncertainty as to practical coverage of the multilateral system. It is noteworthy that a relatively small proportion of the RBC materials fall within this category when one considers that the majority of Contracting Parties to the ITGPFRA still have not sent notifications to the Secretariat/Governing Body concerning collections that are available in the multilateral system.[8] This outcome reflects well on the genebanks and countries concerned and on the criteria and decision making of the IBPGR and the FAO when they identified those genebanks and countries as good candidates for participating in the RBC; their actions over the years retroactively confirm their technical capacities and commitments to making PGRFA internationally available.

A further 14% of RBC materials are samples of crops and forages that are not included in the ITPGRFA's multilateral system (as they are not listed in Annex I) but that were distributed to organizations in countries that are now ITPGRFA Contracting Parties. On the one hand, these materials cannot formally form a part of the multilateral system. However, many of the countries in which these organizations are hosted—and the organizations themselves—have voluntarily adopted the policy of making non-Annex 1 PGRFA that are under their management and control available under the terms and conditions of the ITPGRFA's multilateral system—

[8] As of 6 December 2017, 40 Contracting Parties (out of a total of 144 Contracting Parties) have sent such notices to the Secretariat/Governing Body. See http://www.fao.org/plant-treaty/areas-of-work/the-multilateral-system/collections/en/.

that is to say, using the SMTA. Among the countries/genebanks that received non-Annex 1 RBC materials that have adopted this policy are the Leibniz Institute for Plant Genetics and Crop Plant Research IPK in Germany, the Centre for Genetic Resources CGN in the Netherlands, and the NPGS in the United States. The European Genebank Integrated System's (AEGIS) partnering organizations, with support from national governments, have assembled a distributed European collection of PGRFA, including over 47,000 accessions that are available to anyone around the world under the SMTA.[9] To date, 25% of the accessions in the European collection are not part of the multilateral system.

In total, 23 RBC genebanks located in ITPGRFA member states have received samples of non-Annex 1 genera. In the first 10 years of its operation, 4% of PGRFA reported as being transferred using the SMTA were of non-Annex 1 crops or forages. Only 2% of the RBC materials were distributed to organizations that are in countries that have not ratified or acceded to the Treaty. Regarding the linked materials, we have found that nearly half of them are located in 'Article 15 collections' and another 35% in genebanks that have provided information regarding availability in the multilateral system. As the linking of RBC samples to accession numbers in genebanks requires sufficient and available passport data, these results are not surprising. Given the advanced documentation status in most international collections and the need for genebanks to have a sufficiently developed documentation system that allows them to identify and flag multilateral system accessions, it has been easier to identify accession numbers.

How to move forward?

In this final section, we identify a number of actions for a range of potential actors to ascertain that the RBC materials are (or are not) still being conserved, what their legal status in the respective genebanks is, and whether they are being made available for agricultural research and breeding through the ITPGRFA's multilateral system. As a first step, it is essential to ascertain the status of the outstanding 75% of materials distributed to genebanks around the world as part of the RBC. This effort will require redoubling the efforts and following the methods the authors piloted to track and 'link' 25% of the RBC materials. Our survey has shown that passport information for accessions in general is often not comprehensive and that several of the genebanks were not able to confirm if the materials they held were received from the IBPGR/IPGRI as part of the RBC.

We have demonstrated that it is possible to use the original collecting missions' passport data and the RBC distribution records to 'track down' RBC samples to individual genebanks (see Thormann et al. 2015 for details). An interested organization could support national and international genebanks in mapping/linking their data to the original passport and collecting data to proactively identify more of the RBC materials. Accession numbers should then be communicated to Bioversity International for inclusion in the BCD so that the accession will become retrievable. Ideally, these accessions will have a DOI assigned by the ITPGRFA, as this should become the preferred identifier in the BCD to support the traceability of the RBC material.[10] Identifying the RBC materials and sharing information about them with the international community would be useful with respect to all of the RBC materials, regardless of whether or not they are Annex 1 or if the country concerned is an ITPGRFA member state or not. Value and uses of the BCD and the identified RBC material have recently also been shown in research on genetic erosion in wild barley and barley landraces (Thormann et al. 2017, 2018). In these studies, data from the BCD was used to trace barley accessions collected in the 1980s and to re-collect new samples from the old collecting sites, to compose a set of accessions from two time points for comparison.

As a next step, once the genebanks (and the countries within which the genebanks are located) confirm that they are conserving Annex 1 RBC materials, they should then go through the process of confirming that those materials are available in the multilateral system (by virtue of being in the 'management and control' of the national government and

[9] See 'AEGIS (the European Genebank Integrated System): European Accessions', http://www.ecpgr.cgiar.org/aegis/european-collection/european-accessions/ last (accessed 3 November 2018).

[10] For more about DOIs minted under the Global Information System of the ITPGRFA, see http://www.fao.org/plant-treaty/areas-of-work/global-information-system/doi/en/ (accessed 7 December 2017).

in the public domain). For Contracting Parties hosting RBC materials that have not yet notified the ITPGRFA's Secretariat and Governing Body about materials in the multilateral system, the RBC materials should be given a priority examination, given the nature of the original commitment to make these materials available. If, for some reason, it is determined that the RBC materials are not under the management and control of a contracting party and in the public domain, then the genebank and national authorities should work together to ensure that they are voluntarily included. This would be the most efficacious way to promote the continued availability of those materials in ways that are largely consistent with the original undertakings of the host organizations under the RBC. In both cases—automatic or voluntary inclusion—they should publish information about the existence and availability of those materials through the ITPGRFA's website and other information systems that are part of the global information system under the ITPGRFA.

If the RBC materials are non-Annex 1, the genebanks concerned and the relevant national authorities should work to establish the means to make those materials available using the SMTA. The fact that a significant proportion of RBC materials are non-Annex 1 materials highlights how it has been necessary for the international community to narrow its focus on a more limited range of crops to obtain consensus about standard access and benefit-sharing rules (according to the multilateral system). One day, the scope of Annex 1 may be expanded to include additional crops and forages, or perhaps even all PGRFA. Until that time, it is incumbent upon the organizations and countries that have received RBC materials to make them available through terms of facilitated access and fair and equitable benefit-sharing. Of course, it may be possible to develop systems of expedited, simplified access under national legislation on the Nagoya Protocol, for example.[11] However, it would be most efficacious for the organizations and countries concerned—when it comes to the old RBC collections—to seek to use the SMTA when making these non-Annex 1 materials available. If that is not possible, then some other mechanism and terms and conditions should be developed whereby the materials are made available by the hosting organization on terms as close as possible to those of the Registry of Base Collections, updated to reflect more recent commitments to benefit sharing (ultimately, adopting the SMTA for such purposes would be by far the most practical).

Given the history, as well as international public nature, of the RBC, and the fact that the ITPGRFA/multilateral system carries forward the spirit and purpose of the RBC, one could argue that the FAO, Bioversity International (the successor in title to the IBPGR), the Secretariat and Governing Body of the ITPGRFA, and, possibly, the Global Crop Diversity Trust have an interest in working with the organizations that received RBC collections and their host governments (including the national focal points for the ITPGRFA) to explore ways to ensure those materials are indeed available in the multilateral system. They could work together to raise awareness about the existence of those collections. They could also provide coordination and technical back up to the genebanks to confirm if some of their materials were originally received as part of the RBC. If it is determined that some of the old RBC materials are at risk (e.g., if the genebank is not able to guarantee long-term conservation) relevant organizations could work together to support the transfer of this material to other locations as has been done in recent years with *Hordeum* L., *Pisum* L. and *Pennisetum* Rich. ex Pers. samples (Thormann et al. 2015). If needs for assistance outweigh available resources, consideration would have to be given to the relative importance of those collections. The international organizations listed above could also assist the genebank and national program concerned to assemble the relevant information and publish it on the ITPGRFA's website and other databases that form part of the global-level information system. They could even go further, supporting the genebanks and national programs concerned to analyse the viability of the materials, support their regeneration if warranted, and their characterization and evaluation through partnerships with the genebanks and national programs concerned.

[11] See Nagoya Protocol on Access and Benefit Sharing and the Fair and Equitable Sharing of Benefits Arising from Their Utilization, 29 October 2012, http://www.cbd.int/abs/text/ (accessed 24 October 2017) art. 10(c): 'In the development and implementation of its access and benefit-sharing legislation or regulatory requirements, each Party shall: […] (c) Consider the importance of genetic resources for food and agriculture and their special role for food security'.

Acknowledgements We thank Daniele Manzella and Kent Nnadozie (ITPGRFA Secretariat), and Charlotte Lusty (Global Crop Diversity Trust) for critical revisions. We acknowledge support from the CGIAR Genebank Platform.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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